IMPROVEMENTS RELATING TO HAND HELD ANALYTICAL DEVICES

Field of the Invention

[0001] The present invention is related to an improved handheld analytical device and, more particularly, to an improved handheld analytical device which incorporates a static discharge element.

Background of the Invention

[0002] Handheld meters that are used for analysis of clinical samples, for example blood, interstitial fluid, urine, at the bedside, in the doctor's clinic or for home use, can be adversely affected by electrostatic discharge. Such meters, which are often based on the principles of electrochemical detection, typically make use of disposable test sensors. Test sensors are inserted through a small aperture in the case of the meter, wherein they make contact with a port. The port contains a series of connectors that make electrical contact with the test sensor. Proper contact is required for the correct operation of the analytical system. Typical measurements that may be made using such technology include glucose, HbA1c, ketones, and hematocrit.

[0003] Static electricity will build up in the body of a human walking around a room with a floor covering of man-made fiber, for example nylon carpet or vinyl floor covering; similarly sitting on a stool or chair of man-made materials can also lead to the build up of static within the human body. It is not uncommon for static charge exceeding 30kV to be developed, depending upon the temperature and relative humidity of the environment. Static will discharge from a body when it approaches or contacts material of differing potential, or is connected to ground. Static discharge will typically follow the easiest route to ground, thus for example; lightning is conducted to ground through a pointed lightning conductor attached to a building in preference to discharge through the building itself. As a general rule, static charge of 1kV will discharge across an air gap of 1mm, thus a 30kV charge could potentially bridge a gap of 30mm.

[0004] When someone that has developed a high static charge uses a handheld meter as described above there is a significant risk that discharge of static into the meter could occur, particularly when the user inserts a test sensor. The connector within the port of the

meter where test sensors are inserted is vulnerable to static discharge. More specifically, the circuits and components of the meter that are electrically joined to the connector of the port can be physically damaged if they are exposed to static discharge. Therefore there is a need to alleviate this problem.

[0005] The discharge of static to a meter, or more specifically the port of the meter, could occur under several circumstances, for example: i) a user who has developed a high static charge picks up a meter that has been kept in a bag or cupboard, i.e. the meter is at a different potential charge to the user; ii) a user who has carried a meter in their pocket hands it to another individual, for example a health care professional, who has a different potential charge; iii) the meter comes in contact with an object of different charge such that the gap between them is in the range for static discharge to occur. Under each of these circumstances and possibly others the discharge of static to the connector in the meter could lead to physical damage of the critical circuits and components. Since a malfunctioning meter can be the result of electrostatic discharge (ESD) there is a need to alleviate such effects.

[0006] Methods that are currently in use to alleviate the damaging effects of ESD on sensitive circuits and components on a printed circuit board (PCB) involve the incorporation of surge protection devices, which are costly and relatively complex components. The use of such components, which are based on integrated circuit designs, adds an additional level of complexity to the circuitry into which they are incorporated. There is thus a requirement for further additional testing to validate the integrity of the of the PCB assembly. It must be shown that all of the electrical connections on the PCB have been correctly formed, free from short circuits or other defects. Thus the development of alternative methods and means to alleviate the effects of ESD that can be incorporated more readily into a PCB layout are required.

Summary of the Invention

[0007] The present invention is directed to a meter for the detection of glucose, the meter including an opening adapted to receive glucose monitoring strips, the meter comprising a conductive pad at the opening arranged such that the strip contacts the pad when the strip is inserted into the meter and a plurality of conductive spikes connected to the pad and

arranged to contact the strip as it is inserted into the meter to discharge any static electricity resulting from the insertion of the strip into the meter. The present invention is further directed to a meter wherein the conductive spikes include a plurality of pointed ends positioned at the opening. The present invention is further directed to a meter wherein the conductive spikes are connected to an electrical ground. The present invention is further directed to a meter wherein the meter includes a battery and the conductive spikes are connected to the battery. A meter according to Claim 4 wherein the battery includes a negative terminal and the conductive spikes are connected to the negative terminal of the battery.

Description of the Figures

[0008] The invention will now be described, by way of example only, with reference to the following figures.

[0009] Figure 1 is a perspective view of the inside of a meter showing a prior art strip port connector such as that provided in an Ultra or Fast Take meter available from LifeScan Inc., Milpitas, CA, USA. The strip port connector is enlarged in the insert for clarity.

[0010] Figure 2 is a perspective view of the inside of a meter according to one embodiment of the invention showing a printed circuit board with a strip port connector incorporating an antistatic bar. The strip port connector is enlarged in the insert to show the relationship between the strip port connector and the antistatic bar in this embodiment.

[0011] Figure 3 is a schematic cross section of a meter according to one embodiment of the invention with a strip port connector mounted on a printed circuit board (PCB) with no strip present.

