

ELECTRICAL SAFETY DEVICES AND SYSTEMS FOR USE WITH
ELECTRICAL WIRING, AND METHODS FOR USING SAME

CROSS REFERENCE TO RELATED APPLICATIONS

- 5 [0001] This Application claims priority from U.S. Provisional Application No. 60/820,197, entitled ACTIVE SAFETY DEVICES, which was filed on July 24, 2006, and is incorporated herein by reference.

TECHNICAL FIELD

- 10 [0002] The present invention generally relates to safety devices and systems used in conjunction with electrical wiring and, more particularly, to safety devices and systems used in conjunction with electrical flat wiring.

BACKGROUND

- 15 [0003] Most homes and commercial buildings utilize electrical wiring systems to distribute power throughout the structure. Typically, electrical wiring systems carry a 120 or 240 volt signal at 15 or 30 amps, respectively, to provide electrical power for lighting systems, climate control systems, appliances, and other loads. Many accidents occur annually due to penetrations of electrical wires or due to deterioration of older wiring systems.

- 20 [0004] According to reports issued by the Consumer Products Safety Commission (CPSC) in 1997, home wire systems caused over 40,000 fires that resulted in 250 deaths and over \$670 million of property damage. Further study by the CPSC based on 40,300 electrical circuit fires showed that 36% were due to installed wiring and 16% were due to cord/plugs.

- 25 [0005] Today, circuit breakers primarily protect against certain overload and short circuit conditions which occur primarily in fixed wiring. The overload protection is provided by the slow heating of a bimetal strip that breaks the circuit causing the breaker to trip after a specified period of time. The more current that runs through the bimetal, the shorter the time it takes to trip the breaker. Short circuit protection may be provided magnetically, that is, a high level of current may trip a breaker
30 instantaneously. The lower limit of the magnetic trip setting may be determined by the manufacturer such that the device does not nuisance trip on high inrush loads.

[0006] Circuit breakers do not protect against all hazards that may occur within electrical wiring systems. Therefore, in addition to circuit breakers, there are many other safety devices that have been designed for use with electrical wiring. These safety devices may provide secondary protection, which is additional to any protection
5 provided by the circuit breaker, or they may provide primary protection independent of that provided by the circuit breaker. These safety devices primarily are designed to be used in conjunction with conventional electrical wire. Conventional electrical wire, as we know it today, typically contains two insulated, round inner conductors (e.g., hot/neutral or electrifiable/return conductors) and a non-insulated ground conductor
10 (e.g., grounding conductor), all within a thermoplastic outer insulator. The neutral or return conductor may also be referred to as a grounded conductor.

[0007] One such safety device that is commonly installed in electrical wiring systems is a Ground Fault Circuit Interrupter (GFCI). A GFCI measures the difference between the currents flowing through the hot conductor and the neutral conductor of a
15 conventional electrical wire. If the difference between the current flowing through the hot conductor and the current flowing through the neutral conductor exceeds a few milliamps, the presumption is that current is leaking to ground via some other path. This may be because of a short circuit to, for example, the chassis of an appliance, or to the ground lead, or through a person. Any of these situations may be hazardous, so the
20 GFCI trips, breaking the circuit.

[0008] Another safety device that is commonly installed in electrical wiring systems is an Arc Fault Circuit Interrupter (AFCI). An AFCI adds electronic protection to the standard thermal and magnetic protection provided by circuit breakers. The circuitry in an AFCI detects specific arcs that are determined to be likely to cause a fire.
25 The AFCI uses electronics to recognize the current and voltage characteristics of the arcing faults on the electrical wire, and interrupts the circuit when a fault is detected. Each AFCI has circuit logic, and perhaps control logic, that is designed to detect specific types of arc faults. These arc faults are specific to the type of wiring the AFCI is designed to be implemented with. Current AFCI's are designed to be used in
30 conjunction with conventional wire systems to detect arc faults that commonly occur within those conventional wire systems.

[0009] A problem with many electrical wire safety devices is that they are designed to be used in conjunction with conventional three-conductor electric wire. Current safety devices are not designed to be used in wiring systems that include flat electrical wire. A flat electrical wire and method of fabricating the electrical wire are described in U.S. Pat. App. No. 10/790,055 (Now U.S. Pat. No. 7,145,073), which is incorporated by reference herein in its entirety. Flat electrical wire is designed to be a surface-mounted wiring system that can be installed on surfaces such as a wall, ceiling or floor. Accordingly, flat electrical wire is designed to be thin and flexible in order to allow it to be easily concealed, for example, by being painted or papered over. Currently existing safety devices are not specifically designed to be used in conjunction with and in many cases are incompatible with flat electrical wire. Accordingly, a need exists for one or more safety devices that are suitable for use with flat electrical wire.

SUMMARY

[0010] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description and is not intended to limit the scope of the claimed subject matter.

[0011] Disclosed are devices, systems, and methods for monitoring a wire such as, for example, an electrical flat wire for one or more of miswires, wire faults, or abnormal conditions. According to one embodiment of the invention, there is disclosed a source device for use with electrical flat wire. The source device may include a line side input, a flat wire connection, at least one relay, and a control unit. The line side input may be configured to connect to a line side power source and to receive an electrical power signal from the line side power source. The flat wire connection may be configured to connect to an electrical flat wire. The at least one relay may be configured to control the communication of the electrical power signal onto the electrical flat wire. The control unit may be configured to test the electrical flat wire for at least one of miswires, wire faults, or abnormal conditions and, based at least in part on the results of the testing, to control the actuation of the at least one relay.

[0012] According to another embodiment of the invention, there is disclosed an electrical flat wire system that includes a source device, a destination device, and an electrical flat wire. The source device may be configured to be coupled to a line side power source, and the source device may include an active safety device and a first flat

wire termination. The destination device may include a second flat wire termination. The electrical flat wire may have a first end coupled to the first flat wire termination and a second end coupled to the second flat wire termination. The active safety device may monitor the electrical flat wire for at least one of miswires, wire faults, or
5 abnormal conditions and, based on the results of the monitoring, control the communication of an electrical power signal from the line side power source to the electrical flat wire.

[0013] According to another embodiment of the invention, there is disclosed a method for monitoring an electrical flat wire. An electrical flat wire may be provided
10 between a source and a destination. One or more conductors of the electrical flat wire may be tested for at least one of miswires, wire faults or abnormal conditions. The communication of an electrical power signal from a power source to the electrical flat wire may be controlled based at least in part on the results of the testing.

[0014] According to another embodiment of the invention, there is disclosed an
15 active safety device for use with electrical wiring. The active safety device may include at least one relay and a control unit. The at least one relay may be configured to control the communication of an electrical power signal from a line side power source associated with the active safety device onto an electrical flat wire. The control unit may be configured to test the electrical flat wire for at least one of miswires, wire
20 faults, or abnormal conditions and, based at least in part on the results of the testing, to control the actuation of the at least one relay. Additionally, the control unit may be associated with at least one safety component utilized in the testing of the electrical flat wire.

[0015] Aspects of the invention described below apply equally to the source
25 device, the flat wire system, and to the method for monitoring a flat wire. For simplicity, the aspects are described herein as being applicable to the source device embodiment. According to one aspect of the invention, the control unit may be further configured to test the line side power source for at least one of miswires, wire faults, or abnormal conditions and to control the actuation of the at least one relay based at least
30 in part on the testing of the line side power source.

[0016] According to another aspect of the invention, the control unit may be associated with at least one reactive safety component that is utilized in the testing of

the electrical flat wire. The at least one reactive safety component may be utilized to test the electrical flat wire subsequent to the electrification of the electrical flat wire.

The at least one reactive safety component may include one or more of a ground fault circuit interrupter, an arc mitigation circuit, an over-current protection safety

5 component, and a ground current monitoring safety component.

[0017] According to another aspect of the invention, the control unit may be associated with at least one proactive safety component that is utilized in the testing of the electrical flat wire. The at least one proactive safety component may be utilized to test the electrical flat wire prior to the electrification of the electrical flat wire. The at

10 least one proactive safety component may include one or more of a line side wire integrity component and a load side wire integrity component.

[0018] According to an aspect of the invention, a line side wire integrity component that may be configured to identify one or more conductors associated with the line side power source and to determine whether the one or more identified

15 conductors are properly terminated at the line side input.

[0019] According to another aspect of the invention, a load side wire integrity component that may be configured to communicate at least one test signal onto at least one conductor of the electrical flat wire, to monitor one or more of the conductors for one or more return signals, and to determine whether any miswires or wire faults exist

20 based upon the one or more return signals.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0020] Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and
5 wherein:

[0021] FIG. 1 is a schematic diagram of a flat wire system including an Active Safety Device (ASD), according to an illustrative embodiment of the invention.

[0022] FIG. 2 is a cross-section view of a multi-planar, stacked, or protective layered flat wire that may be used in conjunction with an ASD, according to an
10 illustrative embodiment of the invention.

[0023] FIG. 3 is a block diagram of the components of an ASD, according to an illustrative embodiment of the invention

[0024] FIG. 4A is a block diagram of a control unit that may be associated with an ASD according to embodiments of the invention.

15 [0025] FIG. 4B is an exemplary flowchart of the operation of the control unit of FIG. 4A, according to an illustrative embodiment of the invention.

[0026] FIG. 5 is a schematic diagram of a line side wire integrity component that may be incorporated into an ASD, according to an embodiment of the invention.

[0027] FIG. 6 is an exemplary flowchart of the operation of a line side wire
20 integrity component that may be incorporated into an ASD according to an embodiment of the invention.

[0028] FIG. 7 is an exemplary flowchart of the general operation of a load side wire integrity component, according to an illustrative embodiment of the invention.

[0029] FIG. 8 is an exemplary timing diagram of voltage or current based test
25 signals that may be applied by a load side wire integrity component, according to an illustrative embodiment of the invention.

[0030] FIG. 9A is a schematic diagram of a voltage-based load side wire integrity component that may be incorporated into an ASD, according to an embodiment of the invention.

[0031] FIG. 9B is a schematic diagram of a current-based load side wire integrity component that may be incorporated into an ASD, according to an embodiment of the invention.

5 [0032] FIG. 9C is a schematic diagram of a current-based load side wire integrity component that utilizes testing relays in monitoring a flat wire for miswires and inter-layer shorts, according to an embodiment of the invention.

[0033] FIG. 10 is an exemplary flowchart of the operation of a load side wire integrity component, according to an illustrative embodiment of the invention.

10 [0034] FIG. 11 is a schematic diagram of another exemplary load side wire integrity component that may be incorporated into an ASD, according to an illustrative embodiment of the invention.

[0035] FIG. 12 is a schematic diagram of another exemplary load side wire integrity component that may be incorporated into an ASD, according to an illustrative embodiment of the invention.

15 [0036] FIG. 13 is a schematic diagram of a circuit that may be utilized to test for a flat wire connection at a destination module, according to an embodiment of the invention.

[0037] FIGS. 14A-14F are cross-sectional views depicting an example of the dynamics of a nail or tack penetration of a live multi-planar flat wire.

20 [0038] FIG. 15 is a representative graph of the voltage and current waveforms present during a penetration of a flat wire by a nail as provided for in FIGS 13A-13F.

[0039] FIGS. 16A-16D are cross-sectional views depicting examples of the dynamics of a penetration of a non-live multi-planar flat wire.

25 [0040] FIG. 17A is a schematic diagram of an exemplary source device connection to an electrical outlet and a flat wire, according to an illustrative embodiment of the invention.

[0041] FIG. 17B is a schematic diagram of an ASD with extender outlets, according to an illustrative embodiment of the invention.

[0042] FIG. 18 is a schematic diagram of a flat wire system including an Active Safety Device (ASD) that monitors two flat wires connected to the same destination device, according to an illustrative embodiment of the invention.

5 [0043] FIG. 19 is a schematic diagram of multiple destination devices in a serial configuration being supported by a single source device, according to an illustrative embodiment of an aspect of the invention.

[0044] FIG. 20 is a schematic diagram of a system in which multiple source devices form a central device that monitors multiple flat wires in a room, according to an illustrative embodiment of an aspect of the invention.

10 [0045] FIG. 21 is a schematic diagram of a network of source devices monitored by a central hub, according to an illustrative embodiment of one aspect of the invention.

DETAILED DESCRIPTION

15 [0046] The present inventions now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the inventions are shown. Indeed, these inventions may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable
20 legal requirements. Like numbers refer to like elements throughout.

[0047] The invention is described below with reference to block diagrams of systems, methods, apparatuses and computer program products according to an embodiment of the invention. It will be understood that each block of the block diagrams, and combinations of blocks in the block diagrams, respectively, can be
25 implemented by computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functionality of each block of the block
30 diagrams, or combinations of blocks in the block diagrams discussed in detail in the descriptions below.

[0048] These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction
5 means that implement the function specified in the block or blocks. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions that execute on the computer or other programmable
10 apparatus provide steps for implementing the functions specified in the block or blocks.

[0049] Accordingly, blocks of the block diagrams support combinations of means for performing the specified functions, combinations of steps for performing the specified functions and program instruction means for performing the specified functions. It will also be understood that each block of the block diagrams, and
15 combinations of blocks in the block diagrams, can be implemented by special purpose hardware-based computer systems that perform the specified functions or steps, or combinations of special purpose hardware and computer instructions.

[0050] The inventions may be implemented through an application program running on an operating system of a computer. The inventions also may be practiced
20 with other computer system configurations, including hand-held devices, multiprocessor systems, microprocessor based or programmable consumer electronics, mini-computers, mainframe computers, etc.

[0051] Application programs that are components of the invention may include routines, programs, components, data structures, etc. that implement certain abstract
25 data types, perform certain tasks, actions, or tasks. In a distributed computing environment, the application program (in whole or in part) may be located in local memory, or in other storage. In addition, or in the alternative, the application program (in whole or in part) may be located in remote memory or in storage to allow for the practice of the inventions where tasks are performed by remote processing devices
30 linked through a communications network. Exemplary embodiments of the invention will hereinafter be described with reference to the figures, in which like numerals indicate like elements throughout the several drawings.

[0052] Disclosed are systems and methods for monitoring an electrical wire or electrical wiring system for miswires and wire faults. An Active Safety Device (ASD) may be utilized to perform tests on an electrical wire prior to the electrification of the electrical wire, during the electrification of the electrical wire, and following the electrification of the electrical wire. If a miswire or wire fault is identified or detected by the ASD prior to the electrification of the electrical wire, then the electrical wire may be prevented from being electrified. If a miswire or wire fault is identified or detected by the ASD during or following the electrification of the electrical wire, then the electrical wire may be de-energized. It will be appreciated that an ASD may be utilized in many different types of applications such as, for example, in conjunction with commercial and/or residential wiring. As an example, an ASD may be utilized to monitor electrical wiring that is installed in a home or at a commercial or industrial site. The monitored electrical wiring may be wiring that is installed at the location at the time of construction or during a rewiring project.

[0053] Referring now to FIG. 1, an Active Safety Device (ASD) **100** implemented in a flat electrical wire system **101** is shown, according to an illustrative embodiment of the invention. The flat electrical wire system **101** may include a source device **103**, a flat wire **105**, a line side power source **115**, a destination device **117**, and a load side destination **125**. The source device **103** may include an ASD **100** and a source module **110**. The destination device **117** may include a destination module **120** and an expansion module **122**. For purposes of the present disclosure, an ASD **100** is an electrical safety device, circuit, or module in accordance with the invention containing reactive and/or proactive safety components, circuits, and/or circuitry, as explained in greater detail below. It will be understood that in some embodiments such as, for example, some commercial embodiments, the source device **103** and its associated components, circuitry, and modules may be designated as an ASD. While the illustrative embodiments described herein are in connection with flat electrical wire, an ASD **100** in accordance with embodiments of the invention is equally applicable to conventional electrical wiring, such as electric wire comprising elongated cylindrical conductors based on the teaching disclosed herein.

[0054] A variety of flat wires may be used in conjunction with an ASD **100** in accordance with embodiments of the invention. The flat wire **105** may be a flat

electrical wire or other flat wire such as a speaker wire, telephone wire, low voltage wire, CATV wire, or under surface wire. The flat wire **105** typically will be made up of multiple flat conductors that may be configured in a stacked, multi-planar, or protective layered arrangement or in a parallel or coplanar arrangement having conductors within the same plane. Additionally, the conductors of the flat wire **105** may contain multiple conductive adjacent or non-insulated sub-layers or flat strands. The flat wire **105** may also contain one or more optical fibers. One example of a flat wire that may be used in accordance with the ASD **100** of the present invention is described in U.S. Pat. App. No. 10/790,055 (Publication No. US 2005/0042942), entitled "Electrical Wire and Method of Fabricating the Electrical Wire," which is hereby incorporated by reference in its entirety. Other examples of flat wires that may be used in accordance with the ASD **100** of the present invention include, but are not limited to, the flat wires disclosed in U.S. Pat. No. 5,804,768, entitled "Flat Surface-Mounted Multi-Purpose Wire," U.S. Pat. No. 6,107,577, entitled "Flat Surface-Mounted Multi-Purpose Wire," U.S. Pat. No. 6,492,595, entitled "Flat Surface-Mounted Multi-Purpose Wire," and U.S. Pat. No. 6,774,741, entitled "Non-uniform Transmission Line and Method of Fabricating the Same," the disclosures of which are incorporated by reference herein in their entirety.

[0055] FIG. 2 is a cross-section view of a multi-planar flat wire **105** that may be used in conjunction with an ASD **100**, according to an illustrative embodiment of the invention. The flat wire **105** of FIG. 2 may be an electrical flat wire with stacked conductors. At least one electrifiable conductor **205** (or hot conductor) may be situated between two return conductors **210, 215**, (or neutral conductors) and the two return conductors **210, 215** may be formed such that the electrifiable conductor **205** is substantially entrapped by the first and second return conductors **210, 215**. The term substantially entrapped may be utilized to refer to a situation in which the electrifiable conductor **205** cannot be contacted by a foreign object (e.g., a nail, screw, staple, etc.) without the foreign object first contacting one of the return conductors **210, 215**. The term substantially entrapped does not necessarily mean that the return conductors **210, 215** completely surround the electrifiable conductor **205** (although such a design is possible). Instead, the term may mean that any distance between the return conductors **210, 215** may be small enough that a foreign object cannot reasonably go between the

return conductors **210, 215** and the electrifiable conductor **205** without contacting one or more of the return conductors **210, 215**.

[0056] With continued reference to FIG. 2, two grounding conductors **220, 225** may be included in the flat wire **105**. The various conductors of the flat wire **105** may
5 be assembled in a stacked configuration such that the electrifiable conductor **205** is situated between the two return conductors **210, 215** and that three conductor arrangement is then sandwiched between the two grounding conductors **220, 225**. This configuration may be referred to as a G-N-H-N-G configuration.

[0057] Additionally, insulation material may be disposed between each of the
10 conductors of the flat wire **105**. The insulation material may prevent the various conductors of the flat wire **105** from contacting one another and creating a short circuit in the flat wire **105**. Electrifiable conductor insulation material **230** may surround the electrifiable conductor **205** and prevent the electrifiable conductor **205** from making electrical contact with the other conductors of the flat wire **105**. Additionally, return
15 conductor insulation material **235** may be disposed between the return conductors **210, 215** and the corresponding grounding conductors **220, 225** to prevent the first return conductor **210** from contacting the corresponding first grounding conductor **220** and to prevent the second return conductor **215** from contacting the corresponding second grounding conductor **225**. Grounding conductor insulation **240** may be disposed
20 opposite the first grounding conductor **220** and the second grounding conductor **225**, and the grounding conductor insulation **240** may prevent the grounding conductors **220, 225** from contacting an object or surface that is external to the flat wire **105**.

[0058] Alternatively, each conductor of the flat wire **105** may be individually
25 wrapped with an insulation material. In this alternative configuration, electrifiable conductor insulation material **230** would be disposed on both sides of the electrifiable conductor **205** to separate the electrifiable conductor **205** from the return conductors **210, 215**. Return conductor insulation material **235** would be disposed on both sides of each of the return conductors **210, 215** to separate the return conductors **210, 215** from the electrifiable conductor **205** and the grounding conductors **220, 225**. Grounding
30 conductor insulation material **240** would be disposed on both sides of each of the grounding conductors **220, 225** to separate the grounding conductors **220, 225** from the return conductors **210, 215** and any objects or surfaces that are external to the flat wire

105. In the alternative configuration, two layers of insulation material are disposed between any two conductors of the flat wire **105**, thereby decreasing the possibility of short circuits between the conductors of the flat wire **105**. In other words, a short circuit between two conductors of the flat wire **105** exists when there is a flaw in the insulation material between the two conductors. For example, if only a single layer of insulation material is disposed between each of the conductors of the flat wire **105**, a short circuit might occur if there is a flaw in the insulation material disposed between the electrifiable conductor **205** and one of the return conductors **210**. If, however, each of the conductors of the flat wire **105** is individually wrapped with insulation material, the possibility of a short circuit between two conductors is decreased because flaws would need to be present in both layers of insulation material disposed between the two conductors, and the flaws would need to line up with one another or be situated in close proximity to one another. For example, for a short circuit to occur between the electrifiable conductor **205** and one of the return conductors **210**, flaws must be present in both the electrifiable conductor insulation material **230** and in the return conductor insulation material **235** disposed between the two conductors. Additionally, these flaws would need to line up with one another or be situated in close proximity to one another.

[0059] Although a five-conductor stacked flat wire is depicted in FIG. 2, it will be appreciated that the ASD **100** may be utilized to monitor flat wires with many different conductor configurations. For example, flat wires with a wide variety of stacked conductor configurations may be monitored by the ASD **100**. As an example, a three conductor flat wire having a stacked configuration may be monitored by the ASD **100**. The three conductor flat wire may include an electrifiable conductor that is substantially entrapped by first and second return conductors, and the three conductor configuration may be referred to as a N-H-N configuration. Additionally, various flat wire embodiments containing parallel or coplanar arrangements of conductors may be monitored by the ASD **100**. For example, a three conductor flat wire having a coplanar arrangement may be monitored by the ASD **100**. The three conductor coplanar flat wire may include an electrifiable conductor, a return conductor, and a grounding conductor disposed in a parallel configuration within the same plane.

