Electronically resettable, self-protected AC/DC Intelligent Solid State Relay/Breaker with integrated current/temperature sensing, time-delay overloads and over current / over temperature protections

Abstract

The AC/DC Intelligent Solid-State Relay/Breaker (iSSR\Breaker) power module of the present invention is a multi-terminal device and comprises of a number of paired field-effect devices (such as MOSFETs, IGBTs, etc.) connected in such manner that can commutate either DC or AC power; and an input interface circuit, and a central processing unit (CPU); and an input/output circuitry (I/O); and an address storing and selecting circuitry (AS&S); and a number of signal processing (SP) circuitry, and an isolated DC/DC converter with a multiple isolated outputs, and a number of drivers (DR). The input circuit, with built-in hysteresis to prevent false turn on/off, monitors and translates the input terminal status and converts it into a command signal for the central processor. The central processor monitors the input power supply and input signal, provides duplex communications with each signal processing circuit and generates alarm and warning signals. The signal processing circuitry measures the bypassing current and internal temperature, maintains duplex communication with the central processor, monitors the internal power supply, and generates a command signal to the driver. The driver controls the "on" and "off" states of the paired field-effect transistors and controls a sensing MOSFET. The DC/DC converter provides isolated power to each signal processing circuit and the corresponding driver. Importantly, the present invention uses unique detecting and signal-processing circuitry to simulate the properties of a time-delay fuse thus allowing the device to withstand temporary high current surges and turn off all field-effect transistors if the average current reaches the preset value. Also importantly, unlike other devices, the present invention generates a minimum amount of heat using a field-effect device to gate a sample of voltage that drops across the field-effect transistors. Unlike an electromechanical relay, the present invention is free from arcing and sparking, there are no contact materials to wear, and it is noiseless. Important, unlike electromechanical and solid state relays, the present invention uses Vari-Slope➓ technology, or soft turn-on/off controls, to reduce harmful transient spikes and thus eliminates electro-magnetic interference (EMI) and the need for a transient voltage suppressor or a snubbing network. Additionally important, the present invention generates an alarm signal in case of a trip that may occur due to either over current or over temperature thus providing important information of the internal conditions. Also important, the present invention generates a warning signal that is set at a threshold of about 80% of the trip signal. Also important, the present invention is not limited to a single channel, which is the equivalent of a SPST terminal configuration. It can be comprised of a number of pair field-effect transistors to design DPST, 3DST or "X"DST relay/contactor configuration to control single phase, 2-phases, 3-phases, or n-phases. Further important, the present invention provides over-current protection by shutting down the device if any one output is overloaded. It provides protection to the load by limiting the bypassing current to the preset value. Also important, the present invention provides over-temperature protection by shutting down the device if any of the field-effect transistors temperature reaches a preset value.

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Claims

That which is claimed:

1. A relay for use in an electrical system comprising of paired field-effect transistors having external terminals and Electronic Control Circuitry connecting said paired field-effect transistors. Wherein said Electronic Control Circuitry controls whether the solid-state relay appears as a closed or open circuit by controlling whether said paired field-effect transistors are in the on or off state.
2. A relay according to claim 1, wherein said Electronic Control Circuitry is further comprised of input/output circuitry, a central processor unit, signal processors, a driver, MOSFETs, a pair of opto-couples and a DC/DC converter.
3. A relay according to claim 1, wherein said paired field-effect transistors; paired field-effect transistors could be added to make it a double, triple or n-number to meet the maximum current requirements.
4. A relay according to claim 1, wherein said paired field-effect transistors: a paired field-effect transistors are isolated by opto-couplers and a transformer from the signal-processing circuitry.
5. A relay according to claim 1, further comprising an over-current circuit.
6. A relay according to claim 5, wherein said over-current comprising;. A sensing MOSFET is connected to the drain of said field-effect transistor and where said signal processor is connected across said sensing MOSFET for detecting the residual voltage across said field-effect transistor. Wherein said signal processor is further connect to said central processor such that said processor may monitor the current through the paired field-effect transistors.
7. A relay according to claim 1, is further comprised of an over-temperature circuit.
8. A relay according to claim 7, wherein said over-temperature comprising; a temperature sensor suited in very close proximity to said field-effect transistor; and where said signal processor is connected to said temperature sensor for detecting the temperature of said field-effect transistor. Wherein said signal processor is further connect to said central processor such that said processor may monitor the temperature of the paired field-effect transistors.
9. A relay according to claim 1, wherein said paired field-effect transistors: a driver controls whether the relay appears as a closed or open circuit by controlling whether said transistor is in on or off state.