[0012] Figure 4 is a schematic cross section of the meter of figure 3, showing a strip approaching the port of the meter.

[0013] Figure 5 is a schematic cross section of the meter of figure 3, showing the strip approaching and entering the meter so as to touch the edge of the spring pin.

[0014] Figure 6 is a schematic perspective view of the meter of figure 3, showing three individual spring pins, when no strip is present, along with the antistatic bar near the front edge of the PCB, which is the first point of electrical contact for an incoming strip.

[0015] Figure 7 is a schematic perspective view of the meter of figure 3, with a sensor strip fully inserted, showing three spring pins touching separate contact pads on the strip.

[0016] Figures 8A and 8C show top and bottom plan views of the strip port connector, and Figures 8B and 8D show cross sections through the strip port connector that indicate the location and profile of the spring pins.

[0017] Figure 9 shows a plan drawing of the top of a printed circuit board, which indicates the location of the antistatic bar according to one embodiment of the invention and the contact points that are used to attach the strip port connector.

[0018] Figure 10 shows a plan drawing of the bottom of the printed circuit board, which indicates the location of the antistatic bar according to one embodiment of the invention and the contact point for the negative battery terminal.

[0019] Figure 11 shows a cross section of the printed circuit board shown in Figures 10 through line C-C and highlights the antistatic bar on each surface connected through the board by a via hole. The negative of the battery terminal is also shown, connected to the antistatic bar by a conductive track.

[0020] Figure 12 shows a plan drawing of the upper surface of a printed circuit board according to a fourth embodiment of the invention.

[0021] Figure 13 shows a plan drawing of the lower surface of a printed circuit board according to a fourth embodiment of the invention.

[0022] Figure 14 shows a plan drawing of the printed circuit board of Figure 12 showing a strip port connector in place, indicating the relationship between the case of the meter in proximity of the strip port and the PCB.

[0023] Figure 15 shows a cross section taken through Figure 14 through line D-D and shows the relation ship between the PCB and the case of the meter.

[0024] Figure 16 shows a set of alternative embodiments of the antistatic bar.

Detailed Description of the Invention

[0025] Figure 1 is a perspective view of the inside of a prior art meter, showing a connector that is used to make electrical contact with a disposable test sensor for measuring an analyte or indicator such as glucose mounted on a printed circuit board 2. One example of such a meter is an Ultra or Fast Take meter available from LifeScan Inc.,

Milpitas, CA, USA. The figure includes an expanded view of the connector for clarity. A number of electronic circuits and components (not shown) are assembled on the surface of printed circuit board 2 to form a working meter. The circuits terminate at the connector 6 into which test sensors such as disposable test strips (not shown) are inserted in preparation for making a measurement of a clinical sample. The connector 6 has five individual spring pin contacts 8, 10, 12, 14 and 16, that make electrical contact with individual conductive connection pads on a test sensor (not shown) and in so doing forms a complete analytical system.

[0026] The individual spring pins or connectors 8, 10, 12, 14 and 16, which are resiliently biased towards the printed circuit board (PCB) 2, are held within a support 4 that is physically mounted on the surface of PCB 2. In the absence of a test sensor there is usually a small air gap, typically less than 1mm, between the ends of spring pins 8, 10, 12, 14 and 16 and the surface of PCB 2. The purpose of this air gap is to ensure that spring connectors 8, 10, 12, 14 and 16 are not under stress at the point of manufacture. If the stress experienced by the spring pins 8, 10, 12, 14 and 16 is not controlled at manufacture it could lead to premature failure of the component and hence the meter.

[0027] The spring pins 8, 10, 12, 14 and 16 are fixed within support 4 mounted on PCB 2 and form what is termed a strip port connector (SPC) 6. A groove in support 4 provides a channel 18 on the surface of PCB 2 that allows for guided insertion of a test sensor (not shown), such that it makes electrical contact with spring pins 8, 10, 12, 14 and 16. More specifically electrical contact is made between individual spring pins 8, 10, 12, 14 and 16 and distinct conductive contact pads on the test sensor that allow a measurement to be made on the strip by the meter. A conductive pad 17 is provided part way between SPC 6 and the edge 15 of PCB 2. Pad 17 has two portions on the upper surface of PCB 2 spaced apart to allow a strip to be inserted into channel 18 without traveling over the conductive pad 17. A further part of pad 17 is provided as a continuous bar on the underside of PCB 2, shown by the dotted box in the figure.

[0028] Figure 2 is a perspective view of the inside of a meter according to one embodiment of the present invention, which has been modified to include a conductive bar 26. The figure shows one possible geometrical relationship between conductive or antistatic bar 26 and SPC 6 mounted on PCB 2. SPC 6 is used to make electrical contact

with a strip 32 (shown in Figure 7). The figure includes an enlarged view of SPC 6 for clarity.

