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GROUND CABLE MONITORING SYSTEM AND METHOD OF USING

Abstract

A smart grounding clamp system includes a grounding clamp, the grounding clamp having a clamp member and a cable member. The smart grounding clamp monitoring system further includes a sensor module mechanically coupled to the grounding clamp and having at least one sensor configured to sense an environmental condition of the grounding clamp and a communication module communicatively coupled with the at least one sensor. The smart grounding clamp monitoring system also includes a base station positioned remotely from the grounding clamp and communicatively coupled to the communication module.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This patent application is a Non-Provisional Application that claims priority to and the benefit of U.S. Provisional Patent Application No. 63/552,976, filed on Feb. 13, 2024, entitled “Electrical Cable Monitoring System and Method of Using,” the entire contents of which is incorporated herein by reference for all purposes.

BACKGROUND
[0002] In an industrial setting, the dangers associated with grounding clamps being inadvertently moved, disconnected, or being inadvertently connected to equipment when the equipment is energized without proper communication and coordination can be severe. Grounding clamps play a crucial role in dissipating electrical charges and ensuring the safety of both personnel and equipment. Routinely, one crew of workers will be responsible for connecting the grounding clamps to a piece of equipment to initiate some type of work on the equipment, and a separate crew of workers finishes the work later in the day. In such situations, it is common for one or more clamps to be inadvertently left connected to equipment when the second crew of workers finishes the work and energizes the equipment, resulting in severe damage to the equipment. In other situations, one crew completes the entire job from start to finish, but through fatigue or otherwise, they mistakenly believe that all clamps have been removed when one or more clamps were left connected. When these clamps are moved, disconnected, or left connected when equipment is energized without informing all individuals involved in the work it can leave equipment and people vulnerable to electrical hazards. Without a reliable ground, even a seemingly routine task can turn into a high-risk operation, with the potential for electrostatic discharge, electrical shocks, or even fires.
[0003] One significant danger of improperly handling grounding clamps is the risk of electrostatic discharge. When equipment is not adequately grounded, static electricity can build up on surfaces and components. If this charge is suddenly released, it can result in sparks or electrostatic discharge events. These sparks can ignite flammable materials, damage sensitive electronics, or, in certain environments, cause explosions. In addition, electrostatic discharge can pose a risk to personnel, leading to electrical shocks or injuries. When grounding clamps are inadvertently moved or disconnected without proper communication, the risk of electrostatic discharge significantly increases, putting both equipment and individuals in harm's way.
[0004] Another critical danger arises from the potential for uncontrolled electrical surges and overloads when grounding clamps are mishandled. Proper grounding helps dissipate excess electrical charges to the ground, preventing the buildup of voltage in a circuit or equipment. If a clamp is inadvertently moved or disconnected during work, the protective grounding path is interrupted, leaving the system vulnerable to voltage spikes. These surges can damage sensitive equipment, disrupt processes, and pose a risk to personnel. Without proper communication and coordination in such situations, the consequences can be dire, potentially leading to costly equipment failures, production delays, and, most importantly, jeopardizing the safety of workers within the industrial environment.
SUMMARY OF THE INVENTION
[0005] According to a first aspect a smart grounding clamp system includes a grounding clamp, the grounding clamp having a clamp member and a cable member. The smart grounding clamp system also includes a sensor module mechanically coupled to the grounding clamp and having at least one