10. A relay according to claim 1, wherein said paired field-effect transistors have integrated current sensing, over current and over temperature protection for each individual channel. Combined the alarm signal will turn off all channels and change the state on the "alarm-out" terminal.
11. A relay according to claim 1, wherein said field-effect transistors are MOSFETs, and therein said control circuitry is connected to the gates of said transistors and the sources if said transistors are connected to common.
12. A relay according to claim 1, wherein said MOSFETs are connected in the manner to control either DC or AC power.
13. A relay according to claim 1, wherein said n-number of paired MOSFETs that are isolated of each other.
14. A relay according to claim 1, wherein said paired field-effect transistors are connected to individual output terminals.
15. A relay according to claim 1, wherein said number of paired MOSFETs (1, or 2, or 3, or "n") can be controlled by the same central control and is only limited to the possible physical dimensions.
16. A relay according to claim 8, wherein said number of paired MOSFETs: each pair is isolated and has two external terminals.
17. A relay according to claim 1, where said control signal has a high impedance input. It can be connected directly to other low-power electronic devices.
18. A relay according to claim 9, wherein said control signal:
19. A relay according to claim 1, wherein said number of paired field-effect transistors: a measurement of the by-passed current performed by taking a sample of a residual voltage taken from across the stock-drain of the field-effect transistor at a particular moment.
20. A relay according to claim 1, further comprising time-delay overload protection.
21. A relay according to claim 20, where said time-delay overload protection comprises: a sensing MOSFET connected to the drain of said field-effect transistor; and where said signal processor is connected across said sensing MOSFET for detecting the residual voltage across said field-effect transistor. Wherein the signal processor applies a unique algorithm to detect, process and determine the properties of the bypassing current by analyzing said residual voltage across said field-effect transistor. The information is processed in a frequency dependant, averaging manner, or TRUE I^2t algorithm, that allows to process different current waveforms and precisely measure the amount of energy per unit of time, thus is allowed to pass high-power, short spikes through the relay without setting off an alarm. The device of the present invention can be set to any specification and requirements and available the iSSR/Breaker can continuously passed 8 Amperes and at the same time to pass 30 Amperes during about 100 x 10^{-3} Second and 110 Amperes without a tripping during 3 x 10^{-6} Second.
22. A relay according to claim 1, further comprising of over temperature detection circuitry.
23. A relay according to claim 1, further comprising having a housing confirming to a single-in-line pins (terminals) to ease printed circuit assembly.

24. A relay according to claim 1, further comprising having a housing potted with a highly thermally conductive Epoxy Resin, thus increases the actual effective a heat dissipated area in many times.
25. A relay according to claim 1, further comprising of an opto-isolated control signal and alarm status output.
26. A relay according to claim 1, further comprising of MOSFET driver circuitry that enables a soft turn-on slope to reduce electro-magnetic emission and transient spikes.
27. A relay according to claim 1, further comprising of built-in hysteresis and a noise filter to avoid a nuisance turn-ON/OFF.
28. A relay according to claim 27, wherein said built-in hysteresis, the control signal input is a logic low and is internally pull-up to the power supply through a 10K Ohm resistor. It is designed with a wide hysteresis, it turns ON when the input is pulled below 1/6 of power supply and turns off when the input is left flouted or pulled above ½ of power supply. That design insures extremely high noise filtering thus avoiding a nuisance (faulty) turn-on/off.
29. A relay according to claim 1, further comprising of internal and isolated DC/DC converters for each channel to drive paired MOSFETs and the supply power to the signal processing circuitry.
30. A relay according to claim 1, further comprising a relay according to claim 1, further comprising of the cross-trip feature; failure of one of the poles trips the other.
31. A relay according to claim 1, wherein said solid-state circuit comprises, a MOSFET transistor connected to the drain of the field-effect transistor, to an output said iSSR/Breaker; the signal-processing circuitry (SP) connected across said MOSFET to sense a residual voltage across said field-effect transistor; and the central processing unit for measuring and evaluating the current through said iSSR/Breaker by observing the voltage across said field-effect transistor.

Description

BACKGROUND OF THE INVENTION

[0002] 1. Filed of the Invention

[0003] The present invention relates in general to relays, in particular, to solid-state-relays and more particular to intelligent solid-state power management devices that included a circuit breaker.

[0004] 2. Description of Prior and Related Art

[0005]. For years, electromechanical relays have been used in a wide-variety of power control and electrical applications. However, these mechanical devices, which are built of a coil and contacts, have demonstrated considerable reliability though they suffer from problems associated with having moving parts. Mechanical relays are subject to arching and sparking. In applications, where is required to switch a high DC voltage the cost of a mechanical relay grows very rapidly. The switching of the coil leads to voltage spikes (a fly-back voltage.) A lot of power is required to control the coil and in high power relays the coil could consume tens watts. Material fatigue can shorten the life of the mechanical relay and reliability suffers due to shock and vibration.

[0006] These types of mechanical issues can be major concerns when the relay is used in harsh environments. For example, many vehicles, such as cars, tractor/trailers, heavy vehicles and aircraft include a wide variety of relays in their systems. These relays are subject to constant vibrations introduced from the operation of the vehicles. Furthermore, many of the relays built with contacts are exposed to environmental corrosive substances (liquid gases and the like) that might lead to breakdown.