[0029] Conductive pad 26 is located directly in front of SPC 6 on the surface of PCB 2 with one or more (here three) individual, conductive, spike-shaped pads 68 distributed across the gap in front of strip channel 18. Spikes 68 point in the direction of edge 15 of PCB 2, i.e. towards the direction from which a strip would approach SPC 6. Conductive pad 26 has, in this example embodiment, a common rail 64 located at the rear of the pad between the spikes 68 and SPC 6. Also, in this example embodiment there is one identical conductive pad (not shown) on the underside of PCB 2 directly beneath antistatic bar 26. Conductive vias (not shown) are provided between the conductive pads 26 on the two surfaces of the PCB at end pads 70. In this embodiment conductive pad 26 is opposite but not touching edge 15 of PCB 2. In addition, two parts to pad 26 are provided, each on one of the upper and lower surfaces of PCB 2. The two parts may be identical or similar, for example each may have the same or different numbers and geometry of spikes 68. Spikes 68 are closer to the entrance port of the meter (shown as item 28 in Figure 3 for example) than pins 10, 12 and 14. Therefore when a highly charged item is brought close to the port, charge will be induced primarily at the sharp corners of conductive pad 26 and in particular at the acute angled corners of sharp spikes 68, instead of pins 10, 12 and 14. Both conductive bars 26 on the top and bottom of PCB 2 including spikes 68 are connected to the ground of the PCB. This helps to divert any spark that may enter the meter to PCB ground.

[0030] Conductive pad 26 is an integral part of PCB 2 and can be printed alongside other PCB conductive tracks and pads. As such conductive pad 26 requires no additional components to be applied to the PCB during assembly. Therefore the manufacture and validation of the assembled PCB is simplified when compared with the use of surge protection components as described above.

[0031] The meter is based upon a central processing unit (CPU), along with associated memory chips, and other components, electrically joined together by conductive tracks on the surface of PCB 2. The correct operation of the meter is dependant upon the CPU being constantly under power, which is necessary to maintain the real-time clock function. When the meter, or more specifically the CPU, is in a power saving mode, i.e. when it is not

being used to make a measurement of test sample, spring pins 8, 10, 12, 14 and 16 are vulnerable to electrostatic discharge (ESD) from charged objects that come sufficiently close for a spark to jump from the object to the pins. Indeed, ESD can occur at any time when an object at one potential e.g. a finger, strip or something else, is brought up to a meter sitting at a different potential. Equally, the meter is at risk when under power in the absence of a strip, which can be the case when a user is making use of in built data management facilities of the meter. There is also a risk of ESD damage when a test sensor is present in the meter during use. A user, having inserted a test sensor, places the meter on a table, for example. The user may then move or walk about the room, during which time they may develop a significant static charge. When applying a blood sample to the test sensor, ESD could therefore occur.

[0032] As described above, a person can develop static charge in excess of 30kV. If a meter were to be used by such a person it could therefore experience ESD up to and exceeding 30kV, which would imply a discharge gap in excess of 30mm. The circuits and components of the meter are vulnerable to ESD especially when the meter is being handled by a user or health care professional prior to making a measurement. The discharge of static into the meter conducted by spring pins 8, 10, 12, 14 and 16 can lead to physical damage of the circuits and components of the meter. Thus, following an ESD event the meter may no longer function correctly.

[0033] Spring pins 8 and 16 are used to control whether the meter is in power saving mode or is ready to make a measurement. The meter never completely switches off. When there is no test sensor present within the meter it enters power saving mode to conserve battery life; because of an onboard real-time clock the meter can never completely switch off. In this embodiment of the invention when a conductive track is introduced between pins 8 and 16 the meter is brought out of power saving mode in readiness for making a measurement, as described in patent number WO 01/67099 A1 (Attorney Docket Number: DDI-008 PCT), the contents of which are incorporated herein. Spring pins 10, 12 and 14 are involved with the measurement aspect of the meter; each makes contact with a specific electrode pad on the test sensor thereby completing the analytical system, thus enabling measurements of test sample to be made.

[0034] Figure 3 is a schematic cross section of a meter 20 with SPC 6 mounted on PCB 2 when no strip is present . The meter 20 has an external case 22 which houses and supports PCB 2 upon which SPC 6 is mounted along with additional circuits and components (not shown) required for functional operation of meter 20. A small hole or strip port 28 is provided in the case of meter 20 to allow for insertion of a test sensor (not shown). Strip port 28 is adjacent to SPC 6 mounted on PCB 2, such that when a test sensor (not shown) is inserted through the strip port 28 it engages with SPC 6. SPC 6 comprises a support 4 that is physically attached to the surface of PCB 2 and a series of spring pins 24 that are resiliently biased towards PCB 2. In this second embodiment of the invention a conductive pad 26 is provided on the top of PCB 2 immediately adjacent to edge 15 that is closest to strip port 28. A conductive track on the surface of PCB 2 (not shown) joins conductive pad 26 to PCB ground, which is represented by a negative terminal of the system battery.