sensor configured to sense an environmental condition of the grounding clamp and a communication module communicatively coupled with the at least one sensor. The smart grounding clamp system further includes a base station positioned remotely from the grounding clamp and communicatively coupled to the communication module.
[0006] According to many embodiments, the at least one sensor is an accelerometer configured to sense a change in the position of the grounding clamp.
[0007] In some embodiments, the at least one sensor is a partial discharge sensor.
[0008] According to other embodiments, the at least one sensor is an infrared sensor configured to sense a movement.
[0009] In other embodiments, the smart grounding clamp system further includes a camera sensor configured to capture at least one photograph in response to the infrared sensor sensing the movement.
[0010] According to some other embodiments, the smart grounding clamp system further includes a storage module communicatively coupled to the camera sensor and is configured to store at least one photograph captured by the camera sensor.
[0011] In many embodiments, the base station further includes an external communication module configured communicate with an external device.
[0012] According to many other embodiments, the grounding clamp is a plurality of grounding clamps and the communication module of a first grounding clamp of the plurality of grounding clamps can communicate with the communication module of a second grounding clamp of the plurality of grounding clamps.
[0013] In some embodiments, the communication module is further configured to communicate with an external device.
[0014] According to some embodiments, the base station further includes a display configured to display a status of the grounding clamp.
[0015] According to a second aspect a smart grounding clamp system includes a plurality of grounding clamps, the plurality of grounding clamps each having at least one clamp member and a cable member. The smart grounding clamp system further includes a sensor module mechanically coupled to the at least one clamp member and having at least one sensor, a communication module communicatively coupled with the at least one sensor, and a power module configured to provide power to the at least one sensor and the communications module. The smart grounding clamp system also includes a base station positioned remotely from the plurality of grounding clamps and communicatively coupled to each of the communication modules.
[0016] According to many embodiments, the power module is a replaceable battery.
[0017] In some embodiments, the sensor module is positioned within a waterproof enclosure.
[0018] According to some other embodiments, the at least one sensor is an accelerometer configured to sense a change in the position of the grounding clamp.
[0019] In many embodiments, the at least one sensor is an infrared sensor configured to sense a movement near the infrared sensor.
[0020] According to some embodiments, the at least one sensor is a partial discharge sensor.
[0021] According to a third aspect a method of manufacturing a smart grounding clamp system, includes the step of providing a grounding clamp, the grounding clamp having a clamp member and a cable member. The method further includes the step of mechanically coupling a sensor module to the grounding clamp, the sensor module having at least one sensor configured to sense an environmental condition of the grounding clamp and a communication module communicatively coupled with the at least one sensor. The method finally includes the step of providing a base station configured to be positioned remotely from the grounding clamp and communicatively coupled to the communication module.
[0022] According to many embodiments, the at least one sensor is an accelerometer configured to sense a change in the position of the grounding clamp.

[0023] In many embodiments, the at least one sensor is an infrared sensor configured to sense a movement near the infrared sensor.
[0024] According to some embodiments, the at least one sensor is a partial discharge sensor.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0025] The disclosure will become more fully understood from the following detailed description, taken in conjunction with the accompanying figures, wherein like reference numerals refer to like elements, in which:
[0026] FIG. **1** is a diagram of the ground clamp monitoring system.
[0027] FIGS. **2**A-**2**B depict a top perspective view of an embodiment of a ground clamp and a multi-clamp ground clamp respectively.
[0028] FIG. **3** depicts a block diagram of a sensor module.
[0029] FIG. **4** depicts a front perspective view of a base station.
[0030] FIG. **5** depicts a block diagram of a central communications module.
[0031] FIG. **6** depicts a front side perspective view of a lock box.
[0032] FIG. **7** depicts a block flow diagram of a method of manufacturing a ground clamp monitoring system.
[0033] FIG. **8** depicts a block flow diagram of a method of operating a ground clamp monitoring system.
[0034] The drawings are not necessarily to scale and certain features may be shown exaggerated in scale or in somewhat schematic form in the interest of clarity and conciseness.
DETAILED DESCRIPTION
[0035] Grounding clamps, shorting straps, and other devices or components for transmitting electrical current to ground aid to mitigate risks in the workplace and knowing which grounding camps **10** are still in service and which are not are important for the operations and safety of a work site. Moreover, of the grounding clamps **10** that are in service, knowing which ones may have been disconnected and may require an inspection is similarly important for the safety and operability of the work site. As multiple grounding clamps **10** may be connected and in service across a work site, having the ability to check at a single location, such as a base station **12**, which grounding clamps **10** are still connected and which may not be and thus may require inspection is valuable to increasing the efficiency of the work site. To increase the probability that a base station **12** will be in range of all of the grounding clamps **10** at the work site, the grounding clamps **10** are capable of forming a mesh network such that each grounding clamp can receive the messages from another grounding clamp **10** and subsequently pass that message either directly to the base station **12** or to another grounding clamp **10** that is within range of the base station **12**. In this manner, a single base station **12** is capable of accounting for grounding clamps **10** that the base station **12** is not within range of.
[0036] Embodiments disclosed herein describe a ground clamp monitoring system **100** and methods for manufacturing and operating the same. As shown in FIG. **1**, a ground clamp monitoring system **100** includes at least one ground clamp **10** coupled to a clamp sensor module **20**. The clamp sensor module **20** is configured to sense or detect various environmental conditions that relate to a status of the ground clamp **10** and communicate the same to a base station **12**. The base station **12** is similarly configured to communicate the status of the ground clamp **10** and/or the environmental condition that relates to the status of the ground clamp **10** to an external device **14** directly or to an external server such that the status or environmental condition can be accessed by an external device **14**.
[0037] Reference is now made to FIGS. **2**A-**2**B, which depict embodiments of a ground clamp **10**