[0007] In addition to mechanical problems, electromechanical relays can only manage abrupt "on" and "off" transitions thus introducing large transitional spikes and rather slow.

[0009] Nowadays, some power devices built with an internal protection using either a field-effect transistor with integrated current and temperature sensing. That allows building a self-protective power devices and shortfall there is only a low-voltage field-effect transistors are available. Some designed offered a small-value resistor inserted in series to measure a bypassing current helped in some cases but an extra-generated heat makes that method not much popular. In addition, a current sense resistor added to the overall resistance of a channel thus reducing the efficiency of the device.

BRIEF SUMMARY OF THE INVENTION

[0020] The Intelligent Solid State Relay/Breaker (iSSR) is integrated into a single package. It exhibits a low output terminal resistance equal to $Rds_{(on)}$ of MOSFETs with internal protection and control circuits, make the present invention the most rugged, efficient and compact device available for military, industry or automotive loads in harsh environment. The embedded I/O circuitry makes the interfacing to any external micro-controller very simple with full logic-level compatibility. The present invention incorporates protection features, like over-temperature, under-voltage, over-current and Vari-Slope➊ that increase the survivability of the device against short circuits, stalled motors and excessive ambient temperature. Also incorporated is a preset temperature sensor of around 95^{o}C (which can be set to any reasonable temperature). The iSSR will itself turn-on/off the output powerful field-effect transistors before they go into an avalanche breakdown. Designed to safely handle overload conditions, as well as several extraordinary conditions, the present invention eliminates switch failures with the best efficiency and no additional in part count. Full isolation between the input and output terminals make the present invention invaluable in High-Side and Low-Side switching applications. The internal protection insures the present invention of self-protection, protection of the load and insures a much longer useful life.

[0021] The present invention (iSSR) remedies many of the problems associated with mechanical relays by providing a solid-state relay/circuit breaker system. It is also much better equipped to protect the load compared to any electromechanical or solid-state relay. It only introduces a minimum amount of transitional spikes. Its current limiting capabilities are like that of a time-delay fuse yet it is capable of withstanding a large surge of current that is often required during the initial turn-on cycle. The built-in Vari-Slope⓿ features implement an internal slew rate control for soft turn-on/off that leads to a drastic reduction of destructive high-power spikes and lowers electron magnetic interference (EMI).

[0022] An extremely low (less than 10 mOhm) on-resistance with several integrated features makes the present invention the best candidate to replace electromechanical relays, fuses and discrete power MOSFET/IGBT's in power management applications.

[0023] The present invention, the iSSR, incorporates analog and mixed-signal processing to detect, control, communicate and manage under-voltage, overcurrent, overtemperature and temperature compensation to insure a high precision and stable response in a harsh environment. Either a parallel input or serial peripheral interface communicates can be used for many programmable protections and detection items enhance the capability of the iSSR for relay replacement and other control applications.

[0024] The relay of the present invention is configured to be used with conventional packaging systems. Specifically, the device can be housed in a box having conventional footprints such as housing having ISO or as single-in-line pins to easy PCB assembly.

[0025] Importantly, the central processing unit used to control the relay's function may be built with a various configurations. Specifically, it can receive inputs from other devices such as toggle switches or other types of command control devices. Based on the status of the input the central processing unit controls the relay's status, either open or closed. Furthermore, the central processing unit may be used as a multiplexer with address decoding where several relays are connected to the output pins of a common processor, data and address bus, or a serial communication link such that the processor can selectively configure the polarity of relays based on input commands.

[0026] An additionally important, a relay can be built with a single pair of terminals or with as many as required.

[0027] Also important, a relay can be build to hold any voltage and current by selecting the proper powerful field-effect transistors.

[0028] The relay of the present invention incorporates the Vari-Slope⓿ technology that drastically decreases transitional spikes on the rising and falling edges thus eliminating the need for a transient voltage suppressor.

[0029] The Intelligent Solid State Relay/Breaker (iSSR) of the present invention is particular well suited for applications with a high inrush current such as a power distribution switch with a capacitance load, lamps or motors. It will switch all types of resistive, inductive and capacitive loads and acts as a microcontroller compatible power switch. By replacing electromechanical relays, fuses and some discrete circuitry, this self-protected iSSR will reduce the component count and thus the PCB size in many applications. It is an ideal replacement for electromechanical relays, breakers, the time-delay fuses in Programmable Logic Controllers, Distributed and Close-Loop Control Systems, DC and AC Loads, DC and AC motors, Valves, Solenoids, Heaters, Latches, Brakes, Junction Boxes, Lamp, etc.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0030] Having described the invention in general terms, references will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

[0031] FIG. 1 is a solid-state relay according to one embodiment of the present invention, wherein the relay is packaged in a single housing according to one embodiment of the present invention.