[0035] The PCB 2, upon which the components and circuits of meter 20 are assembled, is prepared according to the standard procedures and practices for manufacturing such a component. The copper layers on each surface of the PCB 2 are etched to reveal the conductive tracks that define the meter circuit and join the individual components that are required for meter operation. It is common for some areas of copper that are revealed on the PCB during the etching process to be coated by a layer of gold using the process of electroplating. The process of gold coating, which provides an inert conductive layer, is generally used when an area of the PCB is designed as a contact point for an external component, for example a strip, where a clean electrical bridge is required. In the present invention an additional area of copper track is preserved on the upper and optionally the lower surfaces of PCB 2 to provide conductive bar 26 at a location closest to strip port 28 of meter 20. This area of copper is coated with a layer of gold that is typically .04 to 1 μm thick to form bar 26. The gold-coated area 26 is connected to PCB ground. PCB ground is effectively the negative terminal of the system battery.

[0036] Because antistatic bar 26, which is directly connected to PCB ground, is in close proximity of strip port 28, it will effectively attract and trap most stray static that discharges into strip port 28 and conduct it to PCB ground. In so doing, antistatic bar 26 can allay potential damage to the static sensitive circuits and components of PCB 2.

[0037] Figure 4 is a schematic cross section of the meter 20 of Figure 3, showing a test sensor herein referred to as a strip 32, approaching strip port 28 of meter 20 . Arrow 30 indicates the direction of movement of strip 32 towards strip port 28. Strip 32 comprises a base material 36 onto which are screen-printed a series of conductive tracks (not shown) that connect electrode pads 34 to sample application area 38. The base 36 of strip 32 can be formed using, but is not limited to for example, ploybutylene teraphthalate available as Valox FR-1 from General Electric Structured Products, GEC, Pittsfield, MA, USA, or polyethylene teraphthalate available as Melinex ST328 from DuPont Teijin Films, Hopewell, VA, USA. Such polymeric materials are well known for their electric insulation properties and provide a suitable substrate to receive screen-printed conductive tracks.

[0038] Sample application area 38 provides a defined area on strip 32 to which test sample such as blood, urine or interstitial fluid can be applied. Electrode pads 34 are in electrical contact with a series of electrodes beneath sample application area 38. The electrodes beneath sample application area 38 typically comprise a "working" electrode, at which the relevant measurement is made and a "counter/reference" electrode, which completes the circuit and is required for functional operation of strip 32, as described in patent number US5,708,247 (Attorney Docket Number: DDI-002 USA). The presence of sample application area 38 over the working and counter/reference electrodes defines a specific dimensional area such that all strips manufactured according to a given design yield the same response, within acceptable error limits, when used to analyze a predefined sample solution, for example a control standard.

[0039] Strip 32, which is typically disposable, is designed to make a single measurement of a clinical sample, e.g. blood, interstitial fluid or urine. Strips can be used to assay for the presence of several key indicators that are regularly used in the management of patients at the bedside or in the doctor's surgery or for self-monitoring in the home. Examples of such indicators include, but are not limited to, glucose, lactate, ketones, HbA1c or hematocrit.

[0040] A range of strips are available for the measurement of blood glucose, for example, the One Touch Ultra strip from LifeScan Inc., Milpitas, CA, USA; the Optimum Test strip from Medisense, Abingdon, Oxon, UK; Ascensia Glucodisc from Bayer Plc, Newbury, Berks, UK.

[0041] The conductive tracks (not shown) on the surface of strip 32 that join electrode pads 34 to sample application area 38 are close enough to the end or sides of strip 32 such that a user handling the strip could make electrical contact with the conductive tracks. Thus it is possible for a user holding strip 32 to discharge static electricity through the strip to a conductive object, for example the circuits and components of meter 20. However, it is more likely that ESD can occur to the meter 20 from a user who has been separate from the meter for a time, such that there is a potential difference between the user and the meter. In particular, ESD from a finger of a user to SPC 6 can occur, for example, when the user moves to pick up the meter 20 from a table.

[0042] In the case of the prior art, as depicted in Figure 1, spring pins 10, 12 and 14 conducted ESD power from the user to the circuits and components of meter 20, leading to damage of critical system components and ultimately failure of meter 20. The presence of antistatic bar 26 in the present embodiment of the invention is intended to divert ESD from the user away from spring pins 24 to PCB ground, thus alleviating potential damage of the critical system components. This is because a strip, finger or other object approaching port 28 "sees" bar 26 before it "sees" pins 24. Also bar 26 is as close as possible to port 28, by being at the very end of PCB 2, in other words immediately adjacent edge 15. Furthermore, the shape of the antistatic bar 26 is such that a charge density will build up around the points and thereby attract any ESD power.