and multi-clamp ground clamp **40**. The ground clamp **10** includes a clamp portion or clamp member **16** electrically coupled to a cable portion or cable member **18** on either end of the cable member **18**. In use, one cable member **16** will be clamped onto or otherwise electrically coupled to a source of electrical ground while the clamp member **16** that is positioned about the opposed end of the cable member **18** will be clamped onto or otherwise electrically coupled to a piece of machinery that is being worked on. Each clamp member **16** is also mechanically coupled to a clamp sensor module **20**, which will be discussed in further detail below. As shown in FIG. **2**B, a multi-clamp ground clamp **40** is functionally similar to the ground clamp **10** with the difference being that the multi-clamp ground clamp **40** can clamp or electrically couple multiple pieces of machinery, or multiple pieces of the same piece of machinery, to a single ground point. The multi-clamp ground clamp **40** includes a plurality of cable members **18** that are coupled together at the ground plate **15** on an end of the cable member **18** and having a respective clamp member **16** coupled to the opposed end of the cable member **18**. It should be understood, that while the clamp sensor module **20** is presently depicted as being mechanically coupled to the clamp member **16**, other embodiments are also envisioned. For example, the clamp sensor module **20** may be mechanically coupled to the cable member **18** or any other suitable or desirable portion of the clamp member **10**.

[0038] It should be understood, that while cable member **18** is presently depicted as a rounded cable, characterized by multiple strands of wire twisted together, providing flexibility and adaptability for various applications, other configurations are also envisioned. For example, cable member **18** can be a flat stranded cables or straps, which consist of wide, flat conductors, offering an expansive contact area suitable for grounding large equipment. As another example, cable member **18** can be a braided cable which is composed of woven or braided strands, combining flexibility with enhanced conductivity. As another example, cable member **18** can be a tape or ribbon cable which features a flat, ribbon-like structure, catering to low-profile design requirements or environments with spatial limitations. As yet another example, cable member **18** can be a bus bar which is a rigid conductor in the form of a bar or strip and well-suited for grounding in electrical panels, the bus bars may be formed of copper, aluminum, or any other suitable or desirable material. As another example, cable member **18** can be a spiral or helical cable which exhibits a helical or spiral configuration, facilitating flexibility and simplifying installation. As another example, cable member **18** can be any suitable or desirable shape for electrical grounding or otherwise transmitting electrical current or voltage therethrough.

[0039] Ground clamp **10** may also be configured as or referred to as bonding clamps, grounding connectors, or earthing clamps, may be known by various names such as grounding straps, shorting straps, shorting clips, or equipotential bonding clamps. Other terms and configurations include grounding latches, cable bonding clamps, and static grounding clamps. Ground clamp **10** may also be configured as or referred to as earth clamps, grounding bridges, or strap clamps, emphasizing their role in establishing a connection between electrical equipment and the ground for safety and operational purposes. The terms used may vary regionally or within specific industries, reflecting preferences, standards, and the nature of the application.

[0040] Reference is now made to FIG. **3**, which depicts an embodiment of a clamp sensor module **20**. As shown, a clamp sensor module **20** includes an enclosure **21**, a clamp communications module **22**, a sensor **24** and a clamp power supply **26**. The enclosure **21** is sized and shaped to contain the clamp communications module **22**, the sensor **24** and the clamp power supply **26** in the interior of the enclosure **21**. The enclosure **21** is also configured to be generally weather-tight such that the ground clamp **10** can operate in outdoor environments largely unimpeded. In many embodiments, the enclosure **21** is an intrinsically safe enclosure such that it satisfies class **1** division **1** ratings for enclosures under the National Electrical Code (“NEC”) or other rating such as NEC class **1** division **2** or other suitable ratings for electrical enclosures operating in environments where ignitable hydrocarbons or other substances may be present. In other embodiments, the

enclosure **21** is fully waterproof and submersible such that the enclosure can be submerged in puddles or other bodies of water without allowing for an ingress of water into the interior of the enclosure **21**.