[0060] With reference back to FIG. 1, in a flat wire system **101**, a flat wire **105** may be connected to the ASD **100** through a source module **110**. The source module

110 may be physically separate from the ASD 100, or alternatively, the source module 110 may be integrated into the ASD 100. The source module 110 may serve as a mechanical or electromechanical connection between the flat wire 105 and the ASD 100. The various conductors of the flat wire 105, may be terminated at the source
5 module 110. Termination points within the source module 110 may include terminal blocks, crimp-on terminals, plug and socket connectors, insulation displacement connectors (IDC), conductor penetration connectors (CPC), or any other suitable electrical connector as will be understood by those of ordinary skill in the art. It will be appreciated that one or more appropriate detection devices may be utilized to verify
10 that the source module 110 is connected to the ASD 100 and/or that the termination points are connected to the source module 110. For example, a ground pin or plug may be extended through the source module 110 and/or the termination points in order to detect the presence of the source module 110 and/or the termination points. As another example, an optical detection device may be utilized. Furthermore, it will be
15 understood that a combination of detection devices may be utilized.

[0061] The ASD 100 may also be connected to a line side power source 115. The line side power source 115 may be any standard electric power source including a power wire coming from a circuit box, a conventional in-wall electrical wire, a flat electrical wire, or any other electrical wire capable of delivering electric power. For
20 flat wire 105 branch circuit applications, the line side power source 115 may be a typical wall-mounted or in-wall power outlet or power receptacle. Typically, the line side power source 115 will carry an electrical voltage of approximately 110-130 VAC or approximately 220-250 VAC.

[0062] The line side power source 115 may be physically separate from the source
25 device 103 or, alternatively, the line side power source 115 may be integrated into the source device 103. For example, if a conventional in-wall electrical wire were directly connected to the source device 103, the line side power source 115 would be physically separate from the source device 103. Alternatively, the line side power source 115 may be integrated into the source device 103 in a situation in which the source device 103
30 includes, for example, a conventional three-prong plug that may be inserted into a standard electrical outlet.

[0063] Still referring to FIG. 1, the flat wire **105** may create a connection between the source module **110** and one or more destination devices **117**. The one or more destination devices **117** may include a destination module **120** and an expansion module **122**. Much like the source module **110**, a destination module **120** may serve as a mechanical or electro-mechanical connection between the flat wire **105** and the destination device **117**. The various conductors of the flat wire **105** may be terminated at the destination module **120**. Termination points within the destination module **120** may include terminal blocks, crimp-on terminals, plug and socket connectors, insulation displacement connectors (IDC), conductor penetration connectors (CPC), or any other electrical connector as will be understood by those of ordinary skill in the art.

[0064] An expansion module **122** may be included in a destination device **117**, and the expansion module **122** may serve as a mechanical or electro-mechanical connection between the destination device **117** and a load side destination **125**. A load side destination **125** may include a power outlet or receptacle, a wired device, a terminal block, a safety component, "flying leads," or any other load side connection as will be understood by those of ordinary skill in the art. Termination points within the expansion module **122** used to connect the load side destination **125** to the expansion module **122** may include terminal blocks, crimp-on terminals, plug and socket connectors, insulation displacement connectors (IDC), conductor penetration connectors (CPC), or any other electrical connector as will be understood by those of ordinary skill in the art. It will also be understood by those of skill in the art that the load side destination may be connected to the destination module **120** as an alternative to being connected to the expansion module **122**.

[0065] The load side destination **125** may be physically separate from the destination device **117** or, alternatively, the load side destination **125** may be integrated into the destination device **117**. For example, if an electrical device such as a lamp were directly connected to the destination device **117**, the load side destination **125** would be physically separate from the destination device **117**. Alternatively, the load side destination **125** may be integrated into the destination device **117** in a situation in which the destination device **117** includes, for example, one or more electrical sockets. The destination device **117** may include any number of electrical sockets configured to

receive electrical plugs. For example, the destination device **117** may include one, two, three, or four sockets that serve as a load side destination **125**.

[0066] Additionally, the expansion module **122** may be used to create a mechanical or electro-mechanical connection between the destination device **117** and a second destination device, as explained in greater detail below with reference to FIG. 18. In such an embodiment, a second flat wire **105** may be, for example, connected to the expansion module **122** and used to create a connection between the expansion module **122** and the second destination device. Termination points within the expansion module **122** may include terminal blocks, crimp-on terminals, plug and socket connectors, insulation displacement connectors (IDC), conductor penetration connectors (CPC), or any other electrical connector as will be understood by those of ordinary skill in the art.

[0067] Additionally, as explained in greater detail below, the destination device **117** may be capable of communicating with the ASD **100** through the source module **110** over the flat wire **105**. The destination device **117** may also be capable of communicating with a second destination device through the expansion module **122** over a second flat wire **105**, as explained in greater detail below with reference to FIG. 15.

[0068] FIG. 3 is a block diagram of the components of a source device **103**, according to an illustrative embodiment of the invention. The ASD **100** may include a line side input **305**, one or more relays **310**, a flat wire I/O interface **311**, a control unit **312**, and various safety components including one or more of a GFCI component **315**, an AMC component **320**, an over-current protection component **325**, a ground current monitoring component **330**, a line side wire integrity component **335**, and a load side wire integrity component **340**.

[0069] The ASD **100** may be powered by a power source, which may be connected to the ASD **100** at the line side input **305**. For example, the line side power source **115** may be connected to the line side input **305** of the ASD **100** to provide power to the ASD **100**. Further, the one or more relays **310** may control the flow of an electrical signal, which may be an electrical power signal, from a power source through the ASD **100** to the source module **110**. Each of the one or more relays **310** may be, for example, a double pole single throw (DPST) relay. It will be understood that a

multitude of other relays may be used by the ASD **100** including, but not limited to, one or more single pole single throw (SPST) relays, one or more single pole double throw (SPDT) relays, one or more single pole changeover or center off relays (SPCO), one or more double pole double throw relays (DPDT), or one or more double pole changeover or center off relays (DPCO).

[0070] The ASD **100** may include a single (common or main) relay **310** or it may include multiple relays in other suitable configurations within the ASD **100**. For example, each safety component of the ASD **100** may include subordinate or dedicated relays or, alternatively, various components of the ASD **100** may share a common or main relay **310**. As another example, a separate relay may be provided for various conductors of a flat wire **105** that is connected to the source module **110**. For example, a first relay may be provided for the electrifiable conductor **205** and a second relay may be provided for the return conductors **210**, **215**. Each of the relays may be actuated independently of one another or, alternatively, a plurality of the relays may be jointly actuated. It will be appreciated that the ASD **100** may utilize one or more relays to communicate test signals onto the flat wire **105** without providing an electrical power signal to the electrifiable conductor **205** of the flat wire **105**. For example, as explained in greater detail below with reference to FIG. 11, the second relay may be utilized to communicate a test signal onto the return conductors **210**, **215** of the flat wire **105**, and the ASD **100** may then monitor the flat wire **105** for miswires and/or wire faults. If the ASD **100** determines that no miswires and/or wire faults exist on the flat wire **105**, then the ASD **100** may utilize the first relay to permit an electrical power signal to be communicated only the electrifiable conductor **105**. Unless otherwise stated in this disclosure, for purposes of simplicity, reference will be made to an ASD **100** that includes a single relay **310** that is utilized to control the communication of an electrical power signal onto the electrifiable conductor **105** of the flat wire **105**.

[0071] In the illustrative embodiment with a single relay **310**, also referred to as the common or main relay, the ASD **100** may maintain the relay **310** in either an opened position or a closed position. When the relay **310** is maintained in a closed position, electrical power may be permitted to flow from a line side power source **115** through the ASD **100** to the source module **110**. As shown in FIG. 3, an ASD power line **350** may be included in the ASD **100** to carry the electrical power from the line

side input **305** through the ASD **100** to the source module **110**; however, it will be understood that electrical power could be propagated through the ASD **100** via circuitry other than an ASD power line **350**, such as through the various individual safety components of the ASD **100**. The ASD power line **350** is included in this disclosure
5 for simplification purposes in order to facilitate the understanding of the invention. From the source module **110**, the electrical power may then be transmitted onto the flat wire **105** and be delivered to the destination module **120**.

[0072] Alternatively, when the relay **310** is maintained in an opened position, an electrical signal is not allowed to flow from a line side power source **115** through the
10 ASD **100** to the source module **110**. The ASD **100** may beneficially be configured to default to maintaining the relay **310** in an opened position. By defaulting to an opened position, the ASD **100** may ensure that no faults are present in the flat wire system **101** prior to full electrification or energization of the flat wire system **101**. Accordingly, whenever the ASD **100** loses power, if the relay **310** is not in an opened position, the
15 relay **310** may be switched to an opened position in order to permit the ASD **100** to perform tests on the flat wire system **101**.

[0073] According to an aspect of the invention, the relay **310** may be part of a zero crossing circuit. Alternatively, the zero crossing circuit may be a part of the control unit **312**, and the control unit **312** may receive a power signal, such as an alternating
20 current power signal, from the line side input **305** and provide a coil control signal (such as a 120 VAC, 24 VDC or 12 VDC signal) to the relay **310**. A zero crossing circuit is an electrical circuit that detects an alternating current load voltage at or close to zero phase occurring once for each alternating current half cycle. The zero crossing circuit may be used in connection with the opening or closing of the relay **310** in order
25 to assist in opening or closing the relay **310** at a point in time that is close to the zero phase of the input signal. Zero crossing circuits may work on voltage zero crossings or on current zero crossings. The zero crossing circuit may take inherent turn-on and turn-off delays associated with the relay **310** into account when making zero crossing contact closures or breaks of the main relay **310**. Since typical power systems in many
30 countries run at 60 cycles per second or Hertz (Hz), a zero crossing occurs approximately every 8.3 milliseconds (ms). A typical relay **310** may have, for example, a 5 millisecond actuation time (closing time) and a 3 millisecond break time

(opening time). In this example, for zero crossing turn-on, the relay coil must be energized for 3.3 ms (or the 8.3 ms cycle time – the 5 ms actuation time) after the last zero crossing of the input signal to produce a contact closure (actuation) of the relay **310** at the next zero crossing of the input signal. Similarly, in the same example, the relay coil must be de-energized for 5.3 ms (or the 8.3 ms cycle time – the 3 ms break time) after the last zero crossing to produce a contact break (de-actuation or opening) at the next zero crossing of the input signal. Accordingly, the output of power from the ASD **100** onto the flat wire **105** will start as soon as possible once the relay **310** is closed. Additionally, the input waveform from the line side **115** will match the output waveform across the flat wire **105** as closely as possible meaning that less energy is dissipated in the ASD **100** and source module **110** circuitry. The ability of the ASD **100** to perform a zero cross turn on or turn off of the relay **310** may extend the lifetime of the contacts in the relay **310**, limit the contact arc-showering effect, limit electromagnetic emissions, and limit conducted electrical noise from the relay **310**.

[0074] According to another aspect of the invention, it will be appreciated that the relay **310** may be actuated for a short period of time in which tests may be performed on the flat wire **105**. For example, the relay **310** may be actuated for a period of time that is less than or approximately equal to the time that it takes for one half of a typical power cycle. As explained in greater detail below with reference to FIGS. 9, 11 and 12, the ASD **100** may test one or more conductors of the flat wire **105** during the time that the relay **310** is actuated.

[0075] According to another aspect of the invention, the ASD **100** may be able to detect slow breaking (i.e., sticky) contacts in the relay **310**. The control unit **312** of the ASD **100** may monitor the contact break times of the relay **310** with a counter or other timing device. The control unit **312** may directly monitor the break time of the relay **310**, or the control unit **312** may monitor the break time of the relay **310** by receiving information from the flat wire I/O interface **311**. By monitoring the break time of the relay **310**, the control unit **312** may detect a slow break time for the relay **310**. For preventative maintenance purposes, the ASD **100** may alert a user of these slow breaking contacts so that the ASD **100** may be repaired or replaced. The user may be alerted in a number of ways by the ASD **100**. One possible method for alerting a user is to activate an LED on the exterior of the ASD **100** that will alert the user to the

potential main relay contact problems. Another method for alerting the user is to transmit a communication from the ASD 100 to either another ASD 100, a central hub or control panel, or some other device, as will be explained in greater detail below with reference to FIGS. 16-17.

5 [0076] According to another aspect of the invention, the ASD 100 may include a control unit 312. The control unit 312 may control the various safety components of the ASD 100. Alternatively, each individual safety component of the ASD 100 may include its own control unit or various components of the ASD 100 may share control units. The control unit 312 may contain one or more microcontrollers and associated
10 components such as resistors, diodes, capacitors, and crystals or, alternatively, the control unit 312 may be any other suitable device and associated circuitry for controlling an electronic circuit including, but not limited to, microprocessors, one or more programmable logic arrays, a state machine, a mini-computer, or a general purpose computer along with any associated firmware and software. It will be
15 appreciated that many different types of control units may be incorporated into, associated with, or in communication with the ASD 100. It will further be appreciated that a control unit may include any number of processors. A control unit may also be external to and/or located remotely to the ASD 100, and the control unit may communicate with the components of the ASD 100 via a suitable network connection
20 such as, for example, a wired network connection or a wireless network connection.

[0077] According to an aspect of the invention, the control unit 312 may be configured to or operable to store various types of data associated with the operation of the ASD 100. The data may include data associated with the operation of the various safety components of the ASD 100. Additionally, the data may include measurements
25 data that has been taken while monitoring the flat wire 105 in accordance with the operation of the various safety components of the ASD 100. The data may also include one or more counters associated with the operation of the ASD 100 and the various safety components of the ASD 100. For example, the data may include a number of counters that the ASD 100 and/or the various safety components of the ASD 100 has
30 recognized a miswire or wire fault on flat wire that is monitored by the ASD 100. The stored data may be utilized during subsequent operations of the ASD 100. For example, data stored in associated with the operation of a safety component of the ASD

- 100 may later be utilized in association with the operation of the safety component of the ASD 100 and/or in association with the operation of other safety components (or the control unit 312) of the ASD 100. It will be appreciated that a wide variety of data may be stored by the ASD 100 or by one or more memory devices associated with the
- 5 ASD 100. The data items that may be stored by the ASD 100 include, but are not limited to those listed in Table 1 below:

Data Item	Type	Initial Value
Hot Relay Normal Actuations Count	counter	0
Hot Relay Normal Actuations limit for end of life	limit	75000
Hot Relay High Current Actuations Count	counter	0
Hot Relay High Current Actuations Limit for end of life	limit	5
Fatal non-resetable (internal) Fault Code	code	0
Non-fatal Limited Resetable Fault Count	counter	0
Non-fatal Unlimited Resetable Fault Count	counter	0
Hot Relay Actuation Time	value	0
Hot Relay Release Time	value	0
Fault code #1 count	counter	0
Fault code #2 count	counter	0
Fault code #3 count	counter	0
Fault code #4 count	counter	0
Fault code #5 count	counter	0
Fault code #6 count	counter	0
Fault code #7 count	counter	0
Fault code #8 count	counter	0
Fault code #9 count	counter	0
Fault code #10 count	counter	0
Fault code #11 count	counter	0
Fault code #12 count	counter	0
Fault code #13 count	counter	0
Fault code #14 count	counter	0
Fault code #15 count	counter	0
Fault code #16 count	counter	0
Fault code #17 count	counter	0
Fault code #18 count	counter	0
Fault code #19 count	counter	0

[0078] Table 1: Data Items that may be Stored

- [0079] It will be appreciated that other data items may be stored by the ASD 100. it will also be appreciated that, in some embodiments of the invention, the initial values
- 10 of one or more of the data items may be different than those listed in Table 1. With reference to Table 1, the Hot Relay Normal Actuations Count may keep track of the

number of times that the relay **310** is actuated during the normal course of the operation of the ASD **100**; the Hot Relay Normal Actuations Limit may establish a limit for the normal actuations of the relay **310** during the lifetime of the ASD **100**; the Hot Relay High Current Actuations Count may keep track of the number of times that the relay

5 **310** is tripped as a result of a high current event, as explained in greater detail below with reference to FIG. 4A; the Hot Relay High Current Actuations Limit for end of Life parameter may establish a limit for the number of high current actuations of the relay **310** during the lifetime of the ASD **100**, as explained in greater detail below with reference to FIG. 4A; the Fatal Non-Resetable Fault Code may establish a code to be

10 stored for any identified Fatal Non-Resetable Faults; the Non-fatal Limited Resetable Fault Count may keep track of the number of Non-fatal Limited Resetable Faults that are identified; the Non-fatal Unlimited Resetable Fault Count may keep track of the number of Non-fatal Unlimited Resetable Faults that are identified; the Hot Relay Actuation Time Parameter may establish a value for the time that it takes to actuate the

15 relay **100**; the Hot Relay Release Time Parameter may establish a value for the time that it takes to release the relay **100**; and the parameters for Fault Codes 1-19 Counts may keep track of the number of different types of faults that are identified by the ASD **100**. It will be appreciated that many different types of faults may be identified and that each fault may be associated with its own counter.

20 [0080] FIG. 4A is a block diagram of an exemplary control unit **312** that may be associated with an ASD **100** according to certain embodiments of the invention. The control unit **312** may include a memory **405** and a processor **410**. The memory may store programmed logic **415** (e.g., software code) in accordance with the invention. The memory **405** may also include measurements data **420** utilized in the operation of

25 the invention, counters or states utilized in the operation of the invention **422**, and an operating system **425**. The processor **410** may utilize the operating system **425** to execute the programmed logic **415**, and in doing so, also utilizes the measurement data **420**. The programmed logic **415** may include the logic associated with the operation of the one or more safety components of the ASD **100**. A data bus **430** may provide

30 communication between the memory **405** and the processor **410**. The control unit **312** may be in communication with the other components of the ASD **100** and perhaps other external devices such as, for example, lights, speakers, keyboards, mouse devices, and other user interface devices, as well as data lines connected to other ASD's or electrical

appliances, via an I/O Interface **440**. Additionally, measurement devices configured to take various electrical measurements of the flat wire **105** may be in direct communication with the control unit **312** via a measurement devices interface **450** or, alternatively, may communicate with the control unit **312** via the I/O Interface **440**.

- 5 These measurement devices may be included in the flat wire I/O interface **311**, as described in greater detail below. Further, the control unit **312** and the programmed logic **415** implemented thereby may comprise software, hardware, firmware or any combination thereof.

- [0081] The control unit **312** may control and/or include the various safety components of the ASD **100**. Additionally, the control unit **312** may store data relating to the status of the flat wire system **101**. For example, the control unit **312** may maintain flags or states for each of the safety components of the ASD **100** in order to determine when to trip the relay **310** of the ASD **100** and to indicate, in the event of a miswire or fault detection, which safety component identified the flat wire **105** miswire or fault. The control unit **312** may also store measurements data **420** associated with the operation of the various safety components of the ASD **100**. In addition, before the relay **310** of the ASD **100** is closed, allowing a flat wire **105** to be electrified, the control unit **312** may cause each safety component to test the flat wire **105** for miswire and/or wire faults. The control unit **312** may also be configured to take a control action when a miswire or wire fault in the flat wire **105** is detected. A control action may include, in addition to maintaining or forcing the relay **310** into its open position, an action that informs a user of the ASD **100** about the miswire or fault detection. For example, a visual indicator such as an LCD display or one or more LED's may be included in the ASD **100**, and the display or LED's may be actuated in such a manner as to inform a user of the miswire or fault detection and the nature of the miswire or fault detected. As one example, the ASD **100** may include a single LED that is activated by the control unit **312** when a fault is detected to inform a user of the fault. As an alternative example, the ASD **100** may include an LED associated with each safety component of the ASD **100** and, when a miswire or fault is detected, the control unit **312** may activate the LED associated with the safety component that detected the miswire or fault. Another control action that may be taken by the control unit **312** is the transmission of a message indicating the detection of the miswire or fault. The control unit **312** may transmit the message to another ASD **100**, to a central hub or

control panel, or to another destination, as will be explained in greater detail below. It will be understood that other indicators such as audible alarms may also be utilized by the ASD **100**. Indicators that may be used by the ASD **100** beneficially add to the overall safety of the ASD **100** by informing a user of a fault and potentially pinpointing the fault for the user.

[0082] The control unit **312** may also include one or more counters and/or timers **422**. Counters and/or timers **422** associated with each safety component may be used by the control unit **312** to track the number of times a particular safety component has detected a miswire or wire fault in the flat wire **105**. Additionally, a universal timer or counter may be used to track the number of times the ASD **100** has detected a miswire or wire fault in the flat wire system **101**. Separate counters may also be utilized to track detected miswires and detected wire faults. These counters and/or timers **422** may be used to monitor the flat wire system **101**, and may be used to generate states that indicate the current condition of the flat wire system **101**. The counts and/or states may be used to perform preventive maintenance on the flat wire system **101**. The storage capability of the counters and/or timers **422** may also be non-volatile such as, for example, in non-volatile memory, so that information including counts and states are not lost during a power outage or brown-out condition.

[0083] According to an aspect of the invention, the control unit **312** may additionally include at least one lifetime counter. It will be appreciated that the relay **310** may have a lifetime associated with it. In other words, the relay **310** may cease to operate properly after it has been actuated normally for a certain number of times or after it has been tripped several times as the result of a detected high current event. For normal actuations of the relay **310**, the lifetime of the relay may be a fairly large value such as, for example, the value shown for the Hot Relay Normal Actuations Limit for End of Life parameter of Table 1. For the number of trips due to detected high current events, a predicted lifetime of the relay **310** may be similar to a mean trips to failure for the relay **310** such as, for example, the value shown in the Hot Relay High Current Actuations Limit for end of Life parameter of Table 1. Different types of relays **310** that may be utilized by the ASD **100** may be associated with different lifetimes. A lifetime counter associated with a relay **310** may be configured to count down from or up to a predetermined threshold value. The threshold value may be a value that is less

than or equal to the predicted lifetime of the relay 310. For example, if the predicted lifetime of the relay is 8-10 trips, then the threshold value may be established as 5 trips of the relay 310. Once the relay 310 has been tripped a number of times equal to the threshold value, the ASD 100 may deactivate the relay 310 and prevent the relay 310 from being closed by a user event such as, for example, a reset of the ASD 100. Utilizing the example of the relay 310 with a threshold value established as 5 trips, a user may reset an ASD 100 and the relay 310 following the first four trips of the relay 310; however, once the relay 310 has tripped for the fifth time, a user will not be permitted to reset the ASD 100 and the relay 310. In such a situation, the user may be required to return or send the ASD 100 to a retailer, distributor, manufacturer, or repair center associated with the ASD 100 in order to have the relay 310 and/or the ASD 100 tested, updated, and/or replaced. It will be appreciated that the lifetime counter may prevent a situation in which the ASD 100 and the relay 310 is reset, but the relay 310 is not capable of tripping when a miswire or wire fault is detected by the ASD 100.