[0043] Figure 5 is a schematic cross section of the meter of figure 3, showing strip 32 sliding over conductive bar 26 and touching the edge of spring pin 24 . Charge from strip 32 is conducted to PCB 2 ground by conductive bar 26 either before and/or during contact of strip 32 with SPC 6. Any potential difference between meter 20, or more specifically the conductive circuits and components on PCB 2, and the incoming strip 32 will have been equalized by the point of initial contact between strip 32 and spring pins 24. Therefore the risk of ESD damage to the circuits and components of meter 20 as strip 32 is pressed into contact with spring pins 24 is greatly reduced compared with the prior art cf. Figure 1.

[0044] Figure 6 is a schematic perspective view of the meter of Figure 3, showing three individual spring pins 10, 12 and 14 each facing forward in the direction of strip port 28, when no strip is present. A conductive bar 26 with three forward facing spike portions 68

is clearly visible at the front edge 15 of PCB 2. Bar 26 and in particular spikes 68 are the first point of electrical contact for any spark that may enter strip port 28. Thus bar 26 will act to divert most and in some cases all incoming static charge to PCB ground and thus allay potential damage of the critical system components and circuits. The relationship between strip port 28 and SPC 6 is also evident. The support 4 defines the depth to which an incoming strip 32 can be inserted into meter 20. Spring pins 8 and 16 can be seen behind spring pins 10, 12 and 14. In the case of the prior art meter in Figure 1 the absence of antistatic bar 26 meant that spring pins 10, 12 and 14 were the first and sharpest point of contact for any static that could discharge into meter 20 through strip port 28.

[0045] Conductive bar 26 has been designed in an attempt to attract static from all points outside strip port 28. The sharp points of the three triangular spikes 68 are intended to develop a highly charged electric field in the proximity of the points when approached by a charged object at a different potential. In other words, charge is induced at the point of the spikes. This provides a means to focus and attract the charge on the charged object that may enter strip port 28. Thus, when an oppositely charged body comes in close proximity of strip port 28, a spark will jump between the spikes 68 of antistatic bar 26 and the incoming object, for example the finger of someone picking up a meter 20 that has been on a table, discharging the charge safely to PCB ground.

[0046] The unique design as well as the close proximity of conductive bar 26 and in particular in this embodiment the spikes 68 to the edge 15 of PCB 2 is such that any highly charged object that approaches strip port 28 will discharge to it in preference to spring pins 10, 12 and 14. Static is thus diverted to PCB ground away from the static sensitive components and circuits of meter 20, conducted by bar 26. Thus the risk of potential damage of the meter 20 and more specifically the static sensitive components is greatly reduced compared with the prior art. Spikes 68 may have an obtuse, perpendicular or more particularly an acute angle at the sharp point. Indeed the spikes may have a sharp point and an elongate body before joining rail 64 (as seen in Figures 12, 13 and 14).

[0047] Figure 7 is a schematic perspective view of the meter of Figure 3, with a strip 32 present in SPC 6, showing spring pins 8, 10, 12, 14 and 16 touching separate contact pads on strip 32. In this embodiment of the invention the initial contact between spring pins 12 and 16 through electrode pad 44 on strip 32 provides a signal to the CPU of meter 20 that

brings it out of power saving mode in readiness to make a measurement of test sample. The use of spring pins 12 and 16 in this way is an improvement over the prior art, cf. Figure 1, wherein the connecting of spring pins 8 and 16 by a unique electrode pad on strip 32 was required to bring the CPU out of power saving mode, as described in patent number WO 01/67099 A1 (Attorney Docket Number: DDI-008 PCT). In the present invention the use of spring pins 12 and 16 as the mechanism to bring the CPU out of power saving mode, instead of spring pins 8 and 16, allowed for simplified manufacturing of strip 32. The connection between spring pins 12 and 16 is made by electrode pad 44 on test strip 32. The use of electrode pad 44 in this way has virtually no impact on the measurement performance of strip 32 or meter 20.

[0048] The connections made between spring pins 12 and 14 and electrode pads 44 and 46 on strip 32 respectively are involved with the functional aspect of meter 20. Electrode pad 44 is connected to the counter/reference electrode and electrode pad 46 is connected to the working electrode beneath sample application area 38 on strip 32. When a test sample is applied to sample application area 38 a measurement reaction is initiated and a signal that is proportional to the concentration of analyte, for example glucose, is generated and displayed as a concentration value on the display of meter 20. Spring pins 8 and 10 of SPC 6 serve no functional purpose in this embodiment of the invention, they exist because of the common component usage between different meter systems, cf. the Ultra or Fast Take Meters produced by LifeScan Inc., Milpitas, CA, USA, as shown in Figure 1. Although spring pins 8 and 10 are electrically connected to PCB 2 at points 56 and 62 respectively, as shown in Figure 9, no conductive tracks exist on PCB 2 beyond the surface mounting points. The risk of ESD damage due to contact with spring pins 8 and 10, and indeed spring pin 12 which represents PCB ground, is thus negligible compared with spring pins 14 and 16, which are electrically connected to the functional circuits and components of the meter 20.