[0041] In many embodiments, the sensor module **20** is configured to be a retrofit application that can be fitted to grounding clamps that previously did not include a sensor module **20**. In such embodiments, the enclosure **21** can include mounting points to facilitate mounting of the enclosure **21** to a component of a ground clamp **10** or multi-clamp ground clamp **40** that was not designed or manufactured to facilitate the mounting of the enclosure thereto. Such mounting of the enclosure **21** can be accomplished with one or more zip ties, hook and loop straps, or any other form of suitable permanent or temporary fastening system or combination of fastening systems.

[0042] With continued reference to FIG. **3**, the sensor **24** is positioned within the interior of the enclosure **21** and is configured to sense an environmental condition that relates to the status of the ground clamp **10**. The sensor **24** can be a movement sensor, such as an accelerometer, configured to sense if the ground clamp **10** has been moved since it was placed in service. The sensor **24** can be a position or location sensor, such as GPS receiver, configured to sense what is the position of the ground clamp **10** or if the ground clamp **10** has changed its position since it was placed in service. In implementations that utilize a GPS receiver sensor **24**, to save or conserve power in the power supply **26**, the location of the ground clamp **10** can be set to only update its location once a day. It should be understood that the GPS receiver sensor **24** can be configured to update the location of the ground clamp **10** once a shift, once a week, on demand, or any other suitable or desirable time period between location updates. A user can also request that the GPS receiver sensor **24** update the location of the ground clamp remotely from the external device **14** or the base station **12**. The location data provided by the GPS receiver sensor **24** can be accessed at the base station **12** or remotely from external device **14**. Knowing the location of the ground clamp **10** can aid in loss prevention and asset recovery operations in the event that a ground clamp **10** is lost or stolen. in some embodiments, the sensor **24** can be a Radio-Frequency Identification (“RFID”) tag. The RFID sensor **24** can be a passive RFID sensor **24**, such that it is not electrically coupled to the power source **26**, or an active RFID sensor **24** that is electrically coupled to and draws power from the power source **26**. For implementations that utilize RFID sensors **24**, a user can enter the work area with a RFID reader and be notified of any and all ground clamps **10** still present in the area.

[0043] The sensor **24** can be a visual sensor, such as a camera configured to capture still or static photographs or a video-camera configured to capture video. The sensor **24** can be a humidity or moisture sensor. The sensor **24** can also be an infrared motion sensor, or other motion sensor, configured to detect if there is motion in the vicinity of the ground clamp **10**. The sensor **24** can also be a temperature sensor, such as a thermocouple, configured to sense or detect changes in the temperature about the proximity of the sensor **24**, such as a fire, controlled or uncontrolled ignition, or other change in temperature. The sensor **24** can also be a combination of sensors such as a camera coupled to an infrared motion sensor in a manner such that when the infrared motion sensor senses a motion in the vicinity of the ground clamp **10**, the infrared motion sensor causes the camera to capture a picture or photograph of the person or thing that is moving in the vicinity of the ground clamp **10**. In many embodiments that utilize a visual sensor **24**, the photograph or video clip captured can be processed through facial recognition process to determine or recognize the individual in the photograph or video clip. Such facial recognition processes can aid in the prevention of theft, vandalism, both, and other undesirable acts committed to the ground clamp **10**. The facial recognition processes can be performed by the base station **12** or on the external device **14**.