[0084] According to an aspect of the invention, each of the one or more lifetime counters of the ASD 100 may be associated with specific types of errors detected by the ASD 100. For example, the lifetime counter may be associated with errors that lead to a tripping of the relay 310 due to a high current event, thereby causing an electrified flat wire 105 to be de-energized. It will be appreciated that not all errors detected or detectable by the ASD 100 will lead to a tripping of the relay 310 as a result of a high current event. For example, an error detected prior to the electrification of the flat wire 105 may not lead to a tripping of the relay 310. According to an aspect of the invention, there are three different types of exceptions or alarms that may be recognized by the ASD 100. The first type of alarm is a fatal non-resetable alarm, which may be recognized if a failure of any of the internal circuitry of the ASD 100 is detected. For example, a fatal non-resetable alarm may be recognized if a stuck relay is identified, if a fuse incorporated into the ASD 100 is blown, if a detected signal is outside of a detectable range, if a failure of self-test circuitry associated with the ASD 100 is detected, and/or if a lifetime counter has exceeded or reached a threshold value. The second type of alarm is a non-fatal limited resetable alarm, which may be an alarm that is associated with a high current event on the flat wire 105. For example, a non-fatal limited resetable alarm may be recognized if a wire fault is detected on an electrified flat wire 105. The third type of alarm may be a non-fatal unlimited resetable alarm,

which may be associated with a non-fatal alarm that does not involve a high current event. It will be understood that the ASD 100 may allow an unlimited number of the third type of alarm to occur; however, it will also be appreciated that a limit may be associated with this type of alarm. It will further be appreciated that an ASD 100 in
5 accordance with the invention may recognize many different types of alarms and that those alarms described herein are merely exemplary types of alarms.

[0085] FIG. 4B is an exemplary flowchart of the general operation of the ASD 100 of FIG. 3 and the control unit 312 of FIG. 4A, according to an illustrative embodiment of the invention. The operation described in FIG. 4B may include the operations that
10 are performed to monitor a flat wire 105 by the ASD 100. At block 455, power may be applied to the ASD 100, and the ASD 100 may commence operation at block 460. At block 460, the ASD 100 may test the line side 115 for miswires. If a line side miswire is detected at block 465, then the ASD 100 may go to block 470 and prevent the relay 310 from being closed, thereby preventing the electrification of the flat wire 105. If, at
15 block 465, no line side miswires are detected by the ASD 100, then the ASD 100 may go to block 475 and test the load side flat wire 105 for miswires and/or wire faults. If, at block 480, a miswire or wire fault is detected on the flat wire 105, then the ASD 100 may go to block 470 and prevent the relay 310 from being closed, thereby preventing the electrification of the flat wire 105. If, however, at block 480, no miswires and/or
20 wire faults are detected on the flat wire 105, then the ASD 100 may go to step 485. At block 485, the relay 310 of the ASD 100 may be closed, and the flat wire 105 may be electrified. During the electrification of the flat wire 105 and after the flat wire 105 has been electrified, the ASD 100 may monitor the flat wire 105 for wire faults at block 490. If a fault is detected on the flat wire 105 at block 495, then the ASD 100 may go
25 to block 470 and open the relay 310, thereby causing the flat wire 105 to be de-electrified or de-energized. If, however, no wire faults are detected on the flat wire 105 at block 495, then the ASD 100 may go to block 490 and continue monitoring the flat wire 105.

[0086] It also will be understood by those of skill in the art that the tests performed
30 by the control unit 312 do not necessarily have to be performed in the order set forth in the logic of FIG. 4B, but instead may be performed in any suitable order. It also will be understood that the control unit 312 does not have to conduct each test set forth in FIG.

4B, but instead may conduct less than all of the tests set forth in FIG. 4B. Additionally, if a miswire or wire fault is detected by the control unit **312** or by a safety component in communication with the control unit **312**, then an indicator may be stored by the control unit **312** or the associated safety component, and the indicator may include
5 information as to which test(s) resulted in the detection of the miswire or wire fault. This indicator may then be transmitted by the ASD **100** to another device such as a second ASD **100**, a central monitoring device, or a computer.

[0087] As mentioned earlier, the ASD **100** may include both reactive and/or proactive safety components. A reactive safety component of the ASD **100** may detect
10 a wire fault in the flat wire **105** after the flat wire **105** has been fully electrified. A reactive safety component may also detect a wire fault during the full electrification of the flat wire **105** or during the time period that it takes to fully electrify the flat wire **105** after a full electrification signal is allowed to flow onto the flat wire **105**. In other words, a reactive safety component may detect wire faults while a voltage in the range
15 of approximately 90 to 130 VAC (for a standard 120 VAC power system, such as a North American power system) or a voltage in the range of approximately 220 to 250 VAC (for a standard 240 VAC power system, such as a European power system) is present on the electrical flat wire **105**. It will be understood that each country or region may have differing voltage or current standards that may be taken into account in the
20 design and implementation of the ASD **100**. Additionally, it will be appreciated that one or more reactive tests may be conducted constantly following the electrification of the flat wire **105**. Alternatively, one or more reactive tests may be conducted periodically following the electrification of the flat wire **105**.

[0088] A proactive safety component of the ASD **100** may detect a wire fault prior
25 to full power electrification of the flat wire **105**. In other words, a proactive safety component may perform checks or tests on the electrical flat wire **105** such as, for example, checks or tests that involve the communication of voltage or current test signals onto the flat wire **105**, prior to allowing full electrification of the flat wire **105**.

[0089] Reactive safety components of the ASD **100** may include one or more of a
30 ground fault circuit interrupter (GFCI) **315**, an arc mitigation circuit (AMC) **320**, an over-current protection component **325**, and a ground current monitoring component **330**. Proactive safety components of the ASD **100** may include one or more of a line

side wire integrity component **335** and a load side wire integrity component **340**. Each of these safety components is discussed in greater detail below.

[0090] The reactive and proactive safety components of the ASD **100** may utilize various electrical measurements associated with line side conventional wiring as well as the flat wire **105** that is connected to the ASD **100** and source module **110** respectively in determining whether or not a miswire condition or wire fault exists on either side of the ASD **100**. The ASD **100** may utilize the various measurements to detect miswires on the line side of the ASD **100** and to detect miswires and/or wire faults on the flat wire **105** that is connected on the load side of the ASD **100**. The ASD **100** may include a flat wire I/O interface **311** that is capable of taking electrical measurements associated with the various conductors of the flat wire **105** connected to the ASD **100**. Alternatively, these electrical measurements may be taken by the various components of the ASD **100**. For example, either the flat wire I/O interface **311** and/or the components of the ASD **100** may measure the voltage, current, impedance, resistance or any other electrical characteristic associated with the flat wire **105**. For example, either the flat wire I/O interface **311** or the components of the ASD **100** may measure the current present on any of the conductors of a flat wire **105** with any suitable current measuring device, such as a current transformer. As another example, the flat wire I/O interface **311** or the components of the ASD **100** may measure the voltages present on any of the conductors of a flat wire **105** with any suitable voltage measuring device, such as a signal conditioning circuit or a volt meter. Each component of the ASD **100** may include measurement devices associated with that component or, alternatively, one component of the ASD **100** may make use of a measurement device used by another component of the ASD **100**. It will be understood that the ASD **100** may also include a single set of measurement devices in the flat wire I/O interface **311** that are used by all of the components of the ASD **100**, as shown in FIG. 3.

[0091] Additionally, the flat wire I/O interface **311** or the components of the ASD **100** may include excitation circuitry or devices that are capable of communicating a signal onto one or more of the conductors of the flat wire **105**. Excitation circuits or devices may be capable of communicating a current signal onto one or more of the conductors or layers of the flat wire **105**. Suitable excitation circuits or devices for

communicating a current signal onto one or more of the conductors of the flat wire **105** include, but are not limited to, current transformers, current sources, isolators, multiplexers, and relays. As an alternative to, or in addition to transmitting a current signal onto the flat wire **105**, excitation circuits or devices may be capable of

5 transmitting a voltage signal onto one or more conductors or layers of the flat wire **105**. Suitable excitation circuits or devices for transmitting a voltage signal onto one or more conductors of the flat wire **105** include, but are not limited to, voltage transformers, multiplexers, drivers, and voltage sources. Each component of the ASD **100** may include excitation circuit devices associated with that component or, alternatively, one

10 component of the ASD **100** may make use of an excitation device used by another component of the ASD **100**. The ASD **100** may also include a single set of excitation circuits or devices in the flat wire I/O interface **311** that are used by all of the components of the ASD **100**, as shown in FIG. 3. As explained in greater detail below, the excitation devices may be used in conjunction with the measurement devices to

15 perform tests on the flat wire **105**.

[0092] The reactive and proactive safety components of the ASD **100** may operate independently of one another, or, alternatively, their operation may be controlled by the control unit **312**. In the illustrative embodiment of FIG. 3 with a single set of measurement devices contained within a flat wire I/O interface **311**, the individual

20 safety components may receive electrical measurements from the flat wire I/O interface **311** or, alternatively, the individual safety components may receive electrical measurements from the flat wire I/O interface **311** through the control unit **312** or through another safety component. Additionally, it will be appreciated that one or more of the various safety components of the ASD **100** may share one or more circuit

25 components.

[0093] According to an aspect of the invention, a ground fault circuit interrupter (GFCI) safety component **315** may be associated with the ASD **100**, which will be referred to herein as a GFCI component **315**. The GFCI component **315** may detect ground faults in a flat wire **105** system. A ground fault is an unintentional electric path

30 which diverts current to ground. The GFCI safety component may be specially designed to account for the fact that it is being used in conjunction with flat wire **105**, as discussed below. As previously mentioned, in connection with FIG. 2, a flat wire

105 will typically have one electrifiable or hot conductor **205** and may have one or more return or neutral conductors **210, 215**. The GFCI component **315** may monitor the current differential between the electrifiable conductor **205** and the one or more return conductors **210, 215** of the flat wire **105**. If the current flowing through the
5 electrifiable conductor **205** differs from the combined current flowing through any of the one or more return conductors **210, 215**, then the GFCI component **315** may cause the ASD **100** to open a relay **310**, thereby preventing the further flow of electrical power onto the flat wire **105**. For example, the GFCI component **315** may cause the ASD **100** to open the relay **310** if the current differential between the electrifiable
10 conductor **205** and the combined current in any of the one or more return conductors **210, 215** (or $H - N$) is approximately 5.5 milliamps or greater. It will also be understood by those of skill in the art that the GFCI component **315** may be set to open the relay **310** of the ASD **100** based on any number or measured current differentials.

[0094] Additionally, the trip time of the GFCI component **315**, or the time it takes
15 the GFCI component **315** to open a relay **310**, may vary with the current differential detected by the GFCI component **315**. For example, a slower trip time may be associated with a smaller current differential, and a faster trip time may be associated with a higher current differential. The trip time of the GFCI component **315** may be a linear function of the current differential detected by the GFCI component **315**.
20 Alternatively, the trip time of the GFCI component **315** may be a non-linear function of the current differential detected by the GFCI component **315**, such as that defined by UL943, a standard established by Underwriters Laboratories, Inc. (UL).

[0095] According to another aspect of the invention, an arc mitigation circuit (AMC) safety component **320** may be associated with the ASD **100**, which will be
25 referred to herein as an AMC component **320**. The AMC component **320** may detect an arcing condition that is present on the flat wire **105**. An arcing condition may include a high power discharge of electrical energy between two or more conductors. The arcing condition does not necessarily need to exceed the normal maximum load limits of a component of the flat wire system **101**. The normal maximum load limit of
30 a standard electrical outlet, for example, is 120 volts at 15 amps, or 1800 watts. The electrical energy discharged by an arcing condition may or may not exceed 1800 watts. For conventional wiring, there is a wide array of arc fault current signatures, but the

signatures are typically characterized by spikes of current near the voltage peaks of an electrical signal as opposed to a sinusoidal signature. Arc faults or arcing faults on conventional wire are one of the major causes of fires attributed to home electrical wiring as normal circuit breakers do not reliably detect and trip on arc faults. When
5 unwanted arcing occurs, it may generate high localized or spot temperatures that can ignite nearby combustibles such as wood, paper and carpets.

[0096] An arcing condition on a flat wire **105** may be very different than an arcing condition on a conventional wire. Unlike convention wire, an arcing condition on a flat wire **105** may be a short duration flash which may be referred to as an arc flash. A
10 typical flash, if not eliminated, may last from the time that electrification of the flat wire **105** is initiated until the time that a wire fault is identified and the relay **310** is opened. The over-current protection component **325** and the ground current monitoring component **330** may be the primary safety components that are responsible for removing power to the flat wire **105** due to a penetration or other type of wire fault
15 resulting in abnormally high RMS currents. In the case of arcing events that result from ohmic or higher resistance "shorts," there may be an associated arc signature current that has a high peak-to-peak value, but an RMS value that does not exceed the standard current limit of 15 amps RMS. Because standard arc faults are relatively slow phenomena, requiring several alternating current cycles to detect and respond to, they
20 are different than the arc flashes that may occur on a flat wire **105**. For flat wire **105**, the AMC component **320** and the other safety components of the ASD **100** may be designed to work as a system to mitigate arc flash events.

[0097] There are typically two types of arc flash events that may occur on a flat wire **105**. The first type is possible during a live (electrified) penetration of the flat
25 wire **105** by a penetrating object whereby, under certain circumstances, a blow-by or escape of hot gases or particulate matter may occur around the perimeter of the penetrating object. The second type of arc flash event is possible after a penetrating object has been removed from the flat wire **105**. If the flat wire **105** is electrified again, an arc flash may occur prior to other safety components of the ASD **100** identifying a
30 wire fault. From the time that the flat wire **105** is electrified until the ASD **100** or other safety device reacts to de-energize the flat wire **105** once again, an arc flash is possible

whereby hot gases and particulate matter are expelled from the orifice left by the removed object.

- [0098] The AMC component **320** may be designed to reduce the amount of energy and temperature of the expelled gases and particulate matter in the aforementioned types of arc flash events. The first and most direct approach centers on current signature analysis during the arc flash events. However, the construction and materials used in the flat wire **105** itself may also have mitigating effect on arc flash events. The flat wire **105** may contain individual layers of insulated conductors which can be further bonded to form an essentially inseparable set of strata. This bonding technique tends to mitigate the arc flash events by enforcing lower impedance interlayer shorts. Accordingly, the safety components of the ASD **100** may be capable of more easily detecting these events. Additionally, the load side wire integrity component discussed below with reference to FIG. 12 may allow potential arcing conditions to be more easily recognized.
- [0099] For arc signature detection of an arc flash, the AMC component **320** may be operable to sense the current waveform on the electrifiable conductor **205** via a suitable current detection device such as, for example, a current transformer. The AMC component **320** may analyze the rate of change of the current, the peak current, and the phasing of the peak current in order to make a decision on the presence of an arcing event.
- [00100] As with the GFCI component **315**, the AMC component **320** may be designed to take the physical characteristics of flat wire **105** into account, as discussed below. The AMC component **320** may detect specific arcing conditions which may occur on the flat wire **105** that may be hazardous. The AMC component **320** may discriminate between unwanted arcing conditions and normal arcing conditions. A normal arcing condition may be the switching on or off of a circuit or unplugging a device from an electrical outlet. An unwanted arcing condition may be present on the flat wire **105** if there is a penetration, puncture, or flaw in the insulation layers **230** between the electrifiable conductor **205** and one of the other conductors of the flat wire **105**. If multiple layers of insulation are present between two conductors of the flat wire **105**, such as to envelope each conductor separately, an arc flash may occur if each layer of insulation has a flaw (e.g., hole) and the flaws are situated in close proximity to one

another. In other words, an arc flash may occur if the insulation layer flaws line up with one another or are in close proximity to one another. An arc flash condition may also occur if the flat wire **105** is penetrated by a foreign object and the penetrating object is removed from the flat wire **105**. A situation might exist in which the
5 conductors are no longer shorted together once the foreign object has been removed, and an arc flash might occur if the flat wire **105** is electrified.

[00101] The AMC component **320** uses current sensing circuitry to discriminate between normal and unwanted arcing conditions within the flat wire **105**. The AMC component **320** may detect specific arc flash current signatures which are unique to flat
10 wire **105**. These flat wire **105** arc flash current signatures are often different than the arc fault current signatures of conventional wire. Additionally, the AMC component **320** may be configured to detect arcing conditions originating at a point in a wire that is beyond the flat wire **105** termination at the destination module **120**, including arc flashes in another flat wire **105** or arc faults in a conventional wire that is external to
15 the flat electrical wire system **101**. Once an unwanted arcing condition is detected in the flat wire **105** or any down-line load, a relay **310** is opened to de-energize the flat wire **105**, thus reducing the potential of a fire or other hazardous situation occurring.

[00102] A flat wire **105** arc flash signature may differ from the arc fault signature of other forms of electrical wire due to the physical construction of the flat wire **105** that
20 includes stacked conductive layers in close proximity to one another. Once an arc flash condition begins in the flat wire **105**, typically at the initial point of penetration or damage to the flat wire **105**, high temperature droplets of copper and carbonized debris may be ejected away from the penetration sight. Although most of the copper and debris are ejected out of the damaged site orifice of the flat wire **105**, some may
25 proceed transversely into the flat wire **105**, thus increasing the radius of the damaged area. If this phenomena proceeds unchecked, it may build or avalanche into larger areas with unique current signatures specific to the flat wire **105**.

[00103] It will be understood by those of skill in the art that a potentially dangerous situation that may lead to an arc flash on the flat wire **105** such as, for example, a wire
30 fault on the flat wire **105**, may be detected by one or more of the other safety components of the ASD **100**, as explained in greater detail below. Accordingly,

potentially dangerous situations that may lead to an arc flash may be detected prior to the formation of an arc flash on the flat wire **105**.

[00104] According to another aspect of the invention, an over-current protection safety component **325** may be associated with the ASD **100**, which will be referred to herein as an over-current protection component **325**. The over-current protection component **325** may provide primary and/or secondary over-current protection. If too much current is allowed to flow through a wire, the wire may overheat and there is a potential that a fire could be started in nearby combustibles such as wood, paper and carpets. The over-current protection component **325** may provide secondary over-current protection in addition to that provided by a standard circuit breaker. Typically, circuit breakers are rated with a maximum current that they can effectively handle in order to trip properly, and a circuit breaker may be ineffective if the current flowing through a circuit (which may be created by a short) is higher than the maximum rated current of the circuit breaker. If such a situation arises, the over-current protection component **325** of the ASD **100** may provide secondary over-current protection. Alternatively, the over-current protection component **325** may provide primary over-current protection if there is no circuit breaker connected to or associated with the line side power supply **115** or if a connected circuit breaker is ineffective. For example, the over-current protection component **325** would provide primary over-current protection if a homeowner closed a circuit in the circuit breaker by placing a penny across the circuit.

[00105] The over-current protection component **325** of the ASD **100** may monitor the current flowing through the electrifiable conductor **305** of the flat wire **105**. If the current flowing through the electrifiable conductor **305** increases above a maximum threshold value, the relay **310** is opened to de-energize the flat wire **105**. It will be understood by those of ordinary skill in the art that the maximum threshold current value may be set at many different values. For instance, the over-current protection component **325** may cause the relay **310** to open if the current in the electrifiable conductor **305** exceeds approximately 15 amps (for 120VAC applications). An over-current protection component **325** may also examine the current flowing through any of the one or more return conductors **210**, **215** of an electrical flat wire **105** in a similar manner to the way in which the electrifiable conductor **205** is monitored.

[00106] The over-current protection component **325** may utilize a variable scale algorithm in its monitoring of the electrifiable conductor **205** current. Based on the level or amount of over-current present on the electrifiable conductor **305**, the over-current protection component **325** may have a variable trip time, or time it takes to de-actuate or open the relay **310**. For example, if the maximum allowable current on the electrifiable conductor is set at 15 amps and the over-current protection component **325** measures a 15.1 amp current on the electrifiable conductor **205**, the trip time of the over-current protection component **325** may be approximately one second. The trip time may or may not be adjusted for the next zero crossing condition. Alternatively, if a current of 50 amps or more is detected on the electrifiable conductor **205**, the trip time of the over-current protection component **325** may be approximately an immediate trip time (no added delay) or set for the next zero crossing condition. Having a longer trip time at lower over-current levels may serve to mitigate false tripping situations due to load inrush currents on the flat wire **105**. It will be understood by those of skill in the art that many different smart algorithms with a wide array of trip times may be used in conjunction with the over-current protection component **325** of the present invention. Additionally, the trip time of the over-current protection component **325** may be a linear function of the amount of over-current detected by the over-current protection component **325**. Alternatively, the trip time of the over-current protection component **325** may be a non-linear function of the amount of over-current detected by the over-current protection component **325**.

[00107] According to yet another aspect of the invention, the ASD **100** may include a ground current monitoring safety component **330** to perform ground current monitoring, which will be referred to herein as a ground current monitoring component **330**. The ground current monitoring component may be utilized as either a reactive component or in conjunction with the proactive components of the ASD **100**. In the flat wire design utilized herein for purposes of disclosing certain embodiments of the invention, there should not be any significant current on a grounding conductor **220**, **225** of any flat wire **105** connected to the ASD **100**. If a significant current is present on a grounding conductor **220**, **225** of the flat wire **105** connected to the ASD **100**, a hazardous condition may exist. For example, there may be a short in the flat wire **105**. Alternatively, a situation might exist in which electrical power is being supplied to a load and some of that electrical power is backfeeding across the flat wire **105** through,

for example, one of the grounding conductors **220, 225**, to the source module **110**. Such a situation might arise if a faulty or malfunctioning appliance is being supplied power by the flat wire **105** or if an external source of power is miswired into the flat wire system **101** via the load side **125**.