[0049] Figure 8A shows a plan view from above of support 4, with the associated spring pins 8, 10, 12, 14 and 16. The figure shows the relative positions of spring pins 8, 10, 12, 14 and 16 respectively within support 4. Spring pins 8 and 16 are fixed within support 4 such that their ends lie beneath spring pins 10 and 14 respectively. Thus when strip 32 is inserted into SPC 6 assembled on PCB 2 spring pins 10, 12 and 14 make initial contact

with strip 32, followed by spring pins 8 and 16; ESD is therefore more likely to occur to spring pins 10, 12 and 14. A means to prevent or greatly reduce the likelihood of ESD from a charged object to spring pins 10, 12 and 14 is preferably required.

[0050] Figure 8B shows a cross section taken through Figure 8A along the line marked A-A. The cross section A-A shows the shape of spring pins 10, 12 and 14, and more specifically represents the forward facing spring pin 12 that makes contact with electrode pad 44 on strip 32. Arrow 54 points to the portion of spring pin 12 that makes direct electrical contact with electrode pad 44 on strip 32. The profile of spring pin 12 is such that when SPC 6 is assembled on the surface of PCB 2 an incoming strip 32 will cause pin 12 to move upwards away from the surface of PCB 2. The material from which the spring pins 8, 10, 12, 14 and 16 are manufactured is such that when a strip 32 is present in the SPC 6, the resilient bias of the spring pins 8, 10, 12, 14 and 16 towards the surface of the PCB 2 holds strip 32 in place. When the strip 32 is removed from SPC 6, spring pins 8, 10, 12, 14 and 16 return to their original position.

[0051] Figure 8C shows a plan view from below of support 4, with the associated spring pins 8, 10, 12, 14 and 16. The figure shows the relative positions of spring pins 8, 10, 12, 14 and 16 respectively within support 4. The dimpled ends of spring pins 8 and 16 that make contact with strip 32 are evident. The support legs 50, that are used to attach support 4 to PCB 2, are also shown.

[0052] Figure 8D shows a cross section taken through Figure 8C along the line marked B-B. The cross section B-B shows the shape of the spring pins 8 and 16, which are involved with the switching on/off of meter 20. Arrow 52 points to the dimple on the end of spring pin 16 that makes electrical contact with the surface of strip 32. The spring pins are deflected away from the surface of PCB 2 when a strip 32 is inserted into SPC 6. The profile of spring pins 8 and 16 differs from that of spring pins 10, 12 and 14 because they experience different mechanical forces when strip 32 is inserted.

[0053] Figure 9, which represents one embodiment of the present invention, shows a plan drawing of the top surface of PCB 2, which indicates the location of conductive bar 26 and holes 58 that are used to attach SPC 6 to PCB 2. The support legs 50 of support 4 (see Figure 8) locate within holes 58 through the surface of PCB 2, wherein they are fixed. Spring pins 8 and 16 are electrically bonded to points 56 and 57, whereas spring pins 10,

12 and 14 are electrically bonded to points 62, 63 and 65 respectively on PCB 2. Bar 26 comprises a common rail 64 onto which are fused the static attracting spikes 68 and connection pads 70. There are two holes, referred to as conductive vias that pass through the surface of PCB 2 beneath connection pads 70. The via hole is used to make electrical connections between copper tracks on each surface of PCB 2, permitting circuits to continue from one side of the PCB to the other.

[0054] Figure 10 shows a plan drawing of the bottom surface of PCB 2, which indicates the location of bar 26 and the contact pad 74 for the negative battery terminal. When PCB 2 is assembled within the outer casing of meter 20, the squat spikes 68 of bar 26 are directly aligned behind strip port 28. Virtually any static entering strip port 28 will thus be conducted to PCB 2 ground by antistatic bar 26.

[0055] The integration of antistatic bar 26 as part of the basic conductive copper track on the surface of PCB 2 provides a simple and reproducible means to equip PCB 2 with inherent protection from ESD. It is a technique that can be readily adopted for the manufacture of a range of PCB layouts that are to be used in the production of meters designed to accept disposable test sensors for the measurement of analytes and indicators of clinical significance, for example blood glucose. However, such meters could equally be used to measure indicators of environmental or other significance, where the analyte of interest can be made in aqueous solution.

