Invention Title

Creating interactive manual control devices utilizing alternative sensor mechanisms

Description

[Para 1] The present invention relates, in general, to means and methods for utilizing alternative sensor mechanisms to design and build interactive human interface devices suitable for a wide variety of applications.

Relevant Background

[Para 2] Since the development of the earliest electric and mechanical devices, it has been a fundamental operational requirement that there exist a wide variety of mechanisms designed to allow individuals to interact with and control the function of these devices. From simple manual control devices like switches, buttons, sliders, and dials to complex manual control devices like keyboards, touch screens, and mice among many others, the continually proliferating array of interactive control devices and human interface devices is a natural consequence of our rapidly evolving technological environment.

[Para 3] Electrical, mechanical, electronic, electromagnetic, and electromechanical devices have become increasingly complex and are utilized in a far wider range of applications and environmental conditions than ever before. The variety and sophistication required of the associated manual control devices has grown in tandem. As a result, the designers of interactive manual control devices and human interfaces are continually forced to address new physical constraints – they must build devices that can survive immersion, high and low pressures, high and low temperatures, chemical toxicity, oxidation, large sudden impacts (g-shocks), vibration, and invasive particulate matter among many others. Device designers are also faced with an ongoing expansion of various market demands – customers require system characteristics like five to nine nines reliability, minimal device footprint, maximal operational lifespan, minimal power consumption, ease of operation, configurable device sensitivity, minimal latencies, real time response profile adjustment, resistance to intentional user abuse, consistent performance, minimal calibration issues, and more.

History

[Para 4] There are a wide variety of different interactive manual control devices currently available within the state of the art. An illustrative but incomplete list of current interactive control devices includes buttons, switches, mice, joysticks, trackballs, pointing sticks, touch screens, keyboards, and touchpads.

[Para 5] Although these devices serve a broad range of applications, their construction generally utilizes a similar array of components. These components commonly include rotary and linear potentiometers, contact switches, resistive strain gauges, load gauges, hall effect sensors, conductor arrays, capacitance sensors, LC circuits, mechanical gearing, chopper wheels, light emitting diodes, infrared laser diodes, photo diodes, optoelectronic sensors, accelerometers, gyroscopes, and many more familiar to those of skill in the art.

[Para 6] These components, and the interactive control devices constructed utilizing them, all have various functional constraints associated with the operating characteristics of the components themselves. Mechanical components, for example, are sensitive to particulate matter, shock, fatigue, oxidation and other types of degradation as a result of various environmental variables. Optical components have additional issues associated with their performance in different environmental conditions as well as calibration issues associated with changes in component power output over time. Electronic and other component types also suffer similar functional constraints as well as many others.

[Para 7] One of the components with the fewest drawbacks as utilized in the construction of interactive control devices is the hall-effect sensor. These are often used in the construction of joysticks designed for industrial or military applications. The primary drawback of hall-effect sensor components is that they require magnetized subcomponents to function effectively, which it should be clear to any of skill in the art is sub-optimal in many common application areas.

[Para 8] Further, as most interactive control devices within the state of the art are constructed utilizing multiple classes of component types, they face some composite issues as well - as devices are only as robust as their most sensitive components. One common example is the 'return to zero' issue faced by joystick type control devices - such devices take a non-zero time to return to a 'zero' or starting state and there is an ongoing calibration issue associated with defining that zero state as the individual components in the device change with time and wear. 'Keyboard' type interactive control devices also experience a similar problem as the individual keys must return to their zero state between each keystroke.

[Para 9] A more complex example of an interactive control device from within the current state of the art will serve to further illustrate some of the problems and challenges that result from the constraints associated with the component types in common use, and those familiar with the art will see how these or similar issues apply similarly to the general class of interactive manual control or human interface devices.

[Para 10] One fairly complex type of interactive control device common in the state of the art is a 'touchpad', a general control or pointing device that in most cases receives and transmits control data along two axis. These devices are most commonly used for the purpose of interacting with a 'GUI' (graphical user interface) in order to control a personal computer, video game system, or to control the operation of other digital and electromechanical devices.