5 [00108] The ground current monitoring component **330** monitors the current flowing through one or more of the grounding conductors **220, 225** of a flat wire **105** connected to the ASD **100**. If the current increases above a predetermined maximum threshold value, then the relay **310** may be opened to de-energize the flat wire **105**. It will be understood by those of ordinary skill in the art that the maximum threshold
10 current value may be set at many different values. For instance, the ground current monitoring component **330** may open the relay **310** if the current in any of the ground conductors exceeds approximately 3.0 milliamps.

[00109] According to an aspect of the invention, the ASD **100** may include a line side wire integrity (or miswire) safety component **335**, also referred to herein as a
15 Source Wire Integrity (SWI) component **335**. The SWI component **335** may be a proactive safety device capable of detecting line side faults or defects in a flat wire system **101** prior to the full power electrification of the flat wire **105**. Before the relay **310** of the ASD **100** is closed, thereby allowing the flat wire **105** to be electrified, the SWI component **335** may test the flat wire system **101** on the line side and determine
20 whether the line side power source **115** has been properly terminated on the line side. For purposes of this disclosure, the term line side may refer to a power line that is input into the ASD **100**. It will be understood that the line side may be a conventional wire, a flat wire, an electrical outlet, or another input to the ASD **100**.

[00110] The SWI component **335** may detect line side miswiring of the line side
25 power source **115**, which may be conventional wiring or flat wire, via the line side input **305**. The line side power source **115** may also be an electrical outlet that the ASD **100** is connected to or plugged into. It will be appreciated that it is a common mistake for an electrical outlet to be miswired, even by an experienced electrician. A line side miswire may include an open conductor of the line side power source **115**, which may
30 occur when a conductor of the line side power source **115** is not connected to the line side input **305** of the ASD **100**. Alternatively, a line side miswire may occur when one or more conductors of the line side power source **115** are improperly connected to the

- line side input **305** of the ASD **100**, such as when two conductors are reversed in their connection to the line side input **305**. For example, if the line side power source **115** is a conventional electric wire, the SWI component **335** may detect a situation in which the line side electrifiable or hot conductor and the line side return or neutral conductor have been switched when connected to the line side input **305**. As another example, if the line side power source **115** is an electrical flat wire **105**, the SWI component **335** may detect a situation in which the line side electrifiable conductor **205** and one of the line side return conductors **210** have been switched when connected to the line side input **305**.
- 10 [00111] The SWI component **335** may contain line side miswire detection circuitry that uses one or more test signals to locate and detect miswire conditions. FIG. 5 is a schematic diagram of an exemplary line side wire integrity component **335** that may be incorporated into an ASD **100** according to the invention. A line side power source **115** connected to the line side input **305** of the ASD **100** may include an electrifiable (or hot) conductor **505**, a return (or neutral) conductor **510**, and a grounding conductor **515**. It will be understood that the line side input **305** may include more than three conductors. For example, if the line side input **305** is an electrical flat wire, then the line side input **305** may include five conductors.
- 15 [00112] The SWI component **335** may include three current sensors **520**, **525**, **530** and a signal conditioning circuit **535**. It will be appreciated that any number of current sensors and/or signal conditioning circuits may be associated with the SWI component **335**. The SWI component **335** may optionally include an SWI relay driver **540** and an SWI relay **545**. The signal conditioning circuit **535** of the SWI component **335** may be in communication with the control unit **312** of the ASD **100** via a control unit communications link **550** or, alternatively, the signal conditioning circuit **535** may be incorporated into the control unit **312**. The signal conditioning circuit **535**, either on its own or in combination with the control unit **312**, may allow a small test current to be transmitted from the line side power source **115** in order to determine whether any line side miswires are present.
- 25 [00113] The signal conditioning circuit **535** may be any appropriate signal conditioning circuit, and the signal conditioning circuit **535** may include any number of circuit components. The signal conditioning circuit **535** may operate to limit the value
- 30

of the currents that are detected on the line side prior to communicating those values to the control unit 312 for analysis. Accordingly, the control unit 312 may receive a current measurement from each of the current sensors 520, 525, 530, and the control unit 312 may utilize these measurements to determine whether the line side is wired correctly. The signal conditioning circuit 535 may locate the electrifiable or hot conductor 505 of the line side power source 115, regardless of where it is connected to the line side input 305, and leak a small test current out of the electrifiable conductor 505. The test signal may be a voltage or current test signal such as, for example, a current test signal that is under approximately one milliamp. If there is no electrifiable conductor 505 connected to the line side input 305, then the SWI component 335 will be unable to locate the electrifiable conductor 505 to obtain a test signal. In such a situation, the signal conditioning circuit 535 of the SWI component 335 and/or the control unit 312 may determine that the electrifiable conductor 505 is open on the line side. If, however, an electrifiable conductor 505 is connected to the line side input 305, the signal conditioning circuit 535 may permit the test signal to leak out of the electrifiable conductor 505. The signal conditioning circuit 535 may then monitor the currents detected by the current sensors 520, 525, 530 to determine whether or not any line side miswires are present. A hot-neutral ("H-N") current sensor 520 may be used to detect a current between the electrifiable (or hot) conductor 505 and the return (or neutral) conductor 510. A hot-ground ("H-G") current sensor 525 may be used to detect a current between the electrifiable conductor 505 and the grounding conductor 515. A neutral-ground ("N-G") current sensor 520 may be used to detect a current between the return conductor 510 and the grounding conductor 515. It will be understood by those of skill in the art that a test current applied to a line side conductor may be limited by appropriate electrical standards and codes. For example, a test current applied to a grounding conductor of a line side power source 115 may be limited to an upper bound of approximately 0.5 milliamps by standards established by Underwriters Laboratory, Inc.

[00114] If the line side is wired correctly, a current between the electrifiable conductor 505 and the return conductor 510 will be detected by the H-N current sensor 520, a current between the electrifiable conductor 505 and the grounding conductor 515 will be detected by the H-G current sensor 525, and no current between the return conductor 510 and the grounding conductor 515 will be detected by the N-G current

sensor **530**. If there is a line side miswire, a different set of current measurements than those discussed above for a properly wired line side may be made by the current sensors **520**, **525**, **530**, and the SWI component **335** may detect the miswire. In addition to an open electrifiable conductor **505**, The SWI component **335** may detect
5 other open conductors on the line side. For example, if the return conductor **510** is open on the line side, no current will be detected between the electrifiable conductor **505** and the return conductor **510** by the H-N current sensor **525**. As another example, if the ground conductor **515** is open on the line side, no current will be detected between the electrifiable conductor **505** and the grounding conductor **515** by the H-G
10 current sensor **525**.

[00115] The SWI component **335** may also detect conductors that have been miswired or switched when connected to the line side input **305**. For example, if the electrifiable conductor **505** and the return conductor **510** have been switched when connected to the line side input **305**, the current detected by the H-N current sensor **520**
15 will be reversed because the current will be flowing across the H-N current sensor **520** from the opposite direction. Additionally, no current will be detected by the H-G current sensor **525** and a current will be detected by the N-G current sensor **530**. If the electrifiable conductor **505** and the grounding conductor **515** have been switched when connected to the line side input **305**, the current detected by the H-G current sensor **525**
20 will be reversed because the current will be flowing across the H-G current sensor **525** from the opposite direction. Additionally, no current will be detected by the H-N current sensor **520** and a current will be detected by the N-G current sensor **530**. It will be understood by those of skill in the art that any other miswire on the line side that produces a different set of currents across the current sensors **520**, **525**, **535** other than
25 the set of currents representative of a properly wired line side will also be detected by the SWI component **335**.

[00116] If the SWI component **335** detects a miswire on the line side, then the relay **310** of the ASD **100** may be maintained in its open position to prevent electrification of the flat wire **105**. If no miswire is detected by the SWI component **335**, then the relay
30 **310** may be closed, to allow electrification of the flat wire **105**. Alternatively, if the SWI component **335** detects a miswire on the line side, then the SWI relay **545** may be maintained in its open position to prevent the flow of electrical power from the line side

input **305** to the source module **110** via a source module communications link **555**. The source module communications link **555** may be any appropriate communication link such as, for example, a wired connection. If no miswire is detected by the SWI component **335**, then the SWI relay driver **540** may be used to close the SWI relay **545** and allow electrical power to flow from the line side input **305** to the source module **110**. The SWI component **335** may perform tests on the line side of the flat wire system **101** during a short time interval after power is applied to the line side power source **115**. For example, the SWI component **335** may perform the tests on the line side of the flat wire system **101** in no more than approximately 500 milliseconds from the point in time at which power is applied to the line side power source **115**. Additionally, a SWI component flag or state may be set in the ASD **100** to indicate that no miswires were detected by the SWI component **335**. The SWI component flag may be, for example, stored in the memory **405** of the control unit **312** and/or in one or more other memories associated with the control unit **312** and/or the SWI component **335**. The SWI component flag or state may be used by the ASD **100** in conjunction with the results of other tests performed by the ASD **100** in order to determine whether or not the relay **310** of the ASD **100** may be closed. It will be appreciated that other data associated with the SWI component **335** and/or the measurements taken in accordance with the operation of the SWI component **335** may be stored in one or more appropriate memories such as, for example, the memory **405** of the control unit **312**.

[00117] Although the SWI component **335** is described above as leaking a current signal from the electrifiable conductor **505** of the line side power source **115** and then testing the line side for current signals, it will be appreciated that other types of signals such as, for example, a voltage signal may be leaked from the line side power source **115**. Additionally, if a voltage signal is leaked from the line side power source **115**, then the SWI component **335** may detect voltage signals on the line side in order to identify or locate line side miswires.

[00118] With continued reference to FIG. 5, the SWI component **335** may include at least one fuse **560** that is operable to act as a fail safe if too much current flows into the ASD **100** from the line side power source **115**. Although the fuse **560** is illustrated in FIG. 5 as being a part of the SWI component **335**, it will be appreciated that a fuse may alternatively or additionally be included in other components of the ASD **100**.

Additionally, it will be understood that many different types of fuses may be utilized by the ASD **100** such as, for example, a standard 50 amp fuse. If a 50 amp fuse is utilized, the fuse **560** may be blown if a current of approximately 50 amps or more flows into the ASD **100** from the line side power source **115**. Once the fuse **560** has been blown,
5 an electrical power signal may no longer be permitted to flow into the ASD **100** from the line side power source **115**.

[00119] FIG. 6 is an exemplary flowchart of the operation of the SWI component **335**, according to an illustrative embodiment of one aspect of the present invention. If power is applied to the SWI component **335** at block **605**, then the SWI component **335**
10 may check a line side power source **115** connected to the line side input **305** for a line side miswire. For example, at block **610**, the SWI component **335** may check the line side power source **115** for an open electrifiable (or hot) conductor **505**. If an open electrifiable conductor **505** is detected, then the SWI component **335** may go to block **640** and prevent the electrification of the flat wire **105** by preventing the relay **310** of
15 the ASD **100** from being closed. If an open line side power source electrifiable conductor **505** is not detected at block **610**, then the SWI component **335** may go to block **615** and check the line side power source **115** for an open return (or neutral) conductor **510**. If an open line side power source return conductor **510** is detected at block **615**, then the SWI component **335** may go to block **640** and prevent the relay **310**
20 of the ASD **100** from being closed. If no open line side power source return conductor **510** is detected at block **615**, then the SWI component **335** may go to block **620** and check the line side power source **115** for an open grounding conductor **515**. If an open line side power source grounding conductor **515** is detected at block **620**, then the SWI component **335** may go to block **640** and prevent the relay **310** of the ASD **100** from
25 being closed. If no open line side power source grounding conductor **515** is detected at block **620**, then the SWI component **335** may go to block **625**. At block **625**, the SWI component **335** may check the line side power source **115** for a reversed electrifiable conductor **505** and return conductor **510**. If the line side power source electrifiable conductor **505** has been reversed with the line side power source return conductor **510**
30 at the line side input **305**, then the SWI component **335** may go to block **640** and prevent the relay **310** of the ASD **100** from being closed. If, however, no reversed line side power source electrifiable conductor **505** and return conductor **510** is detected at block **625**, then the SWI component **335** may go to block **630**. At block **630**, the SWI

component 335 may check the line side power source 115 for a reversed electrifiable conductor 505 and grounding conductor 515. If the electrifiable conductor 505 has been reversed with the grounding conductor 515 at the line side input 305, then the SWI component 335 may go to block 640 and prevent the relay 310 of the ASD 100 from being closed. If, however, no line side power source reversed electrifiable conductor 505 and grounding conductor 515 is detected at block 630, then the SWI component 335 may go to block 645 and allow the relay 310 of the SWI component 335 to be closed.

[00120] It will be understood by those of skill in the art that the tests performed by the SWI component 335 do not necessarily have to be performed in the order set forth in the logic of FIG. 5, but instead may be performed in any suitable order. It also will be understood that the SWI component 335 does not have to conduct each test set forth in FIG. 5, but instead may conduct less than all of the tests set forth in FIG. 5. If any test results in the execution of block 540, then the SWI component 335 may still perform the remaining tests and may record the outcome of each test, or at least the ones that result in a positive miswire indication. Additionally, if a miswire is detected by the SWI component 335, an indicator may be stored by the SWI component 335 or by the control unit 312, and the indicator may include information as to which test(s) resulted in the detection of a miswire. This indicator may also be communicated by the ASD 100 to another device such as a second ASD 100, a central monitoring device, or a computer. The SWI component 335 and/or the control unit 312 may also be associated with one or more memory devices such as, for example, the memory 405 of the control unit 312, that are operable to store a variety of indicators and/or measurements data associated with the operation of the SWI component 335.

[00121] According to another aspect of the invention, the ASD 100 may include a load side or destination integrity (or load side miswire or short/fault detection) component 340, which will be referred to herein as a destination wire integrity (DWI) component 340. The DWI component 340 may be a proactive safety device capable of detecting faults or defects in the flat wire 105 or miswires on the load side prior to the full power electrification of the flat wire 105. For purposes of this disclosure, the term load side may be utilized to refer to a flat wire 105 or other wire connected between the ASD 100 and a downstream destination device 117 and/or a downstream ASD 100.

Before the relay **310** of the ASD **100** is closed, thereby allowing the flat wire **105** to be electrified, the DWI component **340** may test the flat wire **105** on the load side and determine whether the flat wire **105** is free of faults, defects, and/or miswires. The DWI component **340** may test the flat wire **105** by applying either a voltage or a current
5 test signal to one or more of the conductors of the flat wire **105** and measuring a response on the other conductors of the flat wire **105**, as explained in greater detail below. The DWI component **340** may use one or both of a voltage-based test system and a current-based test system to check the flat wire **105** for miswires and wire faults, as described in greater detail below.

10 [00122] According to one aspect of the invention, the DWI component **340** may detect load side miswiring of the flat wire **105**. A load side miswire may include an open conductor of the flat wire **105**, which may occur when a conductor of the flat wire **105** is not connected to the destination module **120** or the source module **110**. In addition, a load side miswire may include conductors of the flat wire **105** that are
15 improperly connected to the destination module **120** such as, for example, two conductors that are reversed in their connection to the destination module **120**. For example, the DWI component **340** may detect a situation in which the electrifiable conductor **205** and one of the return conductors **210** have been switched when connected to the destination module **120**. If the DWI component **340** detects a miswire
20 on the load side, then the relay **310** is maintained in its open position to prevent electrification of the flat wire **105**.

[00123] According to another aspect of the invention, the ASD **100** may detect potentially hazardous conditions that may exist in association with a flat wire **105**. One hazardous situation of particular importance is the penetration of a flat wire **105** that
25 can lead to an inter-layer short in the flat wire **105**. An inter-layer short occurs when a conductor in the flat wire **105** is placed in contact with one or more other conductors in the flat wire **105**. Inter-layer shorts typically occur when an object, and particularly a metal object, penetrates the flat wire **105**. Various types of penetrations of the flat wire **105** have been considered and analyzed. With respect to a flat wire **105** installed on a
30 surface such as a wall or ceiling, typical penetration may be caused by nails, screws, push-pins, thumbtacks, staples, knife cuts, or saw cuts. Each type of penetration offers a different challenge to overcome fire and shock hazards. Penetrations may occur

while the flat wire **105** is electrified or prior to its electrification. Penetrating objects may or may not be present during the initial electrification of a flat wire **105**. In addition to inter-layer shorts, penetrations of the flat wire may lead to arc flashes or other arcing conditions which may be detected by the AMC safety component of the ASD **100**.

[00124] Low impedance inter-layer shorts are typically needed in order to cause a primary safety device such as a circuit breaker to trip. These more desirable low impedance shorts, sometimes referred to as dead or good shorts, typically occur during the penetration of a flat wire **105** or after the penetration of a flat wire **105** when the penetrating object is still embedded in the flat wire **105**. Once the penetrating object is removed from the flat wire **105**, there may no longer be a penetrating metal object to provide a parallel path through which current can flow, thereby removing the good inter-layer short. Additionally, the penetrating object no longer adds a compressive force that serves to press the conductors of the flat wire **105** together. This lack of compressive force may contribute to the failure to maintain a good quality inter-layer short. After the removal of the penetrating object, therefore, the inter-layer shorts are typically not low impedance inter-layer shorts, which makes a successful trip of a primary safety device such as a circuit breaker less likely.

[00125] The DWI component **340** of the ASD **100** may aid in the detection of these inter-layer shorts, as explained in greater detail below. The DWI component **340** may be a proactive safety device capable of detecting faults or defects in a flat wire **105** prior to the full power electrification of the flat wire **105**. Alternatively, as explained in greater detail below with reference to FIG. 11, the DWI component **340** may include a combination of proactive and reactive components. If a proactive device is utilized, then prior to the relay **310** being closed, the DWI component **340** checks for inter-layer shorts in the flat wire **105**, which may have been caused by a penetration of the flat wire **105**. The DWI component **340** may detect both low impedance inter-layer shorts (e.g., dead or good shorts) and high impedance inter-layer shorts in the flat wire **105**. If an inter-layer short is detected, then the DWI component **340** or the control unit **312** may open the relay **310** and prevent electrification of the flat wire **105**. In a DWI component **340** that includes both proactive and reactive components, the DWI component **340** may detect shorts and/or wire faults (and miswires) by electrifying one

or more conductors of the flat wire **105** and monitoring one or more of the conductors of the flat wire **105** for a return signal.

[00126] In both a voltage-based and current-based method of testing, the DWI component **340** may apply or communicate a test signal onto one or more conductors or layers of the flat wire **105** and test for a return signal on one or more of the other conductors or layers of the flat wire **105**. The two return conductors **210, 215** may form a return conductor loop and the two grounding conductors **220, 225** may form a grounding conductor loop. A loop may occur when a signal travels from the ASD **100** through the flat wire **105** via one conductor, to the destination module **120** and then back via another conductor of the flat wire **105** to the ASD **100**. For example, a signal may travel through the flat wire **105** via a first return conductor **210**, through the destination module **120**, and back through the flat wire **105** via the second return conductor **215**. The DWI component **340** may test the return conductor loop and the grounding conductor loop with independent test signals. Alternatively, the DWI component **340** may test the return conductor loop and the grounding conductor loop with a single test signal. If a single test signal is used to test the return and grounding conductor loops, alternating periods of the test signal may be used to test the return and grounding conductor loops independently. Additionally, if both the return and grounding conductor loops are determined to be properly terminated by the DWI component **340**, the DWI component **340** may presume that the electrifiable conductor **205** of the flat wire **105** is properly terminated at the destination module **120**. Alternatively, the DWI component **340** may perform additional tests on the electrifiable conductor **205** in order to determine whether or not the electrifiable conductor **205** is terminated properly. For example, the DWI component **340** may test the electrifiable conductor **205** to determine whether or not the electrifiable conductor **205** is shorted to one or more of the return conductors **210, 215** or the grounding conductors **220, 225**.

[00127] FIG. 7 is an exemplary flowchart of the general operation of a DWI component **340**, according to an illustrative embodiment of the invention. The methodology of FIG. 7 may be implemented by the DWI component **340** for either a voltage-based test system or a current-based test system. If power is applied to the DWI component **340** at block **705**, then the DWI component **340** may go to block **710**. At block **710**, the DWI component **340** may test the grounding conductor loop of the

flat wire **105**. The DWI component **340** may determine whether or not the grounding conductor loop has been terminated properly and whether or not there is a fault in the grounding conductors **220, 225** at block **715**. If the grounding conductor loop is determined not to be properly terminated or a fault is found in one of the grounding conductors **220, 225**, then, the DWI component **340** may go to block **740** and prevent the relay **310** from being closed to prevent electrification of the flat wire **105**. If, however, the grounding conductor loop is determined to be properly terminated and no faults are found in the grounding conductors **220, 225** at block **715**, then the DWI component **340** may go to block **720**. At block **720**, the DWI component **340** may test the return conductor loop of the flat wire **105**. The DWI component **340** may determine whether or not the return conductor loop has been terminated properly and whether or not there is a fault in the return conductors **210, 215** at block **725**. If the return conductor loop is determined not to be properly terminated or a fault is detected in one of the return conductors **210, 215**, then the DWI component **340** may go to block **740** and prevent the relay **310** from being closed to prevent electrification of the flat wire **105**. If, however, the return conductor loop is determined to be properly terminated and no wire faults are found in the return conductors **210, 215** at block **725**, then the DWI component **340** may go to block **730**. At block **730**, the DWI component **340** may test the electrifiable conductor **205** in order to determine whether or not it is properly terminated and whether or not there are any wire faults in the electrifiable conductor **205**. If, at block **735**, it is determined that the electrifiable conductor **205** is not properly terminated or a wire fault is detected on the electrifiable conductor **205**, then the DWI component **340** may go to block **740** and prevent the relay **310** from being closed. If, however, the electrifiable conductor **205** is determined to be properly terminated and no wire faults are detected on the electrifiable conductor **205** at block **735**, then the DWI component **340** may go to block **745** and allow the relay **310** to be closed. Alternatively, a DWI component flag may be set and stored by the control unit **312**, and the flag may be used by the ASD **100** in conjunction with other tests to determine whether or not the relay **310** may be closed.