[0056] Figure 11 shows a cross section through the PCB shown by line C-C in Figure 10. The section highlights the conductive bar 26 and negative terminal of the system battery 74. The bar 26 comprises two portions 26A and 26B, one on each side of PCB 2. Two vias 84 one or sometimes two between each pair of pads 70 form a connection through PCB 2, thus providing an electrical bond between the two halves of bar 26A and 26B respectively. A conductive track 40 on the lower surface of PCB 2 connects antistatic bar 26B to the negative terminal of the system battery 74. Thus any static discharged to antistatic bar 26 is directed to PCB ground and is diverted away from the critical system components and circuits. The inclusion of two conductive areas, 26A and 26B, on each surface of PCB 2 acts to maximize the chance of trapping stray static, thus minimizing the potential risk of ESD to the critical system components. Bar 26 is thus situated to fully cover strip port 28 with respect to incoming sparks that might discharge from a strip 32 or other charged

object coming sufficiently close to strip port 28 that ESD might occur from the object to the conductive circuits and components of the meter.

[0057] Figure 12 shows a plan drawing according to a fourth embodiment of the invention of the uppermost surface of a PCB 2. The figure shows a range of conductive tracks 100 that are involved with the functional aspect of meter 20, and as such they are shown for reference only. When PCB 2 is assembled in case 22, strip port 28 is in direct contact with the edge 15 of PCB 2. The spikes 68 of antistatic bar 26, which extend to the edge of PCB 2, therefore terminate at the opening of strip port 28. They are thus placed to intercept any sparks that might bridge into strip port 28 from any charged object that comes sufficiently close, for example a strip 32, or the finger of a user. The three sharp spikes 68 of bar 26 are each aligned opposite a spring pin 10, 12 or 14 respectively. Induction of high density charge fields at the pointed most ends of spikes 68 will therefore preferentially induce a spark to jump to bar 26 through sharp spikes 68 instead of to spring pins 10, 12 or 14.

[0058] Figure 13 shows a plan drawing of the underside of the PCB shown in Figure 12. The figure shows a range of conductive tracks 100 that are involved with the functional aspect of meter 20. Conductive or antistatic bar 26, which exists on both the upper and lower surface of PCB 2, are joined through PCB 2 by two pairs of vias beneath connection pads 70. Antistatic bar 26 is connected to the negative terminal 74 of the system battery by conductive track 40. The presence of antistatic bar 26 on both surfaces of PCB 2 will minimize the risk of any spark jumping to other conductive points on PCB 2 that might lead to damage of the static sensitive components of meter 20.

[0059] Figure 14 shows a plan drawing of the PCB of Figure 12 to which has been added a strip port connector 6. The figure also indicates the relative position of case 22 in the proximity of SPC 6. In particular the close contact between edge 15 of PCB 2 and strip port 28 is clear. The alignment of spring pins 10, 12 and 14 behind sharp spikes 68 of bar 26 can be observed. The ends of spring pins 10, 12 and 14, the profile of which is shown in Figure 8B, terminate slightly above common rail 64 of the conductive pad 26, as will be seen more clearly in Figure 15. Strip port 28 is aligned directly in front of the spikes 68 of conductive pad 26. The pointed most ends of sharp spikes 68 touch the interface between edge 15 of PCB 2 and case 22 at strip port 28. Thus, with respect to an incoming strip or other highly charged item that approaches strip port 28, sharp spikes 68 of bar 26 are the

first conductive element of meter 20 to be encountered. Therefore it is likely that spikes 68 will induce a high point charge density and thus attract any sparks that should discharge from incoming objects.

[0060] The spring pins 8 and 16 are electrically bonded to points 56 and 57 and spring pins 10, 12 and 14 are electrically bonded to points 62, 63 and 65 respectively. Point 63 is connected to PCB ground and point 65 is connected to the CPU. The circuit formed between points 63 and 65 when a strip is present in SPC 6 in contact with spring pins 12 and 14 completes the analytical system.

[0061] Figure 15 shows a cross section taken through line D-D of Figure 14. Support 4 of SPC 6 is mounted on PCB 2 such that legs 50 penetrate holes within the PCB. Spring pin 12 is fixed within support 4 such that it faces towards strip port 28. Conductive pad 26, comprising parts 26A and 26B respectively, electrically connected through PCB 2 by via hole 84, commences at edge 15 of PCB 2 and terminates beneath the tip of spring pin 12. There is no direct contact between spring pin 12 and conductive pad 26.

[0062] The case 22 of meter 20 abuts edge 15 of PCB 2 to form strip port 28. The upper surface of PCB 2, upon which SPC 6 is mounted, is directly aligned with the surface of the case within strip port 28. The air gap between edge 15 of PCB 2 and case 22 is very small and virtually negligible. However, it is feasible that a spark could penetrate the gap. Hence conductive pad 26 is present on upper and lower surfaces of PCB 2 to attract incoming sparks and divert static to PCB ground. Incoming strip 32 will thus pass smoothly along the semi-continuous surface of case 22 and pad 26, making initial contact with spikes 68 of conductive pad 26 before entering SPC 6. Spring pins 8, 10, 12, 14 and 16 are deflected up, away from PCB 2 when a strip 32 is fully inserted into SPC 6.