[Para 11] The most common touchpad implementation involves 3 layers of material – a layer with conductive traces arranged in parallel lines separated by insulating material, a layer of insulating material, and another layer of conductive traces arranged in parallel lines oriented 90 degrees relative to the first layer of conductive traces. See, e.g. U.S Pat. No. 5,305,017, Gerpheide. Current is applied sequentially to nodes in the two dimensional matrix thus created, and the intervention of a conductive ground (most commonly, a finger) at or near a matrix junction changes the effective capacitance at that junction, thereby resulting in an x,y coordinate signal which is then transmitted to the controlled device.

[Para 12] A touchpad constructed utilizing this or similar techniques, as is common within the state of the art, has several significant constraints on its operating envelope. The first requires that the object used to interact with the touchpad (e.g. stylus) be conductive. This is problematic if the operator is constrained by environmental conditions to wear gloves as the usual stylus for this class of device is the operators finger, for example if the device is operated at low temperatures (arctic), while submerged (aquatic), at low atmospheric pressures (space), etc. Also, if the environment in which the device is operated is conductive or prone to electromagnetic phenomena device operation (submerged, industrial venue, electrical shock transmitted from controlled device, etc) will be impaired or the device rendered non-functional.

[Para 13] The components commonly used in touchpad type of interactive control device are also sensitive to g-shock, invasive particulate matter, corrosives, and high temperatures. This class of devices as commonly constructed are also relatively expensive, device footprint is non-minimal, and sensitivity is limited among other constraints which limit the range of suitable applications.

[Para 14] As should be clear to anyone of skill in the art, current approaches to designing and building interactive manual control devices have some drawbacks, and fail to successfully address the full range of environmental operating conditions, component constraints, and the evolving functional requirements associated with human interface devices.

Summary of the Invention

[Para 15] The present invention involves utilizing a range of alternative sensor mechanisms to build interactive manual control and pointing devices appropriate for a wide variety of applications that address some of the issues associated with the manual control and pointing devices currently available within the state of the art.

[Para 16] Said alternative sensor mechanisms include, but are not limited to, inductive proximity sensors and heat sensors. The specific type of sensor utilized in a specific interactive manual control device will depend on desired device functionality. Sensors selected may be analog or digital in nature, and may have discrete (two state, variable two state, multi-state, etc) or continuous (fixed, feedback linked, etc) attributes depending on the functionality desired. One or more of the selected alternative sensor mechanisms are then arranged in a geometric configuration suited to the dimensionality of data and device sensitivity desired for a specific interactive control device application. The resolution of the control device may be based on a single sensor or an arbitrary array of individual sensor mechanisms depending on the application features desired.

[Para 17] For a switch type interactive control device a single sensor is appropriate (Figure 2), for a 10 state slider type control device such as a volume control 10 sensors arranged in a linear manner may be appropriate (Figure 4), for a 4 directional pad type control device 4 sensors located at the corners of a square then rotated 45 degrees may be appropriate (Figure 5), for a touchpad type control device the number of sensors and relative sensor geometries will depend on desired device resolution, and for other interactive control device applications the number of sensors utilized and the relative sensor geometry will depend in large part on the desired device functionality.

[Para 18] Control and power supply circuitry suitable to the desired interactive manual control device application area and the device to be controlled are then selected and connected to the sensor configuration in an appropriate manner. Control circuitry may store sensor states in a persistent or transient manner as required by the application selected. Control circuitry may only transmit collected sensor data to the controlled device, may process sensor data prior to transmission, may transmit and receive sensor data from the device controlled, may transmit and receive control data that modify the ongoing behavior of the sensors and/or the interactive control device at large, or any number of other options depending on the specific application and functionality selected. Power may be drawn via any number of wired or wireless options from an external source or may be supplied internally as desired.

[Para 19] Depending on the constraints associated with the specific application desired, an appropriate enclosure and structural methods are selected. For some applications, 'potting', or encasing all device components including the sensors within a resin matrix may be suitable. In these cases the resin matrix will be selected from a wide range of readily available options based on the operational envelope and device characteristics desired. For other applications a liquid, gas, ceramic or alternative matrix may be suitable. In all cases, the enclosure and device matrix will depend on the specific interactive control device application and functionality desired.

[Para 20] Depending on the potting method used, complete isolation from the external environment can be assured without interfering with the desired operation of the interactive manual control device itself.

[Para 21] The connection between the interactive control device and the device controlled is then selected based on desired device functionality. This connection may be wired or wireless, and may be suited to mono or bi-directional data transmission as required. This connection may be direct, mediated by suitable hardware or software by the interactive control device, mediated by suitable hardware or software by the controlled device, or any combination of these suitable for the specific application selected.