[00128] It also will be understood by those of skill in the art that the tests performed by the DWI component **340** do not necessarily have to be performed in the order set forth in the logic of FIG. 7, but instead may be performed in any suitable order. As previously mentioned, some of the tests set forth in FIG. 7 may be performed in parallel

with one another. It also will be understood that the DWI component **340** does not have to conduct each test set forth in FIG. 7, but instead may conduct less than all of the tests set forth in FIG. 7. If any test results in the execution of block **740**, then the DWI component **340** may still perform the remaining tests and may record the outcome of each test, or at least the ones that result in a positive miswire indication.

Additionally, if a miswire is detected by the DWI component **340**, an indicator may be stored by the DWI component **340** or by the control unit **312**, and the indicator may include information as to which test(s) resulted in the detection of a miswire. This indicator may then be transmitted by the ASD **100** to another device such as a second ASD **100**, a central monitoring device, or a computer. The DWI component **340** and/or the control unit **312** may be associated with one or more memory devices such as, for example, the memory **405** of the control unit **312**, operable to store a variety of indicators and/or measurements data associated with the operation of the DWI component **340**.

[00129] FIG. 8 is a timing diagram of test signals that may be applied by a DWI component **340**, according to an illustrative embodiment of one aspect of the invention. As mentioned earlier, the return conductor loop and grounding conductor loop may be tested at alternating periods **805** and **810** of the test signal in order to isolate the loop that is being tested. According to an aspect of the present invention, the signal used to drive the return and grounding conductor loops may be any signal with an alternating period such as, for example, a 2400 Hertz (Hz) square wave signal. The signal may be generated by a microcontroller, clocking circuit, or other signal generation device and communicated onto the two loops of the flat wire **105**, as explained in greater detail below. The signal may be passed through a low pass filter before being communicated onto one or more of the conductors of the flat wire **105** to remove any unwanted noise and/or harmonics. Tests on both the return conductor loop and ground conductor loop may be performed with the same test signal and, if it is determined that both loops are properly terminated and no faults are detected on the flat wire **105**, then the relay **310** of the ASD **100** may be closed in order to allow the flat wire **105** to be electrified. In addition, a flag or state may be set in the ASD **100** to indicate whether the conductor loops are terminated properly. A conductor loops termination flag may be used in conjunction with the results of other tests performed by the ASD **100** in order to determine whether or not the relay **310** of the ASD **100** may be closed. The tests on

both loops may be conducted by the DWI component **340** within a first time of approximately 300 milliseconds or less **815** and then the decision of whether or not to close the relay **310** may be made by a second time **820**. The second time **820** may be less than approximately 375 milliseconds. It will be appreciated that the timing set forth in FIG. 8 is merely exemplary timing and that a variety of timing goals or benchmarks may be utilized in accordance with embodiments of the invention.

[00130] According to some embodiments of the invention, the flat wire **105** may be tested by the DWI component **340** by electrifying one or more conductors of the flat wire **105** and testing one or more of the conductors of the flat wire **105** for a return signal. For example, as explained in greater detail below with reference to FIG. 11, one or more of the return conductors **210**, **215** may be electrified and one or more of the conductors of the flat wire **105** may be monitored or tested for a return signal. Miswires and/or wire faults may be identified based at least in part on one or more return signals. It will be appreciated that a similar method may be conducted by electrifying one or more of the grounding conductors **220**, **225** and testing one or more of the conductors of the flat wire **105** for a return signal. It will be appreciated that the one or more conductors that are electrified for testing may be electrified for any period of time in order to conduct the testing.

[00131] As another example, the electrifiable conductor **205** of the flat wire **105** may be electrified for a predetermined period of time, and one or more conductors of the flat wire **105** may be monitored for miswire and/or wire faults. For example, the relay **310** may be closed at one zero crossing and then opened at the next zero crossing, thereby permitting one half cycle of an electrical power signal from the line side power source **115** to be communicated onto the flat wire **105**. One or more conductors of the flat wire **105** may then be monitored for return signals that indicate the presence of miswires and/or wire faults. For example, if a return signal is detected on one or more of the grounding conductors **220**, **225**, a miswire or inter-layer short may be present on the flat wire **105**. If a miswire or inter-layer short is identified, then the DWI component **340** and/or the control unit **312** may prevent the further electrification of the flat wire **105** by maintaining the relay **310** in its opened position. It will be appreciated that the testing described above may be conducted at any time by the DWI component **340** such as, for example, during the initial electrification of the flat wire **105** following

installation or a reset condition of the ASD **100**. It will further be appreciated that the predetermined period of time that the flat wire **105** is electrified for testing may be virtually any predetermined period of time and that a half cycle of an electrical power signal is merely discussed as an exemplary period of time.

- 5 [00132] Additionally, the tests performed by the DWI component **340** may be contained between the source module **110** and the destination module **120** of the flat wire system **101**. Accordingly, a current or voltage is not allowed to pass either to the line side source **115** or to the load side destination **125**.

- [00133] The DWI component **340** may use a voltage-based method to test the flat
10 wire **105** for miswires and wire faults on the load side. The voltage-based method directly applies a voltage test signal to selected conductors or layers (stimulated layers) of the flat wire **105** while measuring voltages on the remaining conductors or layers (non-stimulated layers). Flat wire faults, or unwanted conductance between the conductors in the form of low or high impedance shorts, may be identified by detecting
15 unexpected voltage present on the non-stimulated conductors or layers.

- [00134] FIG. 9A is a schematic diagram of a voltage-based DWI component **340** that may be incorporated into an ASD **100** according to one aspect of the invention. As a preliminary matter, it may be noted that FIG. 9A depicts a different source device **103** than that shown in FIG. 3. In FIG. 9A, the line side power source **115** is incorporated
20 into the source device **103**. Such a situation might occur, for example, if the source device **103** includes a standard electrical plug that may be plugged into an electrical outlet.

- [00135] As shown in FIG. 9A, The voltage-based DWI component **340** may include a source/sense circuit **900**, an electrifiable (or hot) conductor connection **901**, a return
25 conductor connection **902**, a grounding conductor connection **903**, and one or more test signal relays **904**. The source/sense circuit **900** may be configured to transmit a voltage test signal onto one of the conductors of the flat wire **105** and then monitor the conductors of the flat wire **105** for a return voltage. It will be understood that the source/sense circuit **900** may test more than one conductor of the flat wire **105**
30 simultaneously be using alternating periods of the same test signal, as explained in greater detail above with reference to FIG. 8. The source/sense circuit **900** may transmit a voltage test signal onto the electrifiable conductor **205** and/or monitor the

electrifiable conductor **205** via the electrifiable conductor connection **901**. Similarly, the source/sense circuit **900** may transmit a voltage test signal onto one or more of the return conductors **210, 215** and/or monitor one or more of the return conductors **210, 215** via the return conductor connection **902**. Additionally, the source/sense circuit **900** may transmit a voltage test signal onto one or more of the grounding conductors **220, 225** and/or monitor one or more of the return conductors **220, 225** via the grounding conductor connection **902**.

[00136] The voltage-based test signal transmitted by the source/sense circuit **900** may be a low voltage signal. The voltage-based test signal may be, for example, at a voltage of approximately 5 volts or at a voltage of approximately 12 volts, although it will be understood that other voltage levels may be used for the test signal. As a safety precaution, the maximum amplitude of the voltage-based test signal may be limited to approximately 30 volts, although it will be understood that a test signal with an amplitude of greater than 30 volts may be used in conjunction with embodiments of the invention. Additionally, the voltage-based test signal may be derived from the signal coming into the ASD **100** from the line side power source **115**. The source/sense circuit **900** may receive a voltage signal from the line side power source **115** and step that signal down to a low voltage signal that may be used or modified to perform tests on the flat wire **105**. For example, the source/sense circuit **900** may receive a voltage signal of approximately 110-130 V or approximately 220-250 V and step that voltage signal down to a low voltage signal for testing the flat wire **105**. The voltage may be stepped down using a step down transformer, capacitor, or any other suitable device for decreasing the amplitude of a voltage signal, as will be understood by those of skill in the art. It will also be understood that the source/sense circuit **900** may constitute an isolated power source when applying a test signal to the flat wire **105**.

[00137] A voltage test relay **904** may be used by the DWI component **340** to ensure that the flat wire cannot be fully electrified while it is being tested by the DWI component **340**. As shown in FIG. 9A, the voltage test relay **904** may be a double-pole single throw relay, although it will be understood that other types of relays or combinations of relays may be used in accordance with embodiments of the invention. If the voltage test relay **904** is in a closed position, then electrical power may be allowed to flow from the line side power source **115** through the ASD **100** and onto the

flat wire **105**. If, however, the voltage test relay **904** is in a test position (or opened position), then electrical power will not be permitted to flow from the line side power source **115** through the ASD **100** and onto the flat wire **105**. Instead, the voltage-based test signal will be allowed to flow from the source/sense circuit **900** onto the flat wire **105**. It will be understood by those of skill in the art that the voltage test relay **904** may be the same circuit as that used for the main or common relay **310**, as shown in FIG. 9A. Alternatively, the voltage test relay **904** may be one or more separate relays used in conjunction with the DWI component **340**.

[00138] When the voltage test relay **904** is maintained in a test position, the source/sense circuit **900** may transmit or communicate a voltage-based test signal onto one or more of the conductors of the flat wire **105** while monitoring the conductors of the flat wire **105** for a return voltage. For example, the source/sense circuit **900** may communicate a voltage-based test signal onto the electrifiable conductor **205** of the flat wire **105** via the electrifiable conductor connection **901**. The source/sense circuit **900** may then monitor the conductors of the flat wire **105** for a voltage signal to determine whether there are any inter-layer or termination shorts or faults present on the flat wire **105**. If a voltage signal is detected by either the return conductor connection **902** or the grounding conductor connection **903**, the source/sense circuit **900** (or the control unit **312** in communication with the source/sense circuit **900**) may determine that an inter-layer or termination short is present on the flat wire **105** between the electrifiable conductor **205** and one of the other conductors of the flat wire **105**. Similarly, the source/sense circuit **900** may communicate a voltage-based test signal onto the return conductors **210**, **215** of the flat wire **105** via the return conductor connection **902** and then monitor the conductors of the flat wire **105** for a voltage signal to determine whether there are any inter-layer or termination shorts between one or more of the return conductors **210**, **215** and one or more of the other conductors of the flat wire **105**. If a voltage signal is detected by either the electrifiable conductor connection **901** or the grounding conductor connection **903**, it may be determined that an inter-layer or termination short is present on the flat wire **105**. The same method may be used to test the grounding conductors **220**, **225** of the flat wire **105**. The source/sense circuit **900** may communicate a voltage-based test signal onto the grounding conductors **220**, **225** of the flat wire **105** via the grounding conductor connection **903** and then monitor the conductors of the flat wire **105** for a voltage signal to determine whether there are any

inter-layer or termination shorts between one or more of the grounding conductors **220**, **225** and one or more of the other conductors of the flat wire **105**. If a voltage signal is detected by either the electrifiable conductor connection **901** or the return conductor connection **902**, it may be determined that an inter-layer or termination short is present on the flat wire **105**.

[00139] As shown in FIG. 9A, a test signal may be applied to either both return conductors **210**, **215** or both grounding conductors **220**, **225** at the same time by the source/sense circuit **900**. It will, however, be understood by those of skill in the art that a test signal may be individually applied to a single conductor of the flat wire **105**. For example, two return conductor connections may be included to individually apply a test signal to and monitor each of the return conductors **210**, **225** of the flat wire. When determining whether or not inter-layer shorts are present on the flat wire **105**, it is not necessary to individually test and monitor each of the return conductors **210**, **215** or each of the grounding conductors **220**, **225** of the flat wire because a voltage-based test signal applied to one conductor in a loop will be transmitted through the destination module **120** and back to the DWI component **340** in the source device **103** via the associated other conductor in the loop. On the load side, the return signal may be transmitted through only the destination module **120** or, alternatively, the return signal may be transmitted through both the destination module **120** and any load side destination **125** connected to the flat wire system **101**.

[00140] Limits may be placed on the detectable inter-layer impedance range between two conductors of the flat wire **105**. The detectable inter-layer impedance range between the return conductors **210**, **215** and electrifiable conductor **205** may be limited by the possible presence of real loads connected on the load side **125** of the flat wire **105**. An example of such a load would be a hair dryer plugged into an electrical outlet. Real loads connected on the load side **125** may create an impedance on the flat wire **105** as low as 8-10 ohms; therefore, an inter-layer impedance check between the electrifiable **205** and return conductors **210**, **215** may be limited at lower than 8-10 ohms or at approximately less than 1 ohm. For example, if a high impedance inter-layer short is 190 ohms and the real load is 10 ohms, the resulting or combined impedance is 9.5 ohms $[(190 \times 10)/(190 + 10)]$, thus the high impedance interlayer short may be virtually undetectable. This is referred to as the real load effect. To avoid the real load

effect, a destination relay (not shown) may be placed in the destination module **120**.

The destination relay may be timed to delay a connection to the real load on a power up sequence while the DWI component **340** performs its tests, thereby eliminating the 8-10 ohm limitation.

- 5 [00141] Regarding the detectable inter-layer impedance range between return conductors **210**, **215** and grounding conductors **220**, **225**, the DWI component **340** may accurately detect an inter-layer impedance as high as approximately 5000 ohms prior to the full electrification of the flat wire **105**.

- [00142] The DWI component **340** may limit or eliminate the detection of false
10 alarms by performing pre-testing on the flat wire **105** prior to testing the flat wire **105** for inter-layer shorts. The DWI component **340** may also limit or eliminate the detection of false alarms by performing post-testing on the flat wire **105** after testing the flat wire **105** for inter-layer shorts. For pre-testing the flat wire **105**, the source/sense circuit **900** may monitor the conductors of the flat wire **105** for a voltage
15 signal prior to transmitting a voltage-based test signal onto the flat wire **105**. If a voltage signal is detected on one of the conductors of the flat wire **105** prior to applying a test signal to the flat wire **105**, then the source/sense circuit **900** may wait for the flat wire **105** to de-energize before applying a test signal to the flat wire **105**. For post-testing of the flat wire **105**, after the flat wire **105** has been tested with voltage-based
20 test signals, the source/sense circuit **900** may continue to monitor the conductors of the flat wire **105** for a voltage signal. Further voltage-based testing of the flat wire **105** using test signals may not be permitted as long as there is a voltage signal detected on one of the conductors of the flat wire **105**.

- [00143] It will be understood by those of ordinary skill in the art that the voltage-based method of testing the load side of a flat wire **105** for miswires and wire faults
25 may be implemented by devices other than the DWI component **340** of an ASD **100**. For example, the voltage-based method may be particularly useful in a general purpose portable flat wire test system, such as a portable handheld flat wire testing device.

- [00144] According to another aspect of the invention, the DWI component **340** may
30 utilize one or more current-based methods to identify or locate line side faults or miswires of a flat wire **105** connected to an ASD **100**. Before the relay **310** of the ASD **100** is closed, thereby allowing the flat wire **105** to be electrified, the DWI component

340 may use a current-based method to test the flat wire **105** on the load side and determine whether the flat wire **105** has been connected or wired properly.

Determining whether the flat wire **105** is connected properly prior to the full electrification of the flat wire **105** may help prevent electrocution, other bodily harm, or property damage caused by a miswire. By using a current-based method of the DWI component **340**, the DWI component **340** and/or the control unit **312** may determine whether a flat wire **105** has been installed correctly before the flat wire **105** is ever electrified. The DWI component **340** and/or the control unit **312** may also determine whether any faults exist in the flat wire **105** before the flat wire **105** is electrified.

[00145] FIG. 9B is a schematic diagram of a current-based DWI component **340** that may be incorporated into an ASD **100** according to an illustrative embodiment of the invention. As a preliminary matter, it may be noted that FIG. 9B depicts a different source device **103** and destination device **117** than that shown in FIG. 3. In FIG. 9B, the line side power source **115** is incorporated into the source device **103** and the load side destination **125** is incorporated into the destination device **117**. Such a situation might occur, for example, if the source device **103** included a standard electrical plug that may be plugged into an electrical outlet and if the destination device **117** included one or electrical outlets.

[00146] As shown in FIG. 9B, the DWI component **340** may be in communication with one or more excitation or drive circuits **905, 910** and one or more sense circuits **915, 920, 925** that are used to detect miswires and/or wire faults in the flat wire **105**. The excitation circuits **905, 910** and the sense circuits **915, 920, 925** may be included in or controlled by the DWI component. Alternatively, the excitation circuits **905, 910** and the sense circuits **915, 920, 925** may be included in the flat wire I/O interface **311**, and the DWI component **340** may be in communication with the flat wire I/O interface **311** and the excitation circuits **905, 910** and sense circuits **915, 920, 925**. The DWI component **340** may determine whether a flat wire **105** connected to the ASD **100** has been properly terminated prior to the electrification of the flat wire **100**. The DWI component **340** depicted in FIG. 9B is designed to be used in conjunction with an electrical flat wire including an electrifiable conductor **205** and two return conductors **210, 215** formed on opposing sides of the electrifiable conductor **205**. The electrical flat wire may further include two grounding conductors **220, 225** formed on opposing

sides of the combined electrifiable conductor **205** and return conductors **220**, **225**. It will, however, be understood by those of ordinary skill in the art that a DWI component **340** according to the invention may be used in conjunction with any flat wire (and/or any conventional wire), regardless of the number and type of conductors contained in
5 that flat wire.

[00147] Referring to FIG. 9B, the DWI component **340** may test the flat wire **105** for miswires by transmitting a current-based signal over one conductor of the flat wire **105** and testing one or more of the other conductors of the flat wire **105** for a return signal. For example, the associated conductor of the loop may be tested for a current
10 indicating that the flat wire **100** is wired correctly. For instance, the DWI component **340** may transmit a current-based signal over a first grounding conductor **220** and then monitor a second grounding conductor **225** for a current indicating that the grounding conductors **220**, **225** are wired correctly. Alternatively, the DWI component **340** may transmit a current-based signal over a first return conductor **210** and then monitor a
15 second return conductor **215** for a current indicating that the return conductors **210**, **215** are wired correctly. If the grounding conductors **220**, **225** and return conductors **210**, **215** are wired correctly, then the DWI component **340** may presume that the electrifiable conductor **205** of the flat wire **105** is wired correctly. Alternatively, the DWI component **340** may perform additional tests to verify that the flat wire **105** is
20 terminated properly, as discussed in greater detail below with reference to FIG. 13. The current that is tested for may be a predetermined threshold current, which may be, for example, 10 milliamps. If the current detected on the associated conductor of a flat wire loop is less than 10 milliamps, the loop may not be wired or terminated correctly at the destination module **120**.

25 [00148] A method and circuit for determining whether the grounding conductors **220**, **225** of a flat wire **105** have been wired correctly will now be described in greater detail. It will be understood that the same or a similar method may be used to determine whether the return conductors **210**, **215** have been wired correctly. In order to test for correct wiring, a ground excitation circuit **905** under control of the DWI
30 component **340** (and/or the control unit **312**) may transmit a current signal over a first grounding conductor **220**. The ground excitation circuit **905** may be an excitation current transformer or any other suitable device capable of transmitting a signal over a

first grounding conductor **220** including, but not limited to, multiplexers, isolators, and relays. In order to transmit a current signal onto the first grounding conductor **220**, a test signal may be used to drive a voltage-to-current converter, which in turn forces the current through the primary windings of the current transformer in the ground

5 excitation circuit **905**. Additionally, in order to minimize the magnitude of the excitation placed on the flat wire **105**, the signal transmitted by the ground excitation circuit **905** may be at a frequency much greater than 50 or 60 Hz, which is the frequency typically carried over electrical wires. According to an aspect of the invention, the frequency of the signal transmitted by the ground excitation circuit **905**

10 may be at a frequency of approximately 1000 Hz or greater. The current-based signal communicated or transmitted onto the first grounding conductor **220** may be part of an alternating signal that is used to simultaneously test both the grounding conductor loop and the return conductor loop, as described above with reference to FIG. 8.

Alternatively, the current-based signal used to test the grounding conductor loop may

15 be a separate signal than that used to test the return conductor loop.

[00149] After a signal has been transmitted over a first grounding conductor **220**, if the grounding conductors **220**, **225** are properly terminated, then the signal will pass through the destination module **120** and return to the source module **110** via the second grounding conductor **225**. A ground sense circuit **915** connected to the second

20 grounding conductor **225** may be used to detect a current present on the grounding conductors **220**, **225**. The ground sense circuit **915** may be a sensing current transformer or it may be any other suitable device capable of sensing a current including, but not limited to, resistors, isolators, and Hall Effect devices.

[00150] The DWI component **340** may also determine whether the return conductors

25 **210**, **215** have been wired correctly on the load side. In order to test for correct wiring, a return excitation circuit **910** under control of the DWI component **340** transmits a current-based signal over a first return conductor **210**, in the same manner as the ground excitation circuit **905** transmits a signal over a first grounding conductor **220**. The current-based signal communicated or transmitted onto the first grounding

30 conductor **220** may be part of an alternating signal that is used to simultaneously test both the grounding conductor loop and the return conductor loop, as described above with reference to FIG. 8. Alternatively, the current-based signal used to test the return

conductor loop may be a separate signal than that used to test the grounding conductor loop. After a signal has been transmitted over a first return conductor **210**, if the return conductors **210**, **215** are properly terminated, then the signal will pass through the destination module **120** and return to the source module **110** via the second return conductor **215**. A return sense circuit **920** connected to the second return conductor **215** may be used to detect a current present on the return conductors **210**, **215**. The return sense circuit **920** may be a sensing current transformer or it may be any other suitable device capable of sensing a current including, but not limited to, resistors, isolators, and Hall Effect devices.

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10 [00151] According to an aspect of the invention, the DWI component **340** may also determine that the flat wire **105** is not terminated properly if a current is detected on a conductor of the flat wire **105** other than the conductors being tested in any given loop. As explained in greater detail below, such a situation may also indicate a wire fault. It will be appreciated that the DWI component **340** may differentiate between a miswire

15 and a wire fault based upon the magnitude of a current signal detected on one of the other conductors and/or based on the number of other conductors on which a current signal is detected. For example, if a test current is applied to a return conductor **210** and a current that is approximately equal to the test current is detected on the electrifiable conductor **205**, then the DWI component **340** may determine that the

20 electrifiable conductor **205** and the other return conductor **215** have been miswired. As another example, if a test current is applied to a return conductor **210** and a current signal is detected on all of the conductors of the flat wire **105** (the detected current signals may have a lower amplitude than the test current), then the DWI component **340** may determine that a wire fault exists and that the conductors of the flat wire **105**

25 have been shorted together.