[0032] FIG. 2 is a block-diagram of a solid-state relay according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0040]. The present invention now will be described more fully hereinafter with references to the accompany drawings, in which some, but not all embodiments of the invention are shown. Indeed, this invention may be embodied in many different forms and should no be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

[0041]. The present invention remedies many of the problems associated with mechanical relays be providing a solid-state relay/circuit breaker. As illustrated in FIG. 2, this improved relay system is composed of field-effect devices such as MOSFETs. Connected to the MOSFETs is an electronic control circuit that controls the on and off states of the field-effect transistors. Specifically, the circuitry monitors the voltage level at the input terminal and sends the control signal to turn field-effect transistors if the voltage acceded above (fall below) a predetermined level. In some embodiments, the present invention may further include a thermistor, T1, which measures the temperature of the field-effect transistors. This temperature is used by the circuitry, which compensates the current reading for the temperature reading using to measure a bypassing current and to set the alarm out signal.

[0042]. Importantly, the present invention uses field-effect devices and electronic circuitry as opposed to the contacts, a coil and a downstream circuit breaker conventional electromechanical relays possess. Unlike an elecromechanical relay, this solid-state relay is free of the problems that arise from having mechanical parts. The solid-state relay is free of arcing and sparking. There are no contact materials to wear out or generate noise. Because of the use of electronic circuitry, the solid-state relay has a faster switching speed and there are no switching voltage spikes from turning on the coil. Without moving parts that are subject to material fatigue this solid-state relay has a longer operating life and is more reliable. Furthermore, by using semiconductor devices, the solid-state relay is resistant to shock and vibration. Potted in a highly conductive Epoxy resin, the solid-state relay/breaker can work in any environment, including corrosive fluids.

[0043]. The solid-state relay/breaker of the present invention also contains its own means to measure the internal temperature and bypassing current, as opposed to the elecromechanical breaker used in conventional systems. This reduces the number of connections that are used in the system and makes replacement easier.

[0044] Importantly, the present invention also contains its own means to turn on and turn off in such a manner that a surge of power or the discharging of power is minimized to a level where no transient voltage suppressor or other protection is required.

[0045] As mentioned above, conventional relays, solid-state relays and other similar devices provide the maximum possible power (current) to a load. However, the present invention maintained bypassing current in such manner if the current exceeded the preset value it will disconnected automatically. Only the re-cycling of a control signal restores the on status. This advanced power (current) management minimized the number of components required by eliminating the need for a fuse and a switch.

[0044] As mentioned above, conventional external breakers used in many conventional electromechanical relays and a solid sate relay affected by temperature changes. However, the internal temperature sensors of the present invention has a significantly reduces variation in operation over the typical range of operating temperature. This solid-state relay with built-in bypassing current sensors ensures a constant current limit, fast switching speed and high reliability despite changes in temperature and other conditions (shock, vibration, moisture, etc.)

[0045] The present invention corrected many problem associates with common present invention replaces a power-hungry coil and slow-moving mechanical parts with solid state electronics and powerful field-effect transistors that required much less power to operate and can be very fast, as it shown in FIG.2 it consists of an electronic control circuitry and a pair of field-effect transistors. The main function of the electronic control circuitry is to provide a voltage when a turn-on command signal comes onto the gates of the field-effect transistors. In well-known previous arts, the electronic control circuitry could be as simple as an opto-isolated photovoltaic device or a DC/DC converter. The main function of the pair of field-effect transistors is to conduct when a voltage is applied to their gates and not to conduct when the voltage removed.

[0046] As mentioned above in 0045, the pair of field-effect transistors (N-channel MOSFETs as shown in FIG. 2) are connected together by gates to the driver's output (DR-1) and by stokes to the common. The present invention provides simple means to design a variety of devices capable of handling various voltages and power as a shown in FIG. 4. A number of paired field-effect transistors (MOSFET, IGBT etc.) and types (drain-source voltage, current, on-state resistance, etc.) should be chosen depending on a power and voltage needs to be commutated.

[0046] As mentioned above in 0045, the Electronic Control Circuitry, recognized in FIG. 2 of the present invention consists of the following: a sensing field-effect transistor (Q7), a driver (DR-1), signal processing circuitry (SP-1), a pair of opto-couples (ISO1 and ISO2), pair of temperature sensors (S-1 and S-2), and a central processing unit (CPU). It also includes an isolated DC/DC converter, input and output terminals, and input/output circuitry (I/O).

[0047] As mentioned above in 0046 and it is a part of the Electronic Control Circuit, the input/output circuitry (I/O) performs a very important function of interfacing various external devices (such as a semiconductor or mechanical contacts) that generate various voltages with the CPU. The I/O conditions an external voltage to the voltage range that the CPU can work with without being damaged. It also provides the alarm-out signal that can drive numerous external devices.