[0044] The ground clamp **10** status relates to its physical position and/or connection two pieces of machinery as the ground clamp **10** is deployed in the field. For example, a ground clamp **10** that is not in service or otherwise not connected to any piece of machinery or ground may have a status of “out of service,” while a ground clamp **10** that was recently put into service and has not moved or

has been otherwise disturbed since it was put into service may have a status of “in service.” If the sensor **24** senses or detects that the ground clamp **10** may have been moved, jostled, disturbed, had its position changed, or has sensed movement in in its vicinity, or any other combination of change and the ground clamp's **10** environmental conditions, the status may change to “verify if still in service.” it should be understood that while only three different statuses are discussed here other statuses are also envisioned, for example the status may be “small movement detected,” or “small position change detected,” or “partial discharge detected.” In many embodiments, the status relates to the environmental condition sensed by sensor **24**.

[0045] With continued reference to FIG. **3**, the status indicator **23** can be a visual indicator such as an LED light that is configured to flash or illuminate a certain color or in a certain pattern when the status of the ground clamp **10** changes. The status indicator **23** can also be an audio indicator such as a speaker configured to provide an audible alarm when the status of the ground clamp **10** changes. In many embodiments, the status indicator **23** can include both a visual indication component and an audible indication component. The status indicator **23** is communicatively coupled to the sensor **24** such that when the sensor **24** senses or detects a change in the status of the ground clamp **10**, the status indicator **23** can provide the appropriate status indication. The status indicator **23** can also be communicatively coupled to the clamp communications module **22** such that the status indicator **21** can be controlled or adjusted from the base station **12**. For example, if the status indicator **23** is providing a visual indication of a blinking LED light, a user can also activate the audible indication remotely from the external device **14** or the base station **12**. Similarly, if the status indicator **23** is providing an indication (visual, audible, or otherwise), the base station **12** can clear or silence the status indicator **21** such that no indication is provided.

[0046] The clamp communications module **22** is communicatively coupled to the sensor **24** and configured to primarily communicate with the central communications module **30** of the base station **12**. In this manner, the clamp communications module **22** will update the central communications module **30** with the status of the ground clamp **10** on regular intervals such as once every hour, once every day, or any other suitable interval. The clamp communications module **22** can also be configured to update the central communications module **30** with the status of the ground clamp **10** anytime that the sensor **24** senses an environmental condition that may alter or change the status of the ground clamp **10** or anytime a user requests an update at the base station **12** or through an external device **14**.

[0047] In some embodiments, the clamp communications module **22** may be out of range and not able to communicate directly with the central communications module **30**. In such embodiments, the clamp communications module may send its update to another clamp communications module **22** of a separate ground clamp **10** that is still in range. In this manner, the ground clamps **10** can create a mesh network with one another such that so long as one ground clamp **10** is within communication range of the base station **12** (such that the clamp communications module **22** can't communicate with the local communications module **34**), all communications from a plurality of ground clamps **10** can be routed through other surrounding ground clamps **10** to provide the status update to the local communications module **34** of the base station **12**. This mesh network can also act in the reverse such that over the air updates or other communications originating from the local communications module **34** can be sent either directly to the communications module **22**, if it is in range of the local communications module **34**, or routed through the mesh network created by a plurality of communications modules **22**. In this manner, all ground clamps **10** receive the update, message, or other communication from the local communications module **34**. In many embodiments, the clamp communications module **22** is a radio transceiver configured for transmitting and receiving data according to various communication protocols such as Wi-Fi, Bluetooth, Zigbee, or any other suitable wireless communications protocol. As shown in FIG. **1**, the clamp communications module **22** can also be configured to communicate directly with the external server or external device **14** if the clamp communications module **22** is in range of a