[00152] According to another aspect of the invention, the DWI component **340** may use the current-based method to determine whether there are any wire faults or inter-layer shorts present on the flat wire **105** prior to the electrification of the flat wire **105**. The DWI component **340** may detect inter-layer shorts on a non-electrified flat wire

30 **105** by transmitting a low level current through a single flat wire conductor, such as the electrifiable conductor **205**, or through one set of flat wire **105** layers, such as the return conductors **210**, **215**. Then, the DWI component **340** may monitor one or more of the

other flat wire **105** layers for a return current. For instance, a current may be transmitted on the one or more return conductors **210, 215** of the flat wire **105**. The DWI component **340** may then monitor the electrifiable conductor **205** and the one or more grounding conductors **220, 225** of the flat wire **105** for a return current. As
5 another example, a current may be transmitted on the electrifiable conductor **205** of the flat wire **105**, and the DWI component **340** will monitor the one or more return conductors **210, 215** and the one or more grounding conductors **220, 225** of the flat wire **105** for a return current.

[00153] The DWI component **340** may combine testing for miswires in the flat wire
10 **105** with testing for wire faults or inter-layer shorts on the flat wire **105**. For example, with reference to FIG. 9B, when a current-based test signal is transmitted onto the first grounding conductor **220** by the ground excitation circuit **905**, the sense circuits **915, 920, 925** may be used to determine whether the flat wire **105** contains any miswires or inter-layer shorts. As previously mentioned, the ground sense circuit **915** may be used
15 to determine whether or not the grounding conductors **220, 225** have been properly terminated at the load side. Additionally, the return sense circuit **920** and an electrifiable (or hot) sense circuit **925** may be used to monitor the flat wire **105** for a miswire or inter-layer short. If a current-based signal is detected on the second return conductor **210** by the return sense circuit **920**, then the DWI component **340** may
20 determine that there is an inter-layer short between one or more of the grounding conductors **220, 225** and one or more of the return conductors **210, 215**. Similarly, if a current-based signal is detected on the electrifiable conductor **205** by the electrifiable sense circuit **925**, the DWI component **340** may determine that there is an inter-layer short between one or more of the grounding conductors **220, 225** and the electrifiable
25 conductor **205**.

[00154] As an example, a test current of approximately 10 milliamps (mA) may be transmitted onto the first grounding conductor **220** of the flat wire **105** by the ground excitation circuit **910**. If the ground sense circuit **915** detects a signal of approximately 10 milliamps on the second grounding conductor **220**, then the DWI component **340**
30 may determine that the grounding conductors **220, 225** are properly terminated. If, however, the ground sense circuit **915** does not detect a signal of approximately 10 milliamps on the second grounding conductor **220**, then the DWI component **340** may

determine that the grounding conductors **220, 225** are not properly terminated and the DWI component **340** may prevent the relay **310** from being closed to prevent electrification of the flat wire **105**. Additionally, if a current is detected on either the second return conductor **215** by the return sense circuit **920** or on the electrifiable
5 conductor **205** by the electrifiable sense circuit **925**, then the DWI component **340** may determine that there is an inter-layer short in the flat wire **105**. The DWI component **340** may then prevent the relay **310** from being closed to prevent electrification of the flat wire **105**.

[00155] The combination of excitation circuits **905, 910** and sense circuits **915, 920, 925** shown in FIG. 9B is simply one combination of these circuits that may be used in accordance with the present invention. It will be understood that excitation circuits and/or sense circuits may be used to transmit a signal onto or monitor any of the conductors of the flat wire **105**. Using the example above, when a test signal is transmitted onto the first grounding conductor **220**, an additional sense circuit may be
15 used to monitor the first return conductor **210** of the flat wire **105** for a return signal that indicates an inter-layer short between one or more of the grounding conductors **220, 225** and the first return conductor **210**. It will be understood, however, that because the two return conductors **210, 215** form a loop if they are wired correctly, any inter-layer short between one or more of the grounding conductors **220, 225** and the
20 first return conductor **210** would also be detected by the return sense circuit **920** that is monitoring the second return conductor **215**.

[00156] The excitation circuits **905, 910** and the sense circuit **915, 920, 925** may be incorporated into the DWI component **340**. Alternatively, the excitation circuits **905, 910** and the sense circuits **915, 920, 925** may be included in the flat wire I/O interface
25 **311**, and the DWI component **340** may be in communication with the flat wire I/O interface **311** either directly or through the control unit **312**.

[00157] Additionally, the current-based method of the DWI component **340** may utilize one or more testing relays in conjunction with monitoring the sense circuits **915, 920, 925** for a return signal. The testing relays may be used to short one or more
30 conductors or layers of the flat wire **105** together when making a measurement. The shorts created by the testing relays may assist in measuring the current across any two conductors of the flat wire **105**. Accordingly, the testing relays may assist in locating

or identifying conductors that have been miswired and/or in localizing flat wire faults. As an example, two testing relays **930, 935** may be used by the DWI component **340** in conjunction with monitoring the flat wire **105** for miswires and inter-layer shorts. FIG. 9C is a schematic diagram of an exemplary DWI component **340** that utilizes testing relays **930, 935** in monitoring a flat wire **105** for miswires and inter-layer shorts according to certain embodiments of the invention. As shown in FIG. 9C, when neither of the testing relays **930, 935** is actuated or, in other words, neither of the testing relays **930, 935** is in a closed position, a default state may exist in which both the grounding loop and the return loop are allowed to be completed on the flat wire **105**. While neither of the testing relays **930, 935** is actuated, the DWI component **340** may test the flat wire **105** for complete grounding and return conductor loops. When the first testing relay **930** is actuated or in a closed position, the return excitation circuit **910** may be connected or shorted to the ground sense circuit **915**, thereby creating half of a loop necessary to check for an inter-layer short between one or more of the return conductors **210, 215** and one or more of the grounding conductors **220, 225**. If an inter-layer short exists between one or more of the return conductors **210, 215** and one or more of the grounding conductors **220, 225**, then the loop will be complete and the DWI component **340** will detect the inter-layer short. Similarly, when the second testing relay **935** is actuated or in a closed position, the return excitation circuit **910** may be connected or shorted to the electrifiable or hot sense circuit **925**, thereby creating half of a loop necessary to check for an inter-layer short between one or more of the return conductors **210, 215** and the electrifiable conductor **205**. If an inter-layer short exists between one or more of the return conductors **210, 215** and the electrifiable conductor **205**, then the loop will be complete and the DWI component **340** will detect the inter-layer short. When the DWI component **340** completes its testing, then both testing relays **930, 935** may be de-energized back to their original or default states.

[00158] FIG. 10 is an exemplary flowchart of the operation of a current-based detection method by a DWI component **340**, according to an illustrative embodiment of the invention. The flowchart of FIG. 10 may be associated with the current-based detection method and circuitry described above with reference to FIG. 9B. If power is applied to the DWI component **340** at block **1005**, then the DWI component **340** may go to block **1010**. At block **1010**, the DWI component **340** may apply a test signal to the first grounding conductor **220** of the flat wire **105**. Then, the DWI component **340**

may go to block **1015** and monitor the remaining conductors of the flat wire **105** for a return signal. At block **1020**, the DWI component may determine whether the grounding conductor loop has been terminated properly by determining whether or not an appropriate return signal is present on the second grounding conductor **225**. If the grounding conductor loop is not determined to be properly terminated, then the DWI component **340** may go to block **1065** and prevent the relay **310** from being closed to prevent electrification of the flat wire **105**. If, however, the grounding conductor loop is determined to be properly terminated at block **1020**, then the DWI component **340** may go to block **1025**. At block **1025**, the DWI component **340** may determine whether or not a short circuit exists between the grounding conductors **220**, **225** and any of the other conductors of the flat wire **105** by determining whether or not a return signal is present on one or more of the electrifiable conductor **205**, the first return conductor **210**, and the second return conductor **215**. If a return signal is detected on any of the conductors other than the grounding conductors **220**, **225**, a wire fault may be present on the flat wire **105**, and the DWI component **340** may go to block **1065** and prevent the relay **310** from being closed to prevent electrification of the flat wire **105**. If, however, no return signal is detected on any of the conductors other than the grounding conductors **220**, **225**, then the DWI component may go to block **1030**.

[00159] At block **1030**, the DWI component **340** may apply a test signal to the first return conductor **210** of the flat wire **105**. Then, the DWI component **340** may go to block **1035** and monitor the remaining conductors of the flat wire **105** for a return signal. At block **1040**, the DWI component determines whether the return conductor loop has been terminated properly by determining whether or not an appropriate return signal is present on the second return conductor **215**. If the return conductor loop is not determined to be properly terminated, then the DWI component **340** may go to block **1065** and prevent the relay **310** from being closed to prevent electrification of the flat wire **105**. If, however, the return conductor loop is determined to be properly terminated at block **1040**, then the DWI component **340** may go to block **1045**. At block **1045**, the DWI component **340** may determine whether or not a short circuit exists between the return conductors **210**, **215** and any of the other conductors of the flat wire **105** by determining whether or not a return signal is present on one or more of the electrifiable conductor **205**, the first grounding conductor **220**, and the second grounding conductor **225**. If a return signal is detected on any of the conductors other

than the return conductors **210, 215**, then a wire fault may be present on the flat wire **105**, and the DWI component **340** may go to block **1065** and prevent the relay **310** from being closed to prevent electrification of the flat wire **105**. If, however, no return signal is detected on any of the conductors other than the return conductors **210, 215**, then the
5 DWI component may go to block **1050**.

[00160] At block **1050**, the DWI component **340** may apply a test signal to the electrifiable conductor **205** of the flat wire **105**. Then, the DWI component **340** may go to block **1055** and monitor the remaining conductors of the flat wire **105** for a return signal. At block **1060**, the DWI component **340** may determine whether or not there is
10 a return signal in any of the other conductors of the flat wire **105**. A return signal in any of the other conductors may indicate a miswire of the electrifiable conductor **205** or a short between the electrifiable conductor **205** and one of the other conductors of the flat wire **105**. If, at block **1060**, a return signal is detected on one of the other conductors of the flat wire **105**, then the DWI component **340** may go to block **1065**
15 and prevent the relay **310** from being closed to prevent electrification of the flat wire **105**. If, however, no return signal is detected on any of the other conductors of the flat wire **105** at block **1060**, then the DWI component **340** may go to block **1070** and allow the relay **310** of the ASD **100** to be closed. Alternatively, a DWI component flag or state may be set, and the flag or state may be used by the ASD **100** in conjunction with
20 the flags or states from other tests to determine whether or not the relay **310** is allowed to close.

[00161] It also will be understood by those of skill in the art that the tests performed by the current-based method of the DWI component **340** do not necessarily have to be performed in the order set forth in the logic of FIG. 10, but instead may be performed
25 in any suitable order. It also will be understood that the DWI component **340** does not have to conduct each test set forth in FIG. 10, but instead may conduct less than all of the tests set forth in FIG. 10. If any test results in the execution of block **1065**, then the DWI component **340** may still perform the remaining tests and may record the outcome of each test, or at least the ones that result in a positive miswire or fault indication.
30 Additionally, if a miswire or fault is detected by the DWI component **340**, an indicator may be stored by the DWI component **340** or by the control unit **312**, and the indicator may include information as to which test(s) resulted in the detection of a miswire. This

indicator may then be transmitted by the ASD **100** to another device such as a second ASD **100**, a central monitoring device, or a computer. The DWI component **340** and/or the control unit **312** may also cause additional data such as, for example, measurements data taken by the components of the DWI component **340**, to be stored in an
5 appropriate memory such as, for example, the memory **405** of the control unit **312**.

[00162] FIG. 11 is a schematic diagram of an alternative DWI component **340** that may be incorporated into an ASD **100**, according to an embodiment of the invention. As shown, the ASD **100** may include more than one relay **310**, **1105** that may be utilized to test the flat wire **105**. With reference to FIG. 11, the ASD **100** may control
10 the actuation of a first relay **310** in order to control the communication of an electrical power signal from the line side power source **115** to the electrifiable conductor **315** of the flat wire **105**. The ASD **100** may also control the actuation of a second relay **1105** in order to control the communication of an electrical signal from the line side power source **115** to one or more return conductors **210**, **215** of the flat wire **105**. According
15 to an aspect of the invention, the two relays **310**, **1105** may be actuated independently of one another. For example, the second relay **1105** may be utilized in association with the DWI component **340** in order to test the flat wire **105** for miswires and/or wire faults. The second relay **1105** may be closed for a predetermined period of time such as, for example, one half cycle of the electrical power signal of the line side power
20 source **115**, thereby allowing an electrical signal to be communicated onto one or more of the return conductors **210**, **215**. It will be appreciated that the electrical signal communicated onto one or more of the return conductors **210**, **215** may be the electrical power signal communicated from the line side power source **115** or, alternatively, the electrical signal may be an altered version of the line side power source signal. For
25 example, the line side power source signal may be stepped down or stepped up by an appropriate transformer and/or current limited by an appropriate resistor device prior to being communicated onto one or more of the return conductors **210**, **215**.

[00163] Once an electrical signal has been communicated onto one or more of the return conductors **210**, **215**, one or more sensors **1110**, **1115**, **1120** associated with the
30 DWI component **340** may be utilized to test the flat wire **105** for return signals. The one or more sensors **1110**, **1115**, **1120** may be appropriate voltage or current sensors, as previously discussed. For example, the one or more sensors **1110**, **1115**, **1120** may be

current transformers. As shown in FIG. 11, one or more sensors **1110, 1115, 1120** may be utilized to test the electrifiable conductor **205**, one or more of the return conductors **210, 215**, and one or more of the grounding conductors **220, 225** for return signals.

Because the return conductors **210, 215** and the grounding conductors **220, 225** form
5 respective loops if they are properly terminated at the destination module **120**, it will be appreciated that only one sensor may be utilized for each pair of conductors.

Additionally, it will be appreciated that the sensors **1110, 1115** utilized to test for a return signal on the electrifiable conductor **205** and one or more of the return conductors **210, 215** may be the current sensors utilized by the GFCI component **315**.

10 [00164] The DWI component **340** of FIG. 11 may test the flat wire **105** for miswires and/or wire faults in a similar manner to that described above for the return conductors with reference to FIG. 10. For example, following the communication of an electrical signal onto one or more of the return conductors **210, 215**, miswires and/or wire faults may be identified by the return signals that are detected by the one or more sensors
15 **1110, 1115, 1120**. If a return signal is detected on the electrifiable conductor **205** and/or one or more of the grounding conductors **220, 225**, then a miswire and/or wire fault may be present on the flat wire **105**. Additionally, if an electrical signal is applied to the first return conductor **210** and a return signal is not detected on the second return conductor **215**, then a miswire may be identified in the flat wire **105**.

20 [00165] It will be understood that the ASD **100** may include any number of relays and that an electrical signal may be communicated onto any conductor(s) of the flat wire **105** for testing. For example, a relay may be utilized to allow an electrical signal to be communicated onto one or more of the grounding conductors **220, 225** of the flat wire **105**, and the flat wire **105** may be tested for return signals in a similar manner as
25 that described above with reference to FIG. 11. It will be appreciated that the use of more than one relay may assist in preventing bounce and wear and tear on one or more of relays. For example, if a relay **1105** is utilized to control the communication of an electrical signal onto one or more of the return conductors **210, 215**, then the relay **1105** may not be subject to the bounce and/or wear and tear that the relay **310** utilized in
30 association with the electrifiable conductor **205** is subject to.

[00166] FIG. 12 is a schematic diagram of an ASD **100** and a DWI component **340** that may be utilized to detect high impedance shorts or wire faults in a flat wire **105**,

according to an embodiment of the invention. With reference to FIG. 12, more than one relay **310**, **1205** may be incorporated into the ASD **100**. A first relay **310** may be utilized to control the communication of an electrical power signal from the line side power source **115** onto the flat wire **105**. A second relay **1205** may be utilized to

5 control the communication of a test signal onto the flat wire **105**. The test signal may be a current limited version of the electrical power signal. For example, the electrical power signal may be passed through an appropriate resistance device **1210** (e.g., a resistor) in order to limit the current of the termination test signal. It will be appreciated that the current may be limited to any appropriate value such as, for

10 example, a current that is between approximately 6 mA and approximately 100 mA. According to an aspect of the invention, the current may be limited to approximately 20 mA. Additionally, other parameters of the test signal may be altered by appropriate circuitry **1215**. For example, the voltage of the test signal may be altered before it is communicated onto the flat wire **105**. As an example, the voltage of the test signal may

15 be stepped up to a higher voltage value by a suitable transformer before it is communicated onto the flat wire **100**. As another example, the voltage of the test signal may be increased before it is communicated onto the flat wire **100** by an appropriate inversion technique. According to an aspect of the invention, the test signal may have a voltage that is between approximately 120 V and 1000 V, although higher

20 voltage values may be used. Additionally, it will be appreciated that the test signal may be either an alternating current signal or a direct current signal such as, for example, a direct current signal that is obtained by rectifying the electrical power signal received from the line side power source **115**. It will also be understood that the test signal may have virtually any frequency. For example, the test signal may have a frequency

25 between approximately 50 Hz and approximately 1 MHz. According to an aspect of the invention, the test signal may have a frequency of approximately 30 KHz.

[00167] It will be appreciated that the use of a high voltage test signal may assist in detecting high impedance shorts or wire faults on the flat wire **105**. For example, a high voltage test signal may assist in detecting an arc flash or other arcing condition on

30 the flat wire **105**. It will further be appreciated that the use of a current limited single may provide for additional safety if there is a wire fault on the flat wire **105**. Additionally, it will be appreciated that the use of the test signal described with reference to FIG. 12 by the ASD **100** to test the flat wire **105** may be used as a

proactive safety test independently of or in addition to one or more of the other proactive safety tests described herein or apparent to one of ordinary skill in the art.

[00168] The test signal may be communicated onto one or more of the conductors of the flat wire **105** by closing the second relay **1205**. It will be appreciated that the second relay **1205** may be closed for a predetermined period of time. Virtually any predetermined period of time may be utilized, as will be understood by those of skill in the art. Additionally, the test signal may be communicated onto any of the conductors of the flat wire **105**. For example, the test signal may be communicated onto one or more of the return conductors **210, 215** of the flat wire **105**, as discussed above with reference to FIG. 11. As another example, the test signal may be communicated onto one or more of the grounding conductors **220, 225** of the flat wire **105**. As yet another example, the test signal may be communicated onto the electrifiable conductor **205** of the flat wire **105**. After the test signal has been communicated onto one or more conductors of the flat wire **105**, the DWI component **340** may monitor one or more conductors of the flat wire **105** for a return signal in a similar manner as that discussed above with reference to FIG. 11. The detection of a return signal may indicate the presence of a miswire and/or a wire fault on the flat wire **105**. For example, if the test signal is communicated onto the first return conductor **210**, then the detection of a return signal on the electrifiable conductor **205** and/or one or more of the grounding conductors **220, 225** may indicate a miswire and/or a wire fault. If a miswire or wire fault is detected by the DWI component **340**, then the relay **310** may be maintained in an opened position, thereby preventing the full electrification of the flat wire **105**. Additionally, the second relay **1205** may be maintained in an opened position. If, however, no miswires or wire faults are detected by the DWI component **340**, then the first relay **310** may be permitted to be closed, thereby allowing the full electrification of the flat wire **105**.

[00169] As previously mentioned, additional tests may be conducted on the electrifiable conductor **205** of the flat wire **105** in order to determine that the electrifiable conductor **205** has been properly terminated. These additional tests are described herein as reactive tests; however it will be appreciated that proactive tests may also be utilized prior to the full electrification of the flat wire **105**. These tests may also be associated with the load side wire integrity. Accordingly, the DWI component

340 may include both reactive and proactive elements. FIG. 13 is a schematic diagram of an exemplary circuit that may be utilized to test for a proper flat wire termination at a destination module **120**, according to an embodiment of the invention. With reference to FIG. 13, during the electrification of the flat wire **105** and/or after the electrification of the flat wire **105**, the ASD **100** may test for a proper termination of the electrifiable conductor **205**. In other words, once the relay **310** has been closed, the ASD **100** may test for an appropriate return signal that indicates that the electrifiable conductor **205** is properly terminated at the destination module **120**. In order to test for a proper termination of the electrifiable conductor **205** at the destination module **120**, an electrical load **1305** may be incorporated into the destination module **120**. The electrical load **1305** may be a passive load that is detectable by the ASD **100** such as, for example, one or more LED's, one or more resistors, and/or one or more capacitors. The electrical load **1305** may be connected between the electrifiable conductor **205** and one or more of the return conductors **210**, **215** of the flat wire **105**. The electrical load **1305** may have virtually any total impedance that is discernable by one or more current sensing devices included in the ASD **100**.

[00170] Once the relay **310** has been closed and an electrical power signal is communicated onto the flat wire **105**, the electrical load **1305** may operate to generate a current on the flat wire **105** that may be detectable by appropriate current sensors of the ASD **100** such as, for example, the current sensors utilized in association with the DWI component **340**. The generated current may then be detected by one or more appropriate current sensors associated with the ASD **100** and, based at least in part on the amplitude of the detected current, a determination may be made as to whether the electrifiable conductor **205** and/or one or more of the return conductors **210**, **215** have been properly terminated. In other words, if the detected current is above a predetermined threshold value, it may be determined that the electrifiable conductor **205** and/or one or more of the return conductors **210**, **215** have been properly terminated. If, however, the detected current is below the predetermined threshold value, it may be determined that the electrifiable conductor **205** and/or one or more of the return conductors **210**, **215** are not properly terminated, and the relay **310** may be opened, thereby de-energizing the flat wire **105**. Many different predetermined threshold values may be utilized in accordance with the invention, such as for example a predetermined threshold value of approximately 20 mA. It will also be appreciated

that if an electrical device such as, for example, a lamp or a vacuum cleaner is connected to the destination module **120**, then a greater electrical load **1305** may be present on the flat wire **105**. As discussed earlier, the over-current protection component **325** may de-energize the flat wire **105** if the current on the flat wire **105** exceeds a maximum allowed current such as, for example, a current of 15A.