[0048]. As mentioned above in 0046 and it is a part of the Electronic Control Circuit, the CPU performs multiple functions, it process input information and if a signal to turn on received it sends a signal to the SP-1 through the ISO1.

[0049]. As mentioned in 0046 and it is a part of the Electronic Control Circuit, there is a pair of opto-isolators (ISO-1 and (ISO-2) to provide duplex communication between the SP-1 and the CPU.

[0050]. As mentioned above in 0046 and it is a part of the Electronic Control Circuit, the signal processing circuitry, SP-1, may be implemented in various ways and may include a microcontroller with several analog-digital converters (A/D) and I/O ports to receive/send commands and other needed components. The present invention may include a high-speed full-wave bridge, low-pass and high-pass filters, a watchdog, a current-sensing amplifier, temperature amplifiers, compensator circuitry, a circuit to generate control signals for DR-1 and ISO-2, the logic circuitry to provide duplex communication with the CPU and the means of incoming and transmitting information.

[0051]. As mentioned in 0050 the signal processing circuitry SP-1, the SP-1 process two analog signals, one is coming from an analog temperature sensor (S-2) and the other a sample of residual voltage that comes from the filed-effect transistor (Q1), also two logical signals, one is from an opto-coupler (ISO-1) and the other from an integrated temperature sensor that generate a logic a signal if the surrounded temperature reached 95^{o}C. There are two temperature sensors incorporated into the design. S-2 measures the surrounding temperature and the result is used for the precise compensation of the current-sensing amplifiers due to the changes of the on-state resistance of the powerful field-effect transistors. The other temperature sensor, S-1, is set to trip if the temperature of the field-effect transistors reaches a pre-set level, for example at 95^{o}C. At first the circuit used a single temperature sensor to provide information for a compensatory circuitry and

[0052]. As mentioned in 0050 the signal processing circuitry SP-1, the SP-1 constantly measure the internal power supply at five points. It takes a sample of a voltage on the output of the DC/DC converter, +/-12VDC for analog filters and amplifiers, gate-driving voltage, +11VDC that applied to the Q7 and the paired of field-effect transistors, and +5VDC logic voltage for internal logic circuitry. The SP-1 will shutdown both transistors and sends a signal to the CPU via the ISO-1 if any voltage fell below the normal level.

[0053]. As mentioned in 0046, the control signal that comes from the SP-1 the DR-1 will generate two control signals that turn-on the sensing MOSFET (Q7) and the paired field-effect transistors. The SP-1 is a sophisticated driver, which generates two control signals in certain timely alliance and they are quite different. One signal that drives a MOSFET (Q7) is a fast-sloped signal that is generated with a slight delay to the signal that drives a pair of MOSFETs (Q1 and Q2), which is a slow-slopes signal. The Q7 turned-on after the Q1 is fully conductive and behaves exactly as a resistor. The Q7 turned-off a prior the ending of the control signal that drives a pair of field-effect transistors (Q1 and Q2). The Q1 and Q2 control signals have unique properties (Vari-Slope proprietary technology) which drastically reduce the transitional spikes on the rising and falling slopes at a load (output terminals).

[0054]. Further, the present invention can be configured with a single pair of terminals or with as many as a particular application would require. FIG. 4 is an example of an iSSR/Breaker with a single-pole, single throw (SPST) contact configuration. FIG.5 is a relay with a double-pole, single throw (DPST) contact configuration. FIG. 6 is a relay with a three-pole, single throw (3PST) contact configuration that finds a wide variety of uses in 3-phase power management applications.

[0059]. As discussed in the above embodiments, the iSSR/breaker of the present invention uses a central processing unit (CPU) to control the actuation of the relay and send an alarm signal out in the case of malfunction. The CPU can be used for other functions other than just for processing information from the signal-processing (SP) circuitry. Specifically, the CPU could be connected to a data bus or a serial communication link, as shown in FIG. 7.