compatible internet connection.
[0048] With continued reference to FIG. **3**, the power supply **26** is positioned within the enclosure **21** and is electrically coupled or otherwise configured to provide electrical power to both the communications module **22** and sensor **24**. The power supply **26** can be standard batteries of any suitable size such as, AA batteries, AAA batteries, cordless tool batteries, or any other suitable battery size. In other embodiments, the power supply **26** is electrically coupled to an external battery charger or other power source such as a solar panel to ensure that the power supply **26** of the sensor module **20** does not prematurely run out of power.
[0049] Reference is now made to FIG. **4**, which depicts a front perspective view of an embodiment of a base station **12**. A base station **12** includes a base member **28** and a central communications module **30**. The base station **12** is generally positioned remotely from the ground clamps **10** in the system in a location where the central communications module **30** can send and receive a signal through a wireless or wired data connection. The central communications module **30** of the base station **12** is configured to receive communications from the various communication modules **22** of each respective ground clamp **10** regarding the status of the respective ground clamp **10** or data gathered by or sensed by the respective sensor **24**. It should be understood, that while the base member **28** is depicted as a tri-pod in FIG. **4**, alternate embodiments are also envisioned. For example, the base member **28** can be a flat plate with a central rod or pole extending from the plate, or any other configuration that suitably supports the central communications module **30**.
[0050] Reference is now made to FIG. **5**, Which depicts a central communications module **30**. The central communications module **30** includes a local communications module **32**, an external communications module **34**, a base power supply **36**, and a memory **37**. The local communications module **32** is configured to communicate with, receive status updates from, send over the air upgrades, or any other suitable information to each of the ground clamp communication modules **22**. The local communications module **32** is configured to monitor the mesh network created by the plurality of ground clamps **10** and their respective ground clamp communication modules **22**. If the local communications module **32** detects or recognizes a fault or problem with one or more of the ground clamps **10** that are affecting the mesh network, then the local communications module **32** can send an alert to the external communications module **34** to provide the alert directly to the external device **14**. The alert can also be shown or displayed on the central communications module **30** by a visual indicator such as a light or other visual indicator indicating that a fault has been detected by blinking, illuminating a different color such as red, or any other suitable visual indication.
[0051] The external communications module **36** is communicatively coupled to the local communications module **34** and is electrically coupled or otherwise draws power from the base power supply **32**. The external communications module **36** is configured to communicate with or otherwise update an external server or external device **14** with the current status or recent change in status of the ground clamp **10**. From the external device **14**, a user can view the current status of all of the ground clamps **10** that are connected to a single base station **12** without having to go out and physically inspect the ground clamp **10** to ensure that it is still properly in service or is out of service. Through the external device **14**, a user can view and update the status of the ground clamps **10** remotely. It should be understood that the external device **14** can be a smartphone, tablet, laptop computer, desktop computer, or any other device configured to communicate with the external communications module **36** or receive updates from the external communications module **36** via the internet. As such, a user can access the status of any ground clamp **10** that is connected to the internet or external server, directly through the clamp communications module **22** or indirectly through the base station **12**, from anywhere in the world that the external device **14** can connect to the internet. For example, a user can access the status of a particular grouping of ground clamps **10** from an external device **14**, such as a laptop, within an office building located proximate to the work area where the ground clamps **10** are being utilized. As another example, the user can access

the status of a particular grouping of ground clamps **10** from an external device **14**, such as a smartphone, while attending a trade show located hundreds of miles from the work area where the ground clamps **10** are being utilized.

[0052] The memory **37** is communicatively coupled to the local communications module **34** and the external communications module **36**, and also electrically coupled to the base power supply **32**. The memory **37** is configured to store or record a log of activity related with each sensor module **20** and its respective ground clamp **10**. Such activity can include the credentials or identity of the user who has accessed or caused a change in the status of the ground clamp **10**. Such activity can also include a log of the locations of the ground clamp **10**, whether the ground clamp **10** is connected to a piece of equipment or not, which piece of equipment the ground clamp **10** was installed on, which operator installed the ground clamp **10** onto the piece of equipment, or any other suitable or desirable activity can be logged and stored in memory **37**. Memory **37** can also be configured to keep a running log of all activity related to a specific ground clamp **10**, including activity that is not relatively recent for record keeping and auditing purposes. Such information can aid in loss prevention and asset recovery operations as well as troubleshooting and root-cause failure analyses by providing detailed user, use, location, or any other information capable of being stored in memory **37** for a particular ground clamp **10**. The external communications module **36** can also be configured to update the external server or external device **14** with the log of activity stored or recorded in memory **37**. In some implementations, memory **37** is configured to upload or update the external server with all of the data stored thereon when memory **37** has almost reached its data storage capacity and then purge the data stored locally on memory **37**. For such implementations, the action of purging data presently stored on memory **37** ensures that there is capacity to store new updates to activity.