[00171] As an example, once the flat wire **105** has been fully electrified, a 120 VAC signal may be communicated over the electrifiable conductor **205** to the destination module **120**. The 120 VAC signal may then be communicated through an electrical load **1305** that is connected between the electrifiable conductor **205** and one or more of the return conductors **210, 215** in the destination module **120**, thereby generating a current on the flat wire **105**. The current may then be detected at the ASD **100** and compared to a predetermined threshold value in order to verify that the flat wire **105** is terminated properly. If an LED is utilized as part of the electrical load **1305** in the destination module **120**, it will be appreciated that the LED may also provide a visual indication of a proper termination for the flat wire **105**. Furthermore, it will be understood that a similar test as that discussed above with reference to FIG. 13 for the electrifiable conductor **205** may also be conducted on one or more of the other conductors of the flat wire **105**.

[00172] Although the tests to detect a properly terminated electrifiable conductor are described above as reactive tests, it will be appreciated that proactive tests may be utilized prior to the full electrification of the flat wire **105**. For example a voltage test signal may be communicated onto the electrifiable conductor **205** of the flat wire **105** and the voltage test signal may be communicated through a passive load in the destination module **120** prior to being returned to the ASD **100**. The passive load may cause a detectable voltage drop in the flat wire **105**. An appropriate voltage sensor in the ASD **100** may then detect the voltage drop across the passive load and determine whether or not the electrifiable conductor **205** has been properly terminated. It will be appreciated that the destination module **120** may include an appropriate relay that may prevent the voltage test signal from being communicated to an electrical device such as, for example, a lamp or vacuum cleaner. In other words, the passive load may be the only load connected to the flat wire **105** at the destination module **120** during the proactive testing of the flat wire **105**. If the voltage of the termination test signal has

been stepped up prior to being communicated onto the flat wire **105**, it may be easier to detect the electrical load **100**. Based at least in part on the voltage detected at the ASD **100**, the DWI component **340** and/or the control unit **312** may determine whether or not the electrifiable conductor **205** has been properly terminated. It will be appreciated that
5 other conductors of the flat wire **105** may be tested for proper termination utilizing appropriate voltage signals.

[00173] It will be appreciated that other safety components may be included or incorporated into or associated with the ASD **100**. The safety components described herein are merely exemplary. Other safety components will be readily apparent to
10 those of ordinary skill in the art.

[00174] It will also be appreciated that a variety of safety components or other features may be included in a destination device **117**. As discussed above, a destination device **117** may include a passive load that assists in the testing of the proper termination of the flat wire **105**. The destination device **117** may also include one or
15 more safety components that may be utilized to test flat wire that has been connected downstream from the destination device **117**, as discussed below with reference to FIG. 19. The one or more safety components that may be included may be similar to one or more of the safety components discussed above for the ASD **100**. A destination device **117** may also include a light emitting diode (LED) or another suitable device that may
20 indicate to a user when power is being supplied to the destination device **117**. A destination device **117** may also include suitable surge protection devices and associated fuses that may prevent a dangerous high current signal from being passed through the destination device **117**. For example, the destination device **117** may include a suitable surge protection device between the electrifiable conductor **205** and
25 the return conductors **210, 215**. As another example, the destination device **117** may include a suitable surge protection device between the electrifiable conductor **205** and the grounding conductors **220, 225**.

[00175] A destination device **117** and/or the ASD **100** may also include a battery backup that permits at least the conducting of proactive tests on the flat wire **105** in the
30 event of a power outage. The battery backup may be any type of battery such as, for example a rechargeable battery that may be charged while power is provided to the ASD **100** and/or the destination device **117** from the line side power source **115**.

Additionally, as previously mentioned, a destination device **117** and/or the ASD **100** may include any number of electrical sockets. Other features that may be incorporated into a destination device **117** will be apparent to those of ordinary skill in the art.

5 [00176] Safety is an important consideration in the design of wiring systems that can carry dangerous voltage levels, especially when there is a possibility of a penetration of an electrifiable conductor **205**. Penetration or compromise of a flat wire **105** by objects such as nails, screws, drill bits, knife blades, saw blades, scissors, staples, darts, bullets, toys, etc. should be considered.

10 [00177] As one of ordinary skill in the art will appreciate, the flat wire **105** described herein, for purposes of disclosing the present invention, may itself be designed to be safe if it is penetrated. Fire protection and electric shock safety are based on limiting the voltage, and therefore the current in the flat wire **105** while expediting the trip time of a primary safety device such as a circuit breaker or a fuse in a branch circuit main box. Secondary protection may also be provided by the ASD **100**
15 of the present invention.

[00178] The flat wire **105** may be designed to produce a short between a first grounding conductor **220**, a first return conductor **210**, an electrifiable conductor **205**, a second return conductor **215**, and a second grounding conductor **225** (G-N-H-N-G) in that sequence upon penetration. With as much as four times the conductance ultimately
20 tied to earth ground, a voltage divider is formed favoring the ground voltage over the line or hot voltage. Repeated tests show that voltages present at the site of penetrations of the flat wire **105** do not exceed approximately 50 VAC for longer than a primary safety device's trip time, which is typically under 25 milliseconds. Furthermore, the voltage present at the site of penetrations does not exceed approximately 50 VAC for
25 longer than the trip time of a secondary safety device such as the ASD **100**, which may be approximately 8 milliseconds.

[00179] Penetration may occur through the broadside or the flat surface of a flat wire **100** by sharp objects. Alternatively, penetration may occur through an edge of the flat wire **100** by an object such as a knife blade or drywall saw. In either situation, the
30 resulting short may cause a high current to be produced at a low voltage for a short time (less than the trip time). Startle effect, or sound burst, and localized heating may be minimized due to the nature of the protective layered flat wire **105**.

[00180] FIGS. 14A-F are a series of diagrams which depict an example of the dynamics of a nail or tack penetration of a live multi-planar flat wire **105**. Again, protective layered flat wire **105** has a distinct advantage over conventional wire by assuring that a penetrating object **1400** such as, for example, a nail, first passes through
5 a grounding conductor (G1) **220**, then a return or neutral conductor (N1) **210** prior to any contact with the hot electrifiable conductor **205**.

[00181] FIG. 14A depicts a situation in which a penetrating object **1400** has only penetrated one grounding conductor **220** of the flat wire **105**. Similarly, FIG. 14B depicts a situation in which a penetrating object **1400** has penetrated only one
10 grounding conductor **220** and one return conductor **210**. In both FIGS. 14A and 14B, the electrifiable conductor **205** has not yet been penetrated. Accordingly, in both FIGS. 14A and 14B, there may be no voltage or current present on the penetrating object **1400**. Additionally, the current present on the electrifiable conductor **205** of the flat wire **105** may be some normal load current. The normal load current present on the
15 electrifiable conductor **205** may be a current which is less than approximately 15 amps in a standard United States branch application or which is less than approximately 6 amps in a standard European branch application.

[00182] FIG. 14C depicts a situation in which the penetrating object **1400** has shorted the electrifiable conductor **205**, one of the return conductors **210** and one of the
20 grounding conductors **220**. Similarly, FIG. 14D depicts a situation in which the penetrating object **1400** has shorted the electrifiable conductor **205**, both of the return conductors **210**, **215** and one of the grounding conductors **220**. FIG. 14E depicts a situation in which the penetrating object **1400** has shorted the electrifiable conductor **205**, both of the return conductors **210**, **215** and both of the grounding conductors **220**,
25 **225**. In each of FIGS 14C-14E, the short circuit created in the flat wire **105** between the electrifiable conductor **205** and any of the other conductors **210**, **215**, **220**, **225** may act as a voltage divider until a primary safety device such as a circuit breaker or a secondary safety device such as an ASD **100** trips. In each of FIGS. 14C-14E, there may be a relatively low voltage present on the penetrating object **1400**. The low
30 voltage may be less than approximately 50 VAC on a standard 120 VAC wire, and the low voltage may be less than approximately 100 VAC on a standard 240 VAC line. Additionally, in each of FIGS. 14C-14E, the current present on the electrifiable

conductor **205** may exceed approximately 100 amps until the primary or secondary safety device (ASD) **100** trips. There also may be a current present on either of the grounding conductors **220, 225** and/or on either of the return conductors **210, 215** which will also facilitate the tripping of the ASD **100**.

- 5 [00183] The time for penetrating from an outer grounding layer **220** to an electrifiable conductor **205** (FIGS. 14A–14C) may typically be under one millisecond, which is only a fraction of a typical trip time for a primary safety device such as a circuit breaker. Similarly, the time to continue penetration from an electrifiable conductor **205** to the backside grounding layer **225** (FIGS. 14C-14E) may also be
- 10 relatively short. The short circuit created during the penetration may be of a continuous nature. The continuous nature of the short circuit may be due to two primary factors: firstly, the conductor contact at the sides of the penetrating object **1400** is maintained by the insulation displacement process during penetration and secondly, by the molten copper in the proximity of the contact area once the short begins.
- 15 [00184] FIG. 14F depicts a penetration after a penetrating object **1400** has been removed from the flat wire **105**. If the circuit breaker has been reset prior to the flat wire **105** being electrified, then some additional damage may be done to the flat wire **105** before the circuit breaker trips again; however, if an ASD **100** is connected to the flat wire **105**, then any additional damage may be prevented. The proactive safety
- 20 components of the ASD **100** may determine that a fault exists on the flat wire **100** prior to allowing the flat wire **100** to be fully electrified. For example, when testing the flat wire **105** prior to electrification, the DWI component **340** of the ASD **100** may determine that a short exists between the conductors or layers of the flat wire **105**. The ASD **100** will then prevent the flat wire **100** from being electrified.
- 25 [00185] FIG. 15 is a representative graph of the voltage and current waveforms present during a penetration of a flat wire **105**. The voltage waveform present on the penetrating object **1400** and current waveform present on the electrifiable conductor **205** may be captured by an oscilloscope such as a Gould Ultima 500 oscilloscope. For this example, the penetrating object **1400** was a nail of a 4d common size and the
- 30 circuit breaker used was a common 20 amp GE circuit breaker. As shown by FIG. 14, the trip time for the circuit breaker may be approximately 12 to 25 milliseconds when the penetrating object **1400** penetrates the flat wire **105**. Note that the circuit breaker

trip time may be less than the period for one cycle of a standard 120 VAC, 60Hz electrical wire. The trip time for an ASD **100** connected to the flat wire **105** may also be less than the period for one cycle of a standard 120 VAC, 60 Hz electrical wire. Additionally, the trip time of the ASD **100** may be less than the trip time of the circuit
5 breaker. The trip time of the ASD **100** may be, for example, approximately 8 milliseconds or less, causing the ASD **100** to trip before the tripping of the circuit breaker. After the ASD **100** trips, causing the flat wire **105** to be de-energized, the circuit breaker may or may not trip.

[00186] FIGS. 16A-16D are a series of diagrams which depict examples of the
10 dynamics of a penetration of a non-live multi-planar flat wire **105**. FIG. 16A shows the inter-layer shorts that occur when a penetrating object **1600**, such as a nail, penetrates the flat wire **105**. Without electrification, the conductors of the flat wire **105** may not experience additional damage or fusion from high currents; however, multiple inter-layer shorts may be caused. FIG. 16B shows the residual inter-layer shorts after the
15 penetrating object **1600** has been removed from the flat wire **105**. The DWI component **340** of an ASD **100** connected to the flat wire **105** may be able to detect this inter-layer short prior to allowing the flat wire **105** to be fully electrified. The DWI component **340** may also be able to determine that the layer loops of the flat wire **105**, such as the grounding layer loop or the return conductor layer loop, are incomplete prior to
20 allowing the flat wire **105** to be fully electrified. The proactive safety components of the ASD **100** may prevent flashes or plumes (e.g., arc flashes) which may occur upon electrification of the flat wire **105** by recognizing defects prior to allowing the flat wire **105** to be fully electrified.

[00187] If the penetrating object **1600** penetrated the flat wire **105** after the flat wire
25 **105** had been electrified, then the reactive safety components including the GFCI component **315** and the ground current monitoring component **330** may detect the flaw in the flat wire **105** and open the relay **310** of the ASD **100**, thereby de-energizing the flat wire **105**.

[00188] FIG. 16C depicts the transverse cut of a flat wire **105** by a cutting object
30 **1605**, such as a pair of scissors. In FIG. 16C, the cutting object **1605** is shown still in the flat wire **105** during the cut. FIG. 16D depicts how a partially cut flat wire **105** section would appear once the cutting object **1605** has been removed. The DWI

component **340** of an ASD **100** connected to the flat wire **105** may be able to detect the inter-layer shorts created by the cutting object **1605** prior to allowing the flat wire to be fully electrified. Alternatively, the DWI component **340** may be able to determine that the layer loops of the flat wire **105**, such as the grounding layer loop or the return
5 conductor layer loop, are incomplete prior to allowing the flat wire **105** to be fully electrified. The proactive safety components of the ASD **100** may prevent flashes or plumes (e.g., arc flashes) which may occur on the flat wire **105** by recognizing defects prior to allowing the flat wire **105** to be fully electrified.

[00189] If the cutting object **1605** cuts the flat wire **105** after the flat wire **105** has
10 been electrified, then the reactive safety components including the GFCI component **315** and the ground current monitoring component **330** may detect the flaw in the flat wire **105** and open the relay **310** of the ASD **100**, thereby de-energizing the flat wire **105**.

[00190] The various safety components of the ASD **100** may share various circuits.
15 Although the various safety components are described herein as individual components, it will be understood that the safety components may utilize common circuits. For example, the ASD **100** may include only one excitation circuit and one sense circuit that is used as needed by each of the safety components of the ASD **100**.

[00191] The sharing of circuits by the various components of the ASD **100** may
20 facilitate the construction of a compact device. Accordingly, the ASD **100** may be placed in a compact enclosure such as in a wall box or cavity that is roughly the size of a common electrical outlet. For example, an ASD **100** may be placed in a wall cavity that is the size of the cavity used for an electrical outlet. The ASD **100** may be powered by a conventional in-wall electrical wire. Alternatively, an ASD **100** may be
25 plugged into a conventional wall receptacle outlet and powered by that outlet. If the ASD **100** is to be plugged into an outlet, the source device **103** may include, for example, a plug, such as a traditional three-prong electrical plug, that may be inserted into the outlet. In such a situation, the plug would be the line side power source **115** for a flat wire system **101**, and the line side power source **115** would be incorporated into
30 the source device **103**. A flat wire **105** may then be connected to and monitored by the ASD **100**. Additionally, the ASD **100** may have auxiliary receptacles, or plugs,

situated on the exterior surface of the ASD **100**. These plugs may be common two-prong or three-prong plugs and may be used to power electronic devices.

[00192] According to an aspect of the invention, the ASD **100** may be configured to receive power and an electrical power signal from a line side power source **115** that is a standard electrical outlet. Additionally, the ASD **100** may be configured to prevent the communication of the electrical power signal onto the flat wire **105** without the electrical power signal first being communicated through the ASD **100**. Accordingly, the ASD **100** may conduct on or more tests on the flat wire **105** prior to electrification of the flat wire **105**, during the electrification of the flat wire **105** and/or subsequent to the electrification of the flat wire **105**. FIG. 17A is a schematic diagram of an exemplary source device connection to an electrical outlet **1705** and a flat wire **105**, according to an illustrative embodiment of the invention. The source device **103** may be connected to a termination device **1710** associated with the flat wire **105**. With reference to FIG. 17A, the source device **103** of the ASD **100** may include an electrical plug **1715** that is configured to be plugged into a corresponding socket **1720** of an electrical outlet **1705**. Additionally, the source module **110** of the ASD **100** may include one or more source termination points **1725** that are configured to be plugged into one or more corresponding termination plugs **1730** associated with the termination device **1710**. The flat wire **105** may be connected to the termination device **1710**, and each conductor of the flat wire **105** may be terminated at a respective termination plug **1730** of the termination device **1710**. The conductors of the flat wire **105** may be terminated at the termination device **1710** in an appropriate order such as, for example, in a G-N-H-N-G configuration. For example, a grounding conductor **220** of the flat wire **105** may be terminated first and then the other conductors of the flat wire **105** may be terminated in order until the other grounding conductor **225** is terminated. It will be appreciated that, given the symmetry of the exemplary flat wire **105** described in this disclosure, the flat wire **105** should be terminated correctly regardless of which grounding conductor **220**, **225** is terminated first provided that a G-N-H-N-G configuration is used and that the flat wire **105** conductors are terminated in order starting with a grounding conductor **220**, **225**.

[00193] With continued reference to FIG. 17A, when the ASD **100** is plugged into the electrical outlet **1705**, the source termination **1725** points will also be connected to

the corresponding termination plugs **1730** of the termination device **1710**. When the ASD **100** is unplugged from the electrical outlet **1705**, the connection with the termination device **1710** will also be severed. Additionally, the termination device **1710** may be situated remotely from the electrical outlet **1705**, requiring the ASD **100** to complete the connection between the line side power source **115** and the flat wire **105**. Accordingly, the ASD **100** may test the flat wire **105** prior to the communication of an electrical power signal from the line side power source **115** to the flat wire **105**.

[00194] As shown in FIG. 17A, the source termination points **1725** are male termination points and the corresponding termination plugs **1730** of the termination device **1710** are female termination points. However, it will be understood that the source device **103** may include female termination points and the termination device **1710** may include male termination points. Additionally, it will be understood that other types of connections may be utilized between the source device **103** and the termination device **1710**, as will be understood by those of skill in the art.

Additionally, It will be appreciated that the connections illustrated in FIG. 17A only require the use of one socket **1720** of an electrical outlet **1705**. Accordingly, any remaining sockets of the electrical outlet **1705** may be free for use with other devices.

[00195] According to another aspect of the invention, the ASD **100** may include or incorporate one or more electrical sockets or extender outlets that permit standard electrical plugs to be plugged into the ASD **100**. FIG. 17B is a schematic diagram of an ASD **100** that includes extender outlets, according to an illustrative embodiment of the invention. The ASD **100** of FIG. 17B is illustrated as being plugged into an electrical socket such as, for example the electrical socket **1705** of FIG. 17A, that is situated on a wall **1735**. It will be appreciated that the ASD **100** may include any number of extender outlets and that the extender outlets may be situated on any surface of the ASD **100**. As shown in FIG. 17B, the ASD **100** may include two extender outlets **1740**, **1745** on a peripheral surface of the ASD **100** that extends from the front of the ASD **100** to the front surface of the wall **1735**. The extender outlets **1740**, **1745** may be configured in such a manner that the female connections of the extender outlets **1740**, **1745** are situated in a horizontal manner relative to the floor or ceiling of a room. Accordingly, each of the extender outlets **1740**, **1745** may permit an electrical plug that includes a transformer to be inserted without contacting the wall **1735**. It will be

appreciated that the extender outlets **1740, 1745** may be configured in such a manner that their female connections are situated in any manner such as, for example, that of the standard electrical outlet **1705** of FIG. 17A. It will also be appreciated that a destination device **117** may also include one or more electrical outlets.

5 [00196] According to another aspect of the invention, the ASD **100** may be capable of supporting and monitoring more than one flat wire **105**. Multiple flat wires **105** may extend from the ASD **100** to separate destination modules **120** or separate loads **125**. Alternatively or additionally, more than one flat wire **105** may be disposed between the ASD **100** and a destination device **117** or the load **125**, as shown in FIG. 18. Illustrated
10 in FIG. 18 is a schematic diagram of a flat wire system **1801** including an ASD **100** that monitors two flat wires **105, 1805** connected to the same destination device **117**, according to an illustrative embodiment of the invention. For example, as shown in FIG. 18, both a primary flat wire **105** and a secondary flat wire **1805** may extend from the ASD **100** to a destination device **117**. If the ASD **100** detects a wire fault in the
15 primary flat wire **105**, then the ASD **100** may maintain the relay **310** connected to the primary flat wire **105** in its open position, thereby preventing electrification of the primary flat wire **105**. The ASD **100** may then close a relay connected to the secondary flat wire **1805** and allow electrification of the secondary flat wire **1805** in order to power the load **125**. It will be appreciated that the secondary flat wire **1805** may be
20 monitored by the ASD **100** in the same way as the primary flat wire **105**. Additionally, the control unit **312** of the ASD **100** or, alternatively, a safety component of the ASD **100**, may provide an indication of the change to the secondary flat wire **1805** to a user. This indication may be any control action such as activating an LED that indicates the change by the ASD **100** to the secondary flat wire **1805**. Another control action that
25 may be taken is the transmission of a message indicating the change by the ASD **100** to the secondary flat wire **1805**. The message may be transmitted to another ASD **100**, to a central hub or control panel, or to another destination, as will be explained in greater detail below.

[00197] According to another aspect of the invention, an ASD **100** or source device
30 **103** containing an ASD **100** may be used in conjunction with more than one destination device **117** connected in series. FIG. 19 is a schematic diagram of multiple destination devices **117a-n** in a serial configuration being supported by a single source device **103**,

according to an illustrative embodiment of the invention. As shown in FIG. 19, a single source device **103** containing an ASD **100** may monitor a flat wire **105** that runs from the source device **103** to a series of destination devices **117a-n**. Each of the destination devices **117a-n** may be an electrical load such as an outlet assembly or receptacle. This type of configuration may also be referred to as an add-a-receptacle configuration or as a daisy chain configuration. It will be understood that any number of ASD's and/or destination devices may be connected in series.