[0060]. FIG. 2 illustrates only one example of the present invention and in particular that functional block diagram of the iSSR/Breaker works in the following order. Since the power supply was sensed by the input/output (I/O) circuitry and the Signal Processing (SP) the information processed by the CPU and sends the alarm-out signal to an external device. The alarm-out output is current limited and fully protected against any electrostatic discharge (ESD) and shorting to the ground. It delivers about 10mA of current and can be connected to ground indefinitely. It stays high as long as the relay functioned and no alarm such as over-current, under-voltage, and over-temperature was detected. The logic high would be an indication that the iSSR/Breaker is operative and ready for a command. The control signal input is a logic low input and internally pull-up to the power supply through 10 KOhm. It designed with a wide hysteresis, it turns ON when the input is pulled below 1/6 of power supply and turns off when the input left flouted or pulled above ½ of power supply. That designed insures extremely high noise filtering thus avoiding the nuisance of a faulty turn-on/off. Both input terminals (the alarm-out and control signal) are kept low as long as the power supply stays outside of the normal range for the relays operation. Once, the CPU has received information from the I/O and the SP that the power supply is within the tolerance and the control signal is pulled down, it applies a voltage to the opto-coupler (ISO-1). Upon receiving a signal from the CPU, the SP generates an enable signal that is applied to the driver (DR). Once enabled, the DR generates two signals. At first, it applies a signal to turn-on the powerful-paired field-effect transistors and, with a slight delay, applies another signal to turn-on a sensing MOSFET. Since that moment the information about the bypassing current starts processing and if it's level holds inside of the allowed tolerance and the internal temperature did not reach the limit, the iSSR maintains its status without change until the control signal on the outside terminal went down. This represents the end of the "ON" condition. The SP constantly processes the bypassing current, the internal temperature, and the voltage level of both gates and the power supply. All gathered information is processed with high accuracy because it is vitally important that their values stay in the tolerance for proper operation and self-protection. If any parameters got out of range, the SP applies a voltage onto the ISO2, in this manner sends information to the CPU, and at the same time turns-off the signal that enables the DR. The DR in its turned turn-off at first the sensing MOSFET and after that it will shutdown the paired field-effect transistors. Once the CPU receives the alarm information, from the SP it will send a command to the I/O and the I/O then turns-off the alarm-out output.

[0058] FIG. 7 illustrates the iSSR/Breaker of the present invention housed in similar footprints as mechanical relays. They have single-in-line pins for easy printed circuit board mounting or plug-in sockets. However, there are other ways that the relay could be assembled and package. For example, the relay could be assembled on a circuit board having functional sub-blocks and components spread through it and connected by conductive traces to other system. In this regard, the present invention describes the iSSR/Breaker design and functional diagram and not only the packaging.

[0059]. As mentioned above, the CPU of the iSSR/Breaker of the present invention may also be used to accept control inputs from a remote location for configuring the iSSR. Where the iSSR is used with a power distribution center, such as in submarine, to provide power from an AC generator and, in the case of an emergency switch to DC power from a battery, the iSSR may also be used as a multiplexing device. Specifically, numerous iSSR's can be connected to a distribution center, where each is connected to a separate point on a common control device (a microprocessor for example); such that the microprocessor can individually control each relay based output to designated pins. In this embodiment, the microprocessor acts as a central control device for controlling various relays connected thereto. Further, the microprocessor may also be considered a multiplexer in this context in that it can receive inputs from various switches and selectively configured different relays based on these control inputs. For example, a common microprocessor may be connected to two separate relays via the power distribution center. One relay may control a DC motor, while another relay controls a solenoid.

[0060]. Furthermore, the CPU of the iSSR/Breaker on the present invention may be used to program the relay to work as a flasher when it is combined with a lamp to produce pulse-width modulation for a precise duration of time in controlling a solenoid in soft-stop mode, valves or a power control by implementing a pulse-width modulation control. In additional various duration's and configurations of a time-delay switch can be implemented easily.

[0060]. Many modifications and other embodiments of the invention 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 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 embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in generic and descriptive sense only and not for purpose of limitation.