Brief Description of Figures

[Para 22] Brief Description of Figure 1 – this figure provides a cutaway depiction of the construction of a single, resin potted PNP or NPN type inductive sensor module.

[Para 23] Brief Description of Figure 2 – this figure illustrates the design of a two state 'switch' type control device utilizing a PNP type inductive sensor.

[Para 24] Brief Description of Figure 3 – this figure provides the circuit diagram for an exemplar PNP type inductive sensor.

[Para 25] Brief Description of Figure 4 – this figure illustrates the design of a single axis 'slider' type control device utilizing two or more PNP type inductive sensors.

[Para 26] Brief Description of Figure 5 – this figure illustrates the design of a four directional 'directional pad' type interactive control device utilizing 4 PNP type inductive sensors.

[Para 27] Brief Description of Figure 6 – this figure illustrates the application of a 4 directional 'directional pad' type interactive control device as used to control the operation of a personal computer via a 'GUI' or graphical user interface utilizing a standard display device.

Brief Description of the Invention

[Para 28] A novel means and methods for designing a wide range of interactive manual control and pointing devices utilizing a variety of alternative sensor mechanisms. Said alternative sensor mechanisms include, but are not limited to, proximity induction sensors and heat sensors. Using the means and methods described herein, it is possible to design and build a variety of interactive manual control devices or human interface devices with a range of functionality unavailable within the current state of the art.

Detailed Description of the Preferred Embodiment

[Para 29] In general, the present invention is preferably implemented using the components, component geometry, and functional architecture described in the following paragraphs. For illustrative purposes, the preferred embodiment is restricted to a specific type of interactive manual control device, in this case a four directional, 'directional pad' type interactive manual control device used to control the operation of a personal computer device via a GUI or graphical user interface and a standard display device. This restriction by no means constrains the scope of the present invention, as the modifications required to provide specific support for other types of interactive control devices and control device application areas as well as modifications to allow the utilization of other alternative sensor mechanisms should be obvious to those of ordinary skill in the art.

[Para 30] The preferred embodiment of the present invention is best characterized first by construction and component selection, then by function. The primary components of the present invention are 4 PNP type binary inductive proximity sensors (Figure 3). Each binary sensor has two states – on, meaning a triggering object is within the sensing field defined by the specifications of the sensor, and off, meaning that there is no triggering object currently within the sensing field (Figure 1). These sensors are arranged geometrically at the corners of a virtual square with 4 centimeter sides, if such a square were then rotated by 45 degrees in either direction along a perpendicular axis through its center. Traces supplying power and state signals from the sensors extend to an interface circuit which connects to a standard USB cable terminator at the edge of the enclosure (Figure 5).

[Para 31] In the preferred embodiment of the present invention, the device enclosure is constructed by 'potting' the functional control device components including the sensors, in a solid block of standard non-conductive epoxy resin. The inductive sensors are oriented perpendicular to the surface of the enclosure, .3 cm within the resin (Figure 1).

[Para 32] In the preferred embodiment of the present invention, the use of inductive proximity sensors in conjunction with an epoxy resin enclosure allow a user to utilize the interactive manual control device in virtually any environment without negatively impacting the functionality of the control device itself.

[Para 33] In the preferred embodiment of the present invention, a standard USB cable connects the wired terminator on the surface of the interactive manual control device enclosure to a standard USB port of a personal computer device. The control device is powered via this cable through the interface circuit, and this cable carries binary state signals from the control device to the personal computer device via its USB port. A software driver on the personal computer device accepts binary state signals from the control device and translates them to a form accepted by the operating system running on the personal computer device where they are used to control a pointer in a graphical user interface. The results of these signals are demonstrated via a standard display device (Figure 6).

[Para 34] In the operation of the preferred embodiment of the present invention, a user will trigger one of the 4 PNP type inductive sensors by placing a triggering device, in this case either a finger or metal stylus, into the sensing field of that sensor. For the purpose of clarity, let us assume the user triggers sensor 1 (Figure 5). The sensor will be triggered, and the sensor state will be transmitted via trace to the interface circuit, to the USB terminator of the control device and then over the USB cable to the USB port on the personal computer device. The device driver running on the personal computer device will poll the USB device at specified time intervals, and for every interval in which the sensor remains triggered the driver will increment the current y-position (in the case of a trigger signal from sensor 1) of the virtual pointer within the graphical user interface by a configurable amount. These changes to the virtual state of the graphical user interface will then be displayed on a standard display device.