[0053] with continued reference to FIG. **5**, the base power supply **32** is electrically coupled or otherwise configured to provide electrical power to the local communications module **34**, the external communications module **36**, and memory **37**. The base power supply **32** is either directly connected to an external consistent power supply or is a standalone battery. In embodiments where the base power supply **32** is a battery, the batteries can be standard batteries of any suitable size such as, AA batteries, AAA batteries, cordless tool batteries, or any other suitable battery size. In other embodiments, the base power supply **32** is electrically coupled to an external battery charger or other power source such as a solar panel to ensure that the base power supply **32** of the base communications module **30** does not prematurely run out of power.

[0054] In many embodiments, the base member **28** can be disconnected or uncoupled from the central communications module **30**. In such embodiments, the central communications module **30** can be placed on a stable surface such as a table or other suitable support structure.

[0055] In some embodiments, the base station **12** can include a display that is configured to display the status of the various ground clamps **10** or data gathered by or sensed by sensor **24** of a particular ground clamp. In such embodiments, the display can be configured to depict a list of the status of all ground clamps **10** associated with the base station **12**. However, alternative embodiments are also envisioned, for example, the display of the base station **12** can also be configured to show the status of only a single ground clamp **10** at one time while also showing more detailed information about the specific ground clamp **10**. Such detailed information can include when the ground clamp **10** was placed in service, when the ground clamp **10** was last moved, what was the last recorded data for the sensor **24** of the ground clamp **10**, and any other set or subset of information that the operator may deem suitable.

[0056] Reference is now made to FIG. **6**, which depicts a front side perspective view of an embodiment of a lock box **11** shown in FIG. **1**. A lock box **11** includes a sensor module **20** as described above and throughout this disclosure. The lock box **11** can have the sensor module **20** fully integrated into a structural side or component of the lock box **11**. The lock box **11** can also be a common lock box **11** with the sensor module **20** retrofitted to the lock box **11**. In such

embodiments that utilize a lock box **11** in the system **100**, the lock box **11** can aid in expanding the geographic scope of the mesh network, aid in strengthening the mesh network, or both by acting as another point that can receive and transmit messages from surrounding sensor modules **20**. The status of the lock box **11** can be whether the lock box **11** is locked, unlocked, open, closed, or any other suitable status. The lock box **11** is otherwise configured to function as a standard lock out tag out ("LOTO") box with a master key stored in the interior of the lock box **11** and points for workers to hang or affix personal locks, work-group locks, or any other suitable lock on the exterior of the lock box **11** such that the lock box **11** cannot be opened to access the master lock without the removal of the exterior locks thereon. From the base station **12** or external device **14**, a user can request that the sensor module **20** of the lock box **11** (or ground clamp **10**) update its status such that the user can see the present status of the lock box **11**.

[0057] Reference is now made to FIG. **7**, which depicts a block flow diagram of a method **700** of manufacturing a ground clamp monitoring system **100**. The method **700** includes step **702**, providing a grounding clamp, the grounding clamp having a clamp member and a cable member. The method **700** further includes step **704**, mechanically coupling a sensor module to the grounding clamp, the sensor module having at least one sensor configured to sense an environmental condition of the grounding clamp and a communication module communicatively coupled with the at least one sensor. The method **700** finally includes step **706**, providing a base station configured to be positioned remotely from the grounding clamp and communicatively coupled to the communication module.

[0058] Reference is now made to FIG. **8**, which depicts a block flow diagram of a method **800** of operating a ground clamp monitoring system **800**. The method includes step **802**, providing a grounding clamp, the grounding clamp having a sensor module mechanically coupled to the grounding clamp and having at least one sensor. The method **800** further includes step **804**, providing a base station communicatively coupled to the sensor module. The method **800** further includes step **806**, positioning the grounding clamp remotely from the base station. The method **800** further includes step **808**, sensing an environmental condition by the at least one sensor. The method **800** further includes step **810**, communicating the environmental condition to the base station.

[0059] Although embodiments of a ground clamp monitoring system **100** apparatus and method have been described in detail, those skilled in the art will also recognize that various substitutions and modifications may be made without departing from the scope and spirit of the appended claims.

[0060] In the foregoing description of certain embodiments, specific terminology has been resorted to for the sake of clarity. However, the disclosure is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes other technical equivalents which operate in a similar manner to accomplish a similar technical purpose. Terms such as "left" and "right," "front" and "rear," "above" and "below" and the like are used as words of convenience to provide reference points and are not to be construed as limiting terms.