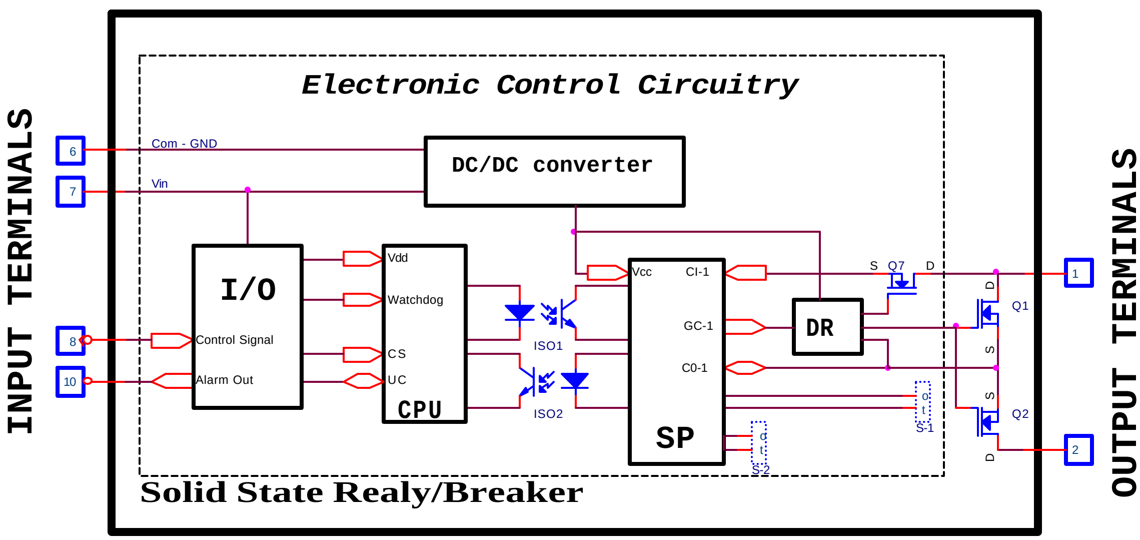
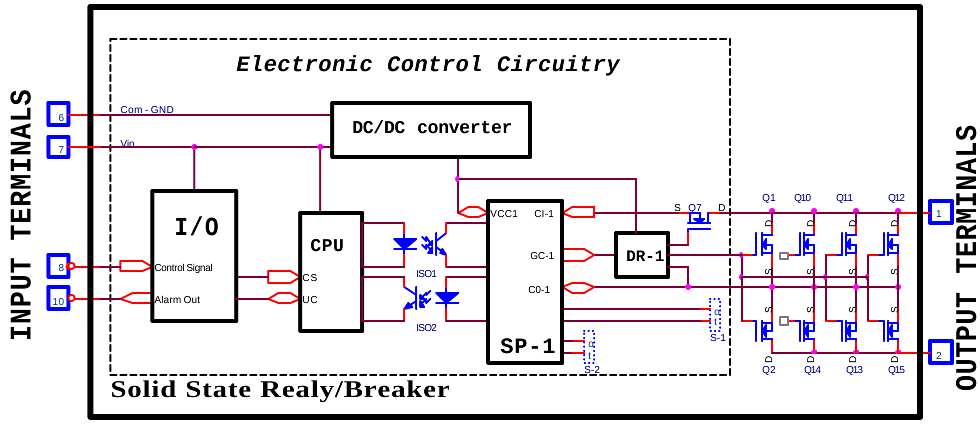


FIGURE 3

A typical functional block diagram of the iSSR/Breaker with a SPST-contact configuration