[Para 35] Although the invention has been described in terms of certain preferred embodiments, it will become apparent to those of ordinary skill in the art that modifications and improvements can be made to the inventive concepts herein without departing from the scope of the invention. The embodiments shown herein are merely illustrative of the inventive concepts and should not be interpreted as limiting the scope of the invention.

Abstract

[Para 36] A novel means and methods for designing a wide range of interactive manual control and pointing devices utilizing a variety of alternative sensor mechanisms. By using inductive proximity sensors or other alternative sensors, appropriate control and power supply circuitry, and a device enclosure and matrix that provides an arbitrary degree of environmental isolation without negatively impacting interactive control device functionality, the present invention provides compelling end user advantages over traditional methods for designing and building interactive control and human interface devices.

Drawings

Figure 1

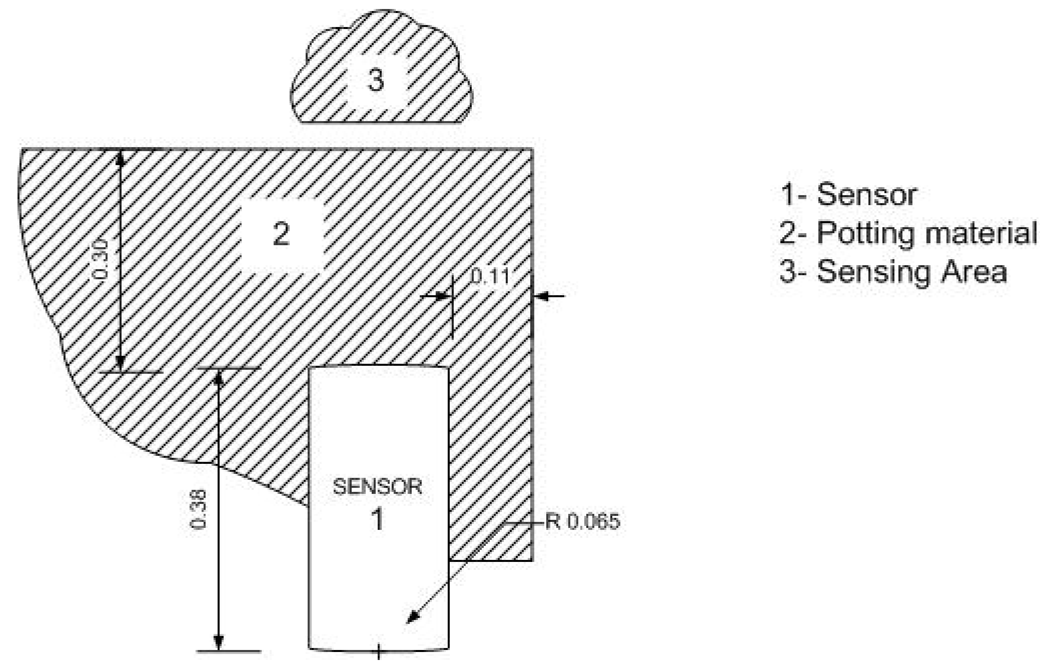

Figure 2

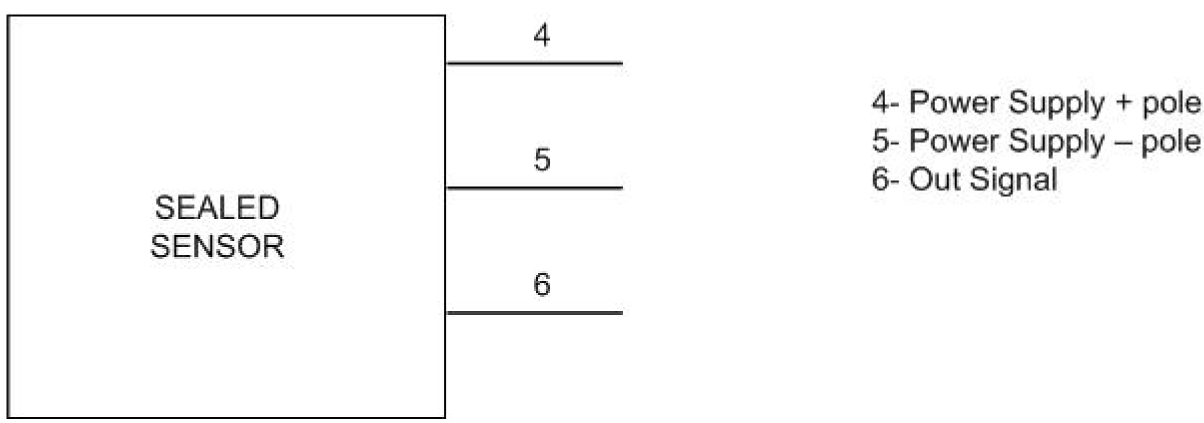

Figure 3

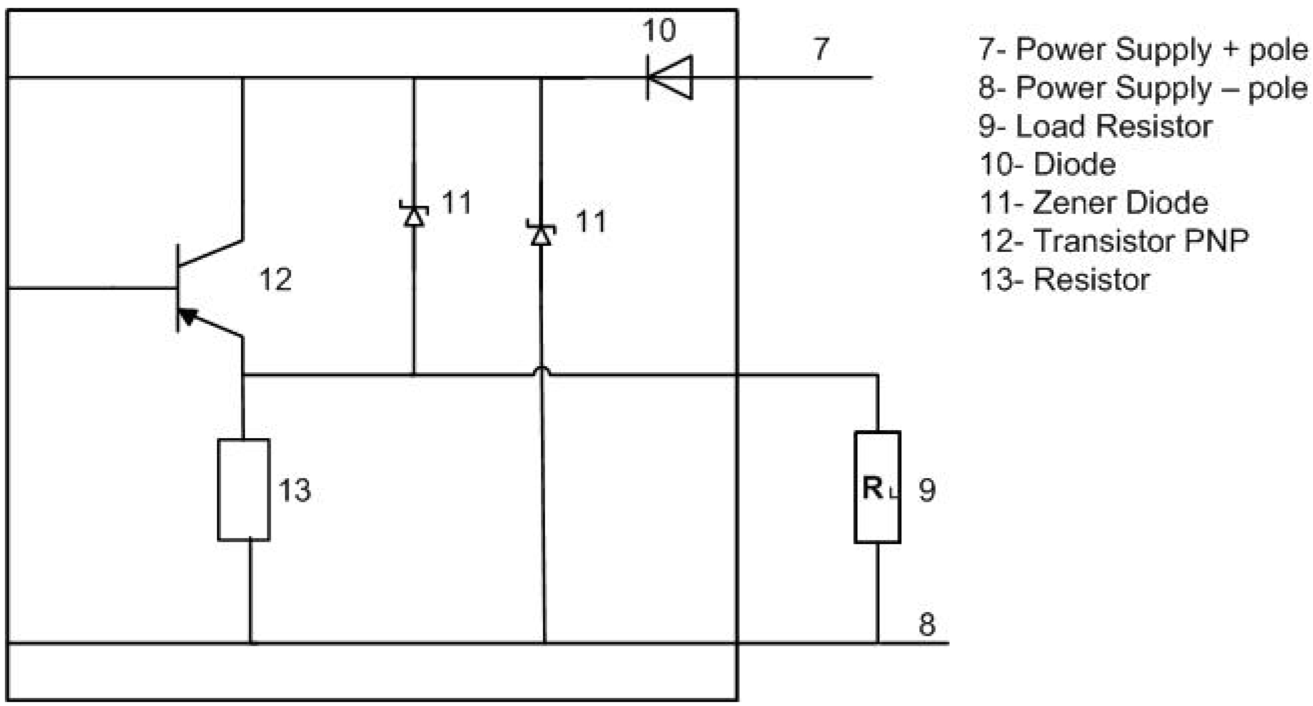

Figure 4

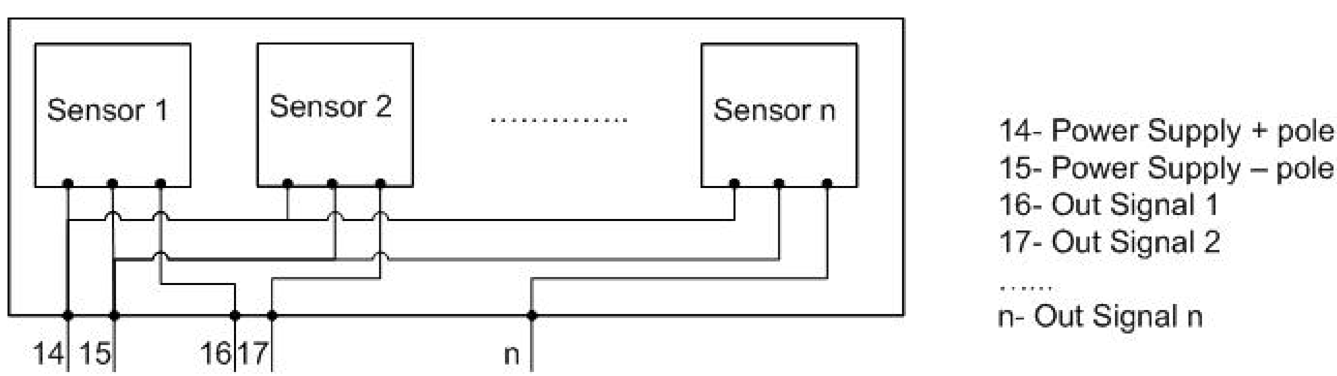

Figure 5

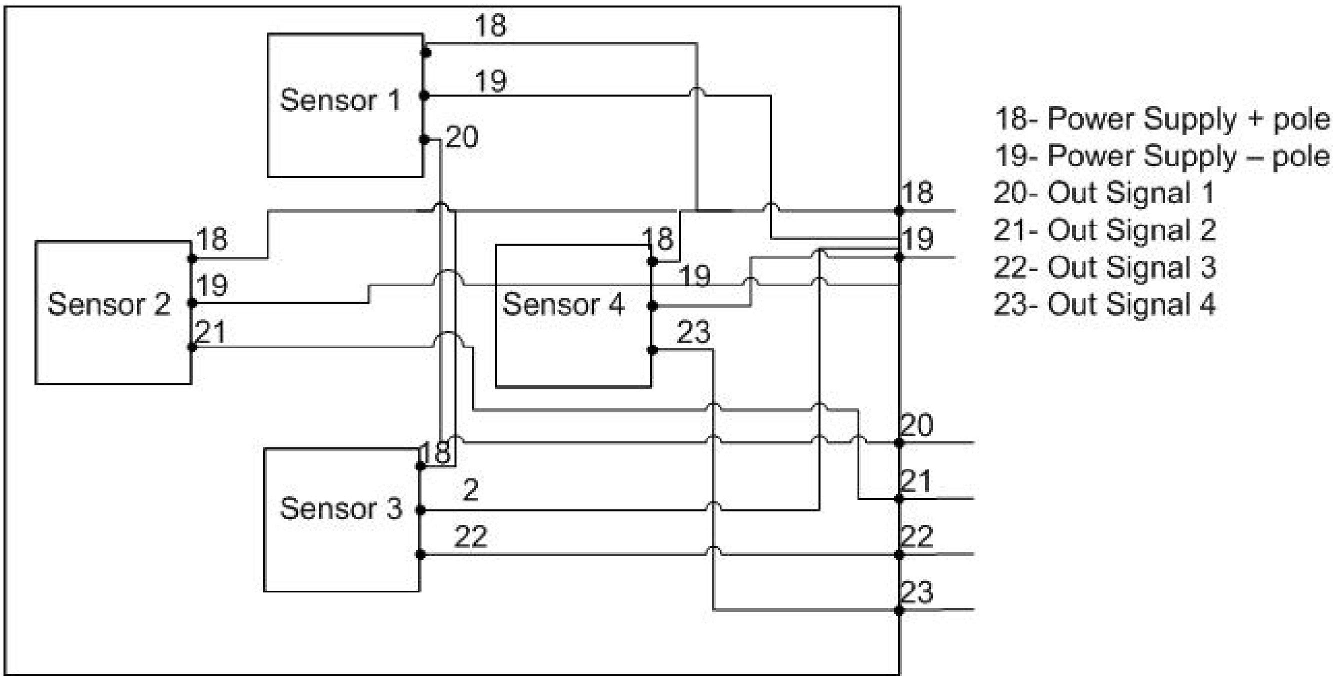

Figure 6