[0061] In this specification, the word "comprising" is to be understood in its "open" sense, that is, in the sense of "including," and thus not limited to its "closed" sense, that is the sense of "consisting only of." A corresponding meaning is to be attributed to the corresponding words "comprise," "comprised" and "comprises" where they appear.

[0062] In addition, the foregoing describes some embodiments of the disclosure, and alterations, modifications, additions and/or changes can be made thereto without departing from the scope and spirit of the disclosed embodiments, the embodiments being illustrative and not restrictive.

[0063] Furthermore, the disclosure is not to be limited to the illustrated implementations, but to the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the disclosure. Also, the various embodiments described above may be implemented in conjunction with other embodiments, e.g., aspects of one embodiment may be

combined with aspects of another embodiment to realize yet other embodiments. Further, each independent feature or component of any given assembly may constitute an additional embodiment.

Claims

1. A smart grounding clamp system comprising: a grounding clamp, the grounding clamp having a clamp member and a cable member; a sensor module mechanically coupled to the grounding clamp and having at least one sensor configured to sense an environmental condition of the grounding clamp and a communication module communicatively coupled with the at least one sensor; and a base station positioned remotely from the grounding clamp and communicatively coupled to the communication module.
2. The smart grounding clamp system of claim 1, wherein the at least one sensor is an accelerometer configured to sense a change in a position of the grounding clamp.
3. The smart grounding clamp system of claim 1, wherein the at least one sensor is a partial discharge sensor.
4. The smart grounding clamp system of claim 1, wherein the at least one sensor is an infrared sensor configured to sense a movement.
5. The smart grounding clamp system of claim 4, further comprising a camera sensor configured to capture at least one photograph in response to the infrared sensor sensing the movement.
6. The smart grounding clamp system of claim 5, further comprising a storage module communicatively coupled to the camera sensor and is configured to store the at least one photograph captured by the camera sensor.
7. The smart grounding clamp system of claim 1, wherein the base station further includes an external communication module configured communicate with an external device.
8. The smart grounding clamp system of claim 1, wherein the grounding clamp is a plurality of grounding clamps and the communication module of a first grounding clamp of the plurality of grounding clamps can communicate with the communication module of a second grounding clamp of the plurality of grounding clamps.
9. The smart grounding clamp system of claim 1, wherein the communication module is further configured to communicate with an external device.
10. The smart grounding clamp system of claim 1, wherein the base station further includes a display configured to display a status of the grounding clamp.
11. A smart grounding clamp system comprising: a plurality of grounding clamps, the plurality of grounding clamps each having at least one clamp member and a cable member; a sensor module mechanically coupled to the at least one clamp member and having at least one sensor, a communication module communicatively coupled with the at least one sensor, and a power module configured to provide power to the at least one sensor and the communications module; and a base station positioned remotely from the plurality of grounding clamps and communicatively coupled to each of the communication modules of the plurality of grounding clamps.
12. The smart grounding clamp system of claim 11, wherein the power module is a replaceable battery.
13. The smart grounding clamp system of claim 11, wherein the sensor module is positioned within a waterproof enclosure.
14. The smart grounding clamp system of claim 11, wherein the at least one sensor is an accelerometer configured to sense a change in a position of the respective grounding clamp.
15. The smart grounding clamp system of claim 11, wherein the at least one sensor is an infrared sensor configured to sense a movement near the infrared sensor.
16. The smart grounding clamp system of claim 11, wherein the at least one sensor is a partial discharge sensor.

17. A method of manufacturing a smart grounding clamp system, the method comprising: providing a grounding clamp, the grounding clamp having a clamp member and a cable member; mechanically coupling a sensor module to the grounding clamp, the sensor module having at least one sensor configured to sense an environmental condition of the grounding clamp and a communication module communicatively coupled with the at least one sensor; and providing a base station configured to be positioned remotely from the grounding clamp and communicatively coupled to the communication module.

18. The method of claim 17, wherein the at least one sensor is an accelerometer configured to sense a change in a position of the grounding clamp.

19. The method of claim 17, wherein the at least one sensor is an infrared sensor configured to sense a movement near the infrared sensor.

20. The method of claim 17, wherein the at least one sensor is a partial discharge sensor.