FUGURE 4

Functional block diagram of the iSSR/Breaker with multiple pairs of MOSFETs

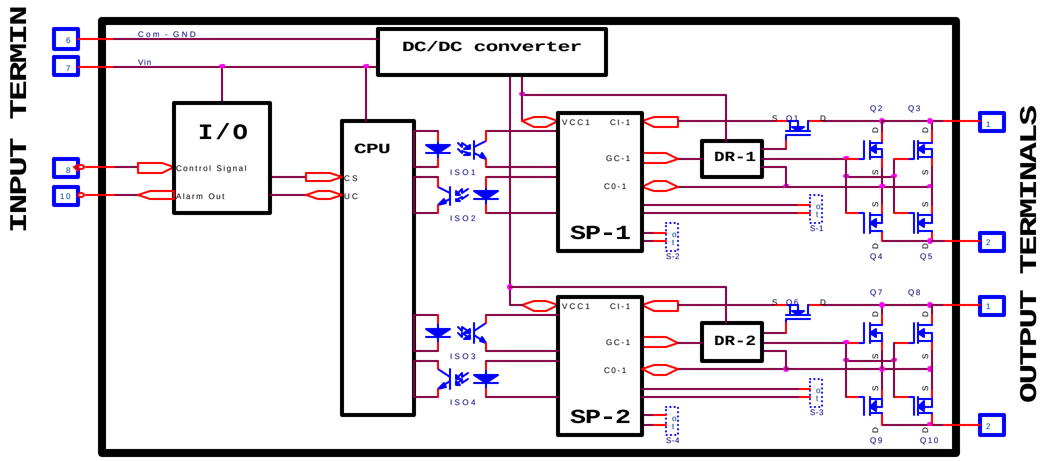
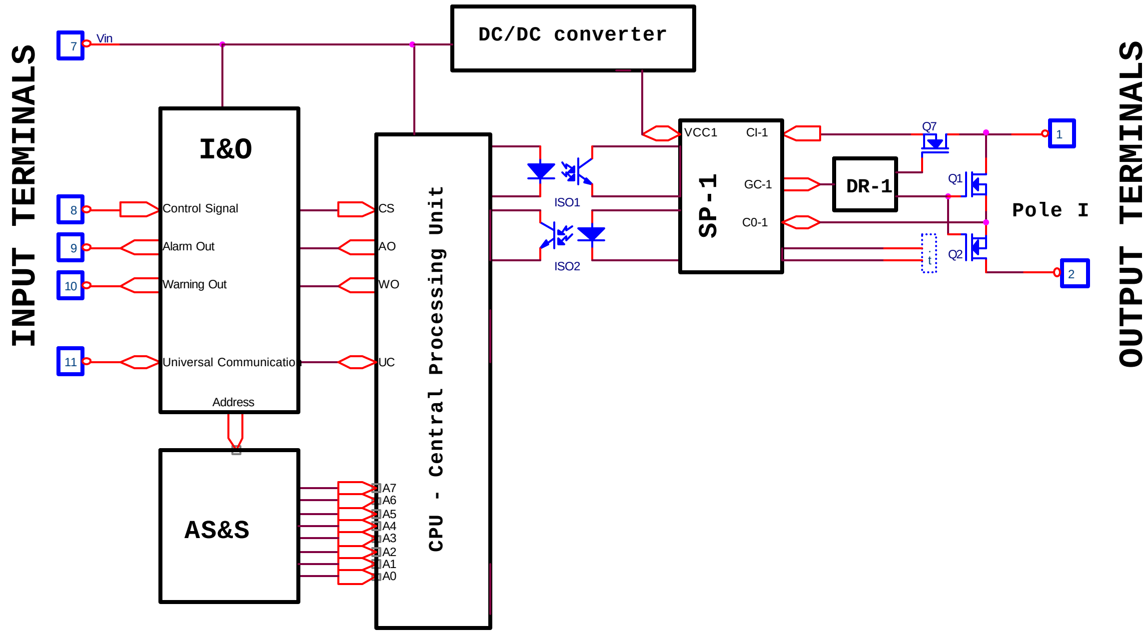
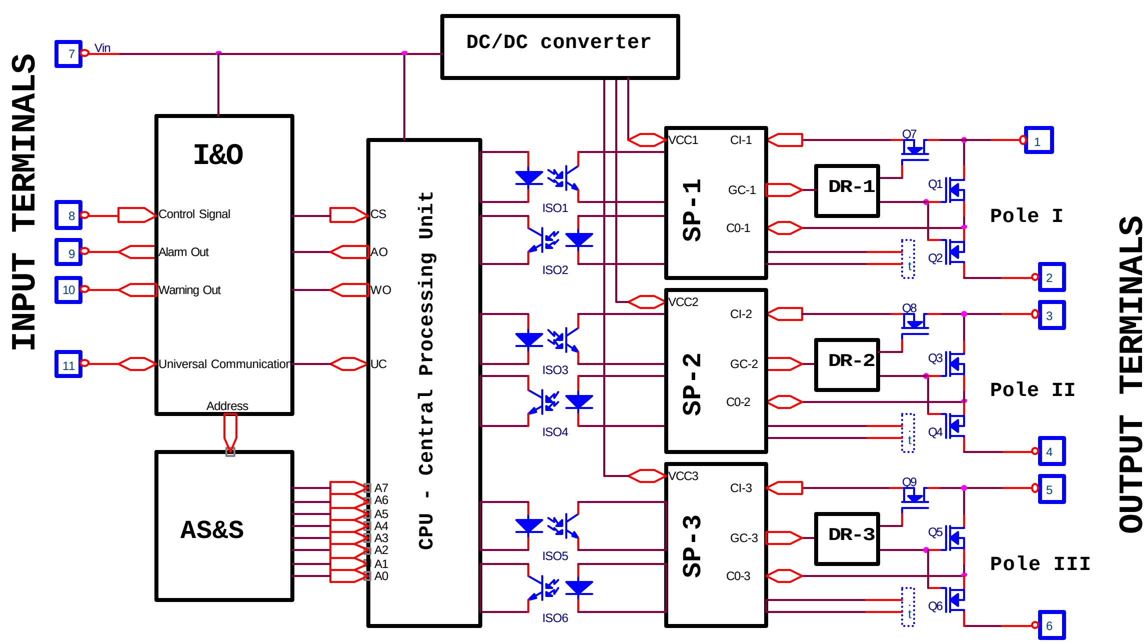


FIGURE 5

Typical functional block diagram of the iSSR/Breaker with a DPST contact configuration


INPUT TERMINALS
OUTPUT TERMINALS
DC/DC converter
Vin
I&O
Control Signal
Alarm Out
Warning Out
Universal Communicatio
Address
AS&S
CPU - Central Processing Unit
CS
AO
WO
UC
A7
A6
A5
A4
A3
A2
A1
A0
ISO1
ISO2
SP-1
VCC1
CI-1
GC-1
C0-1
DR-1
Q7
Q1
Q2
Pole I


INPUT TERMINALS
OUTPUT TERMINALS
DC/DC converter
Vin
I&O
Control Signal
Alarm Out
Warning Out
Universal Communication
Address
AS&S
CPU - Central Processing Unit
CS
AO
WO
UC
A7
A6
A5
A4
A3
A2
A1
A0
ISO1
ISO2
ISO3
ISO4
ISO5
ISO6
SP-1
SP-2
SP-3
VCC1
VCC2
VCC3
CI-1
GC-1
C0-1
CI-2
GC-2
C0-2
CI-3
GC-3
C0-3
DR-1
DR-2
DR-3
Q7
Q1
Q2
Q8
Q3
Q4
Q9
Q5
Q6
Pole I
Pole II
Pole III

Description

Figure 1
Block-diagram of the Solid State Power Controller