[00198] As shown in FIG. 19, the flat wire **105** may extend from the source device **103** through each destination device **117a-n**. An input segment of the flat wire **105** may be terminated at each destination device **117a-n** and then a new output segment of flat wire **105** may be used to connect the next destination device **117a-n**. For example, a first segment of flat wire **105** may connect the source module **110** to the destination module **120** of the first destination device **117a**, where the first segment of flat wire **105** is terminated. A separate segment of flat wire **105** may then connect the first destination device **117a** to the second destination device **117b**. This pattern may continue until the flat wire **105** reaches the last destination device **117n**. Alternatively, a single segment of flat wire **105** may be used to connect all of the destination device **117a-n**. Each destination device **117a-n** may be connected to the flat wire **105** with a suitable terminal that connects each conductor of the flat wire **105** to the destination device **117a-n**. Termination points within the destination module **120** and expansion module **122** of each destination device **117**, which are used to connect the flat wire **105** to the destination device **117**, may include terminal blocks, crimp-on terminals, plug and socket connectors, insulation displacement connectors (IDC), conductor penetration connectors (CPC), or any other electrical connector as will be understood by those of ordinary skill in the art.

[00199] Each destination device **117a-n** may include a relay in communication with and controlled by the ASD **100** for passing the signal carried by the flat wire **105** on to the next destination device **117a-n**. For example, the first destination device **117a** may include a relay that passes the electrical power and/or signals carried by the flat wire **105** on to the second destination device **117b**. The flat wire **105** may be relayed through each destination device **117a-n-1** until the flat wire reaches the last destination device **117n**, at which point no relay is necessary. Optionally, each destination device

117 may include a DWI component 340 that is used to test the flat wire 105 extending from the destination device 117 to the next downstream destination device. The relays may be time delay relays, meaning that each of the relays may be actuated or closed after it receives power for a minimum period of time. The period of time that each relay needs to receive power before it is actuated may be a period of time that is sufficient for testing the next downstream segment of flat wire 105 such as, for example, approximately 375 milliseconds. Additionally, the period of time that each relay needs to receive power before it is actuated may be an adjustable period of time. It will be understood that, as an alternative to a relay, each destination module 117a-n may include a control unit or other control logic that is in communication with the ASD 100, and that is used to isolate a flaw in the flat wire 105, as described in greater detail below with reference to destination device 117a-n that include relays.

[00200] Additionally, each of the destination device 117a-n may be in communication with the ASD 100, as described in greater detail below. While the ASD 100 is monitoring the flat wire 105, if a miswire or fault is detected in the flat wire 105, then the miswire or fault may be isolated by the ASD 100 by using the relays. As an example, before the relay 310 of the ASD 100 is closed, the ASD 100 may test the flat wire 105 for miswire or faults. The ASD 100 may first test the first segment of flat wire 105 that runs between the source module 110 and the destination module 120 of the first destination device 117a. If a miswire or fault is detected, then the ASD 100 may maintain the relay 310 in its open position and prevent electrification of the flat wire 105. If no miswire or fault is detected in the first segment of the flat wire 105, then the ASD 100 may test the combined first segment of the flat wire 105 and the second segment of the flat wire 105 that connects the first destination device 117a and the second destination device 117b. If a miswire or fault is detected, then the ASD 100 may prevent electrification of the flat wire 105 or it may transmit a signal to the relay of the first destination device 117a instructing the relay to remain open. The first segment of the flat wire 105 may then be electrified permitting a load connected to the first destination device 117a to receive power; however, none of the destination devices 117b-n connected down the line from the first destination device 117a will receive power. Accordingly, a miswire or fault in the flat wire 105 may be isolated by the ASD 100, and any destination devices 117a-n connected to the ASD 100 prior to the flat wire segment containing the miswire or fault are identified and may be permitted to

receive power. The other flat wire segments may be prevented from receiving power. As another example, if the ASD 100 detects a miswire or fault in flat wire 105 while the flat wire 105 is electrified, the ASD 100 may open its relay 310 and de-energize the flat wire 105. Then, the ASD 100 may use the method described in the example above to isolate the segment of the flat wire 105 in which the miswire or fault occurs, and the ASD 100 may allow electrification of the flat wire 105 up until the segment of the flat wire 105 at which the miswire or fault occurs. As another example, in order to avoid timing delays associated with incremental testing, an entire length of flat wire 105 (or more than a single flat wire segment) may be tested prior to electrifying the flat wire 105. In order to accomplish this, the relays in each of the destination devices 117a-n may be closed and a test signal may be communicated through the flat wire 105 by the ASD 100. If a miswire or fault is detected in the flat wire 105, then the incremental method described above may be utilized to isolate the miswire or fault.

[00201] Alternatively, if each destination device 117a-n includes a DWI component 340, then each destination device 117a-n may test the next downstream segment of flat wire 105 before that segment of flat wire 105 is electrified. The tests performed by the DWI component 340 of each destination device 117a-n may also be used to isolate a miswire or fault in the flat wire 105 and prevent the miswired or faulty segment of flat wire 105 and any downstream flat wire segments from receiving electrical power. As an example, the ASD 100 may first test the first segment of flat wire 105 that runs between the source module 110 and the destination module 120 of the first destination device 117a. If a miswire or fault is detected, then the ASD 100 may maintain the relay 310 in its open position and prevent electrification of the flat wire 105. If no miswire or fault is detected in the first segment of the flat wire 105, then the ASD 100 may allow the first segment of the flat wire 105 to be electrified. Then, the DWI component 340 of the first destination device 117a may test the second segment of the flat wire 105 that connects the first destination device 117a and the second destination device 117b. If a miswire or fault is detected, then the first destination device 117a may prevent electrification of the second segment of the flat wire 105 by opening the relay of the first destination device 117a. If, however, no miswire or fault is detected in the second segment of the flat wire 105, then the first destination device 117a may allow the second segment of the flat wire 105 to be electrified. The destination devices 117b-n downstream from the first destination device 117a may contain the same

functionality as the first destination device **117a**. Accordingly, a miswire or fault in the flat wire **105** may be isolated by the ASD **100** and any destination devices **117a-n** connected to the ASD **100** prior to the miswired or faulty segment of flat wire **105** are identified and may be permitted to receive power. The other flat wire segments are prevented from receiving power. As another example, if the ASD **100** detects a miswire or fault in flat wire **105** while the flat wire **105** is electrified, the ASD **100** may open its relay **310** and de-energize the flat wire **105**. Then, the ASD **100** and the destination devices **117a-n** may use the method described in the example above to isolate the segment of the flat wire **105** in which the miswire or fault occurs, and the ASD **100** and the destination devices **117a-n** may allow electrification of the flat wire **105** up until the segment of the flat wire **105** at which the miswire or fault occurs.

[00202] Additionally, if multiple segments of flat wire **105** are used to connect each destination device **117a-n**, the ASD **100** may cause a switch in each destination device **117a-n** to be toggled in order to route a signal transmitted over the flat wire **105** through a secondary flat wire segment rather than a primary flat wire segment, as described above with reference to FIG. 17. Using the previous example prior to the electrification of the flat wire **105**, if a miswire or fault existed in a segment of flat wire **105** that connected the first destination device **117a** and the second destination device **117b**, then the ASD **100** may cause a switch in the first destination device **117a** to be toggled in order to switch the segment of flat wire that connects the first destination device **117a** and the second destination device **117b** to a secondary segment of flat wire **1805** rather than a primary segment of flat wire **105**. At this point, the ASD **100** and/or the destination devices **117a-n** may resume testing of the flat wire **105** by testing the secondary segment of flat wire **105** that connects the first destination device **117a** and the second destination device **117b**.

[00203] FIG. 20 is a schematic diagram of a system in which multiple source devices **103a-d** form a central device that monitors multiple flat wires **105a-d** in a room, according to an illustrative embodiment of the invention. Each source device **103** may contain an ASD **100**. As shown in FIG. 19, more than one source device **103a-d** may be assembled into a single device that is capable of monitoring multiple branches of flat wire **105a-d** extending from the combined device. Accordingly, the combined device may form a central device that is capable of controlling multiple flat

wire branches **105a-d**. Each of the flat wire branches **105a-d** may be terminated at a destination device **117a-d**. For example, the combined source device **103a-d** may be placed in, on, or near one wall of a room and separate flat wire branches **105a-d** may extend from the combined source device to each wall of the room. The individual ASD's within the combined source device may then monitor one or more of the flat wire branches **105a-d** extending from the combined device. Although the central device of FIG. 19 is depicted as a combination of source devices **103a-d**, it will be appreciated that a single device may be utilized in accordance with embodiments of the invention to monitor multiple flat wire branches **105a-d**.

10 [00204] FIG. 21 is a schematic diagram of flat wire network **2100** that includes a network of source devices **103** monitored by a central hub **2105**, according to an illustrative embodiment of the invention. Each of the source devices **103** may include one or more ASD's **100** capable of monitoring flat wire branches **105** connected to the source devices **103**. A network may be established in which one or more electrical
15 wires **2110**, which may be conventional wire and/or flat wires **105**, are connected between the central hub **2105**, which may be associated with a common circuit breaker box, to each room in a building. Each of these electrical wires **2110** may be connected to a source device **103** in a separate room. Accordingly, each source device **103** may be used as a power center that services an entire room. This method of wiring may be,
20 for example, an inexpensive way to rewire a home where in-wall renovation is not practical, such as in some older homes. Once an electrical wire has been extended from the central hub **2105** to a room, the flat wire **105** becomes an economical and feasible way to distribute power to each of the room's walls or to the room's ceiling or floor. The source devices **103** may act as a power center that services each room by providing
25 a gateway between the electrical wire **2110** and the flat wire **105** branch circuits within the room. Each of the flat wire **105** branch circuits may be connected to one or more destination devices **117**, as previously described. It will also be understood that each of the source devices **103** shown in FIG. 21 may contain a single ASD **100** capable of monitoring one or more flat wire **105** branch circuits or, alternatively, each of the
30 source devices **117** may contain more than one ASD **100** for monitoring flat wire **105** branch circuits, as described with reference to FIG. 20 above.

[00205] Within a room, each source device **103** may service any of the walls, ceiling, and floor with a flat wire **105** branch circuit. Each source device **103** may individually control the flat wire **105** branch circuits to which it is connected.

Additionally, each source device **103** may communicate with branch circuit destination devices **117** over the flat wire **105** in order to monitor circuit safety and electrification status. As previously discussed, the destination devices **117** may include a relay, detection circuitry, and/or a control unit that is in communication with the source device **117** monitoring the flat wire branch circuit **105** to which the destination device **117** is connected. Accordingly, any segment of the flat wire network may be isolated and shut off if a flaw is detected in that segment. Additionally, each source device **117** may be surface mounted on a wall or mounted inside a wall within the room, or situated nearby.

[00206] Each source device **103** also may communicate with a central hub **2105**. The central hub is preferably located near the circuit breaker box or at least in the building. It also is possible, however, for the central hub **2105** to be situated remotely to the building. The central hub **2105** may collect data from each of the source devices **103** and provide safety and electrification status for all of the branch circuits **105** in the building. The central hub **2105** may also be surface mounted or mounted inside a wall.

[00207] If a flat wire **105** miswire or fault is detected on any given branch circuit, then either the central hub **2105** or the source device **103** controlling that branch circuit, or both, may render that branch circuit unusable and isolate it from the other branches. Alternatively a downstream destination device **117** connected to a source device **103** may render the miswired or faulty branch circuit unusable and isolate it from the other branches. In other words, that branch circuit may not be permitted to be electrified. In this manner, a miswired or faulty branch circuit may be rendered unusable while at least a portion of the other branch circuits are not affected. Therefore, a penetration of a flat wire **105** or a miswire of the conductors of a flat wire **105** may only result in power loss in one branch of the flat wire network.

[00208] According to another aspect of the invention, the flat wire **105** may be used to communicate signals. These signals may be communicated between any device in a flat wire network or flat wire branch circuit over the flat wire **105**. For example, with reference to FIG. 20, a signal may be communicated between the ASD **100** in the

source device **103** and any of the destination devices **117a-n** over the flat wire **105**.

Similarly, with reference to FIG. 21, a signal may be transmitted over the flat wire **105** from one source device **103** to another source device **103** or between the central hub **2105** and one of the source devices **103**. It will be understood, however, that devices in a flat wire network or flat wire branch circuit may be in communication with one another through wires, conductors, or optical fiber external to the flat wire **105** or, alternatively, through wireless communication means such as, for example, via a wireless local area network.

[00209] A communications signal may be transmitted over any of the conductors of the flat wire **105**. A separate communications signal may be transmitted over each of the individual conductors of the flat wire **105**. A signal may be communicated onto one or more of the conductors of the flat wire **105** by an excitation circuit such as, for example, the excitation circuit described above with reference to FIG. 9B. The signal may then be identified and read from the one or more conductors of the flat wire **105** by a sense circuit such as, for example, the sense circuit described above with reference to FIG. 9B. As an example, the grounding conductors **220, 225** of the flat wire **105** may be used for communicating signals. The signal communicated across the grounding conductors **220, 225** may be a low voltage signal in the range of approximately 0.1 and 5.0 volts. Additionally, the frequency of a signal communicated across the grounding conductors **220, 225** may be a frequency at or above approximately 1000 Hz. There is normally no voltage or current present on the grounding conductors **220, 225**; therefore, the grounding conductors **220, 225** may beneficially be used to transmit communications signals even when the flat wire **105** has been fully electrified. Similar to the grounding conductors **220, 225**, a communications signal may be transmitted over the return conductors **210, 215** of a flat wire **105**. The signal communicated across the return conductors **210, 215** may be a low voltage signal in a range of approximately 0.1 to 5.0 volts. Additionally, the frequency of a signal communicated across the return conductors **210, 215** may be a frequency at or above approximately 1000 Hz. A signal may be communicated across the conductors of the flat wire **105** while the flat wire **105** is electrified. It will be appreciated that a signal may include an appropriate identifier such as, for example, a signal header that may be utilized to identify the signal and, therefore, prevent false trips by one or more of the safety components of an ASD **100**.

[00210] A communications signal may also be transmitted over the electrifiable conductor **205** of the flat wire **105**. The signal communicated across the electrifiable conductor **205** may be a low voltage signal at a voltage of approximately 0.1 to 5.0 volts. Additionally, the frequency of a signal communicated across the electrifiable conductor **205** may be at a frequency at or above approximately 1000 Hz. A signal may be transmitted over the electrifiable conductor **205** both when the flat wire **105** is electrified and when the flat wire **105** is not electrified. In accordance with the flat wire **105** used in conjunction with the present disclosure, an electrified flat wire **105** may carry a voltage signal of approximately 110-130 volts (for North America applications) or approximately 230-250 volts (for European applications) at a frequency of approximately 50-60 Hertz. A communications signal, however, may still be transmitted over the electrifiable conductor **205** using power line carrier (PLC) or broadband over power line (BPL) technology, as will be understood by those of ordinary skill in the art. A PLC or BPL signal transmitted over the electrifiable conductor **205** may be at a voltage of approximately 0.1 to 20 volts. In an exemplary embodiment, the voltage of the signal transmitted over the electrifiable conductor **205** may be at a voltage of approximately 0.1 to 5 volts. Additionally, a PLC or BPL signal transmitted over the electrifiable conductor **205** may be at a frequency that is greater than approximately one megahertz (MHz). For example, the frequency may be in a range of approximately 2 to 20 MHz, although it will be understood that frequencies up to and greater than approximately 40 MHz may be used in conjunction with the present invention. Additionally, as discussed above, a signal may include an appropriate identifier.

[00211] According to another aspect of the invention, communications signals transmitted over one or more of the conductors of a flat wire **105** may be used to establish communication between devices that are connected by a flat wire **105**. For example, the communications signals may be used to establish communication between two ASD's **100**, between an ASD **100** and a destination device **117**, or between an ASD **100** and a central hub **2105**. Additionally, communication signals may be transmitted over the flat wire **105** by devices that are connected by the flat wire **105** according to a communications protocol. For example, the communications signals may be transmitted via a user datagram protocol (UDP), via a transmission control protocol (TCP), or via another protocol as will be understood by those of ordinary skill

in the art. Additionally, a communications signal may be used to establish a connection between two devices connected by flat wire **105**. The connection established may be point-to-point connection or it may be some other type of connection, such as a peer-to-peer or local area network connection.

- 5 [00212] Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other
- 10 embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

THAT WHICH IS CLAIMED

1. A source device for use with electrical flat wire, comprising:
a line side input configured to connect to a line side power source and receive
5 an electrical power signal from the line side power source;
a flat wire connection configured to connect to an electrical flat wire;
at least one relay configured to control the communication of the electrical
power signal onto the electrical flat wire; and
a control unit configured to test the electrical flat wire for at least one of
10 miswires, wire faults, or abnormal conditions and, based at least in part on the results of
the testing, to control the actuation of the at least one relay.
2. The source device of claim 1, wherein the at least one relay and the control unit
comprise an active safety device.
- 15 3. The source device of claim 1, wherein the control unit is further configured to
test the line side power source for at least one of miswires, wire faults, or abnormal
conditions and to control the actuation of the at least one relay based at least in part on
the testing of the line side power source.
- 20 4. The source device of claim 1, wherein the control unit is associated with at least
one reactive safety component that is utilized in the testing of the electrical flat wire.
5. The source device of claim 4, wherein the at least one reactive safety
25 component tests the electrical flat wire subsequent to the electrification of the electrical
flat wire.
6. The source device of claim 3, wherein the at least one reactive safety
component comprises one or more of a group consisting of a ground fault circuit
30 interrupter, an arc mitigation circuit component, an over-current protection safety
component, and a ground current monitoring safety component.

7. The source device of claim 1, wherein the control unit is associated with at least one proactive safety component that is utilized in the testing of the electrical flat wire.
8. The source device of claim 7, wherein the at least one proactive safety component tests the electrical flat wire prior to the electrification of the electrical flat wire.
9. The source device of claim 7, wherein the at least one proactive safety component comprises one or more of a group consisting of a line side wire integrity component and a load side wire integrity component.
10. The source device of claim 9, wherein the at least one proactive safety component comprises the line side wire integrity component that is configured to identify one or more conductors associated with the line side power source and to determine whether the one or more identified conductors are properly terminated at the line side input.
11. The source device of claim 9, wherein the at least one proactive safety component comprises the load side wire integrity component that is configured to communicate at least one test signal onto at least one conductor of the electrical flat wire, to monitor one or more of the conductors for one or more return signals, and to determine whether a miswire or wire fault exists based upon the one or more return signals.
12. An electrical flat wire system, comprising:
a source device configured to be coupled to a line side power source, wherein the source device comprises an active safety device and a first flat wire termination;
a destination device, wherein the destination device comprises a second flat wire termination; and
an electrical flat wire having a first end coupled to the first flat wire termination and a second end coupled to the second flat wire termination;
wherein the active safety device monitors the electrical flat wire for at least one of miswires, wire faults, or abnormal conditions and, based on the results of the

monitoring, controls the communication of an electrical power signal from the line side power source to the electrical flat wire.

13. The electrical flat wire system of claim 12, wherein the active safety device
5 further monitors the line side power source for miswires and controls the communication of the electrical power signal based at least in part on the results of the monitoring of the line side power source.

14. The electrical flat wire system of claim 12, wherein the destination device
10 further comprises at least one connector that is configured to be coupled to at least one electrical load.

15. The electrical flat wire system of claim 11, wherein the active safety device is associated with at least one reactive safety component utilized in the testing of the
15 electrical flat wire.

16. The electrical flat wire system of claim 15, wherein the at least one reactive safety component comprises one or more of a group consisting of a ground fault circuit interrupter, an arc mitigation circuit component, an over-current protection safety
20 component, and a ground current monitoring safety component.

17. The electrical flat wire system of claim 12, wherein the active safety device is associated with at least one proactive safety component utilized in the testing of the electrical flat wire.
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18. The electrical flat wire system of claim 17, wherein the at least one proactive safety component comprises at least one of a group consisting of a line side wire integrity component and a load side wire integrity component.

30 19. A method for monitoring an electrical flat wire terminated between a source and a destination, comprising:
testing one or more conductors of the electrical flat wire for at least one of miswires, wire faults or abnormal conditions; and

controlling communication of an electrical power signal from a power source to the electrical flat wire based at least in part on results of the testing.

20. The method of claim 19, wherein testing the one or more conductors of the electrical flat wire comprises testing the one or more conductors of an electrified flat wire, and further comprising:

identifying at least one wire fault or abnormal condition on the one or more conductors; and

in response to identifying at least one wire fault or abnormal condition, de-energizing the electrical flat wire by ceasing the communication of the electrical power signal onto the electrical flat wire.

21. The method of claim 20, wherein identifying the abnormal condition comprises identifying a current signal on an electrifiable conductor of the electrical flat wire that is greater than a predetermined threshold value.

22. The method of claim 20, wherein identifying the abnormal condition comprises identifying a current signal on a grounding conductor of the electrical flat wire.

23. The method of claim 20, wherein identifying the abnormal condition comprises identifying a current differential between an electrifiable conductor of the electrical flat wire and one or more return conductors of the electrical flat wire that is greater than a predetermined threshold value.

24. The method of claim 19, wherein testing the one or more conductors of the electrical flat wire comprising testing the one or more conductors of the electrical flat wire prior to communicating the electrical power signal onto the flat wire.

25. The method of claim 24, wherein testing the one or more conductors of the electrical flat wire comprises:

communicating at least one test signal onto at least one conductor of the electrical flat wire; and

monitoring at least one of the one or more conductors of the electrical flat wire for a return signal.

26. The method of claim 19, further comprising:
monitoring the power source for at least one miswire; and
controlling the communication of the electrical power signal from the power
5 source to the electrical flat wire based at least in part on the results of the monitoring.

27. An active safety device for use with electrical flat wire, comprising:
at least one relay configured to control the communication of an electrical
power signal from a line side power source associated with the active safety device
10 onto an electrical flat wire that is connected between a source device and a destination
device; and
a control unit configured to test the electrical flat wire for at least one of
miswires, wire faults, or abnormal conditions and, based at least in part on the results of
the testing, to control the actuation of the at least one relay;
15 wherein the control unit is associated with at least one safety component utilized
in the testing of the electrical flat wire.

28. The active safety device of claim 27, wherein the control unit is further
configured to test the line side power source for at least one of miswires, wire faults, or
20 abnormal conditions and to control the actuation of the at least one relay based at least
in part on the testing of the line side power source.

29. The active safety device of claim 27, wherein the at least one safety component
comprises at least one reactive safety component that tests the electrical flat wire
25 subsequent to the electrification of the flat wire.

30. The active safety device of claim 27, wherein the at least one safety component
comprises at least one proactive safety component that tests the electrical flat wire prior
to the electrification of the flat wire.