[0063] Figure 16 shows a range of alternate embodiments of conductive bar 26. Any sharp geometry will act to intensify the electric field around the point, and as such it can be used to increase the probability that a spark will jump to that point. Static electricity is known to bridge between two conductive bodies of differing electrical potential when they come in close proximity. The purpose of bar 26 is thus to equalize any differences in potential between the circuits and components of meter 20 and a user, or other charged, conductive objects that come sufficiently close to strip port 28 that a spark could bridge the gap between the conductive components of meter 20 and the charged object. In normal use,

predominantly at the point of strip insertion, meter 20 is most vulnerable to the effects of ESD.

[0064] The alternate designs 90 to 98 represent various embodiments of antistatic bar 26, each making use of different conductor spikes 68. The example embodiment 26 is such that maximum protection of strip port 28 is provided. The individual conductor spikes 68 are aligned equally across PCB 2 behind strip port 28, and more specifically opposite and in some cases in line with spring pins 10, 12 and 14, thereby placing them to cover the entire strip port 28. The induction of a high charge density at the pointed most ends of spikes 68 serves to attract static and thus cause a spark to jump from the charged object approaching strip port 28 and antistatic bar 26 in preference to spring pins 10, 12 or 14. However, if the number of spikes 68 were to be increased this would have the effect of reducing the effective point charge density, thus decreasing the likelihood of a spark jumping to bar 26 in preference to spring pins 10, 12, and 14. In an extreme case bar 26 could exist as a solid rectangular bar in front of SPC 6. However, such a structure would not induce the same high point charge density, as for example is the case with the example embodiment 26. Therefore, such a structure would not be expected to provide any significant protection of meter 20.

Advantages

[0065] The present invention presents a simple, robust means of equipping the PCB used in the manufacture of hand held instrumentation designed to measure analytes of clinical significance with a means to allay the effects of ESD. For example, during the measurement of glucose using disposable sensor strips that are inserted into a meter through a strip port, it is possible for static to discharge from a user, via a strip, to the sensitive circuits and components of the meter. The addition of a conductive area at the front edge of the PCB, which is the primary point of electrical contact with the PCB, acts to transfer any stray static quickly and efficiently to PCB ground. In so doing the potentially damaging effects of ESD on the meter are thus minimized.

[0066] The inclusion of the antistatic bar, which is formed during initial processing of the PCB upon which the meter is based, requires no additional components to be added. It is a simple, cost effective means of including antistatic protection to the PCB. The structure of the conductive or antistatic bar is such that a common rail joins two conductive pads, one

at each end. The conductive pads are used to integrate two bars, one on each surface of the PCB, connected through the PCB by vias. A series of conductive spikes are provided on the common rail pointing towards the strip port, the purpose of which are to induce high point charge and thus provide a route for electrostatic discharge. The presence of a conductive bar on each surface of the PCB at the interface with the case is intended to attract and thus divert any static away from the sensitive components of the meter to PCB ground.

[0067] The case of the meter and more specifically the port through which strips are inserted has been designed such that when the PCB is assembled within the case a semi-continuous path is formed. An incoming strip will initially slide over the upper surface of the case at the mouth of the strip port. The strip will then make initial contact with the conductive pad and more specifically the sharp spikes of the conductive pad that lie across the interface between the PCB and the case. The strip will therefore discharge any static to the spikes before it makes contact with the pins within the connector that contact the individual electrode pads of the strip. Thus potential damage to the static sensitive components and circuits of the meter is allayed.

[0068] It will be recognized that equivalent structures may be substituted for the structures illustrated and described herein and that the described embodiment of the invention is not the only structure that may be employed to implement the claimed invention. In addition, it should be understood that every structure described above has a function and such structure can be referred to as a means for performing that function.

[0069] While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to hose skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

[0070] It will be recognized that equivalent structures may be substituted for the structures illustrated and described herein and that the described embodiment of the invention is not

the only structure that may be employed to implement the claimed invention. In addition, it should be understood that every structure described above has a function and such structure can be referred to as a means for performing that function.

[0071] While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to hose skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

WHAT IS CLAIMED:

1. A meter for the detection of glucose, said meter including an opening adapted to receive glucose monitoring strips, said meter comprising:

a conductive pad at said opening arranged such that the strip contacts said pad when said strip is inserted into said meter; and

a plurality of conductive spikes connected to said pad and arranged to contact said strip as it is inserted into said meter to discharge any static electricity resulting from the insertion of said strip into said meter.

2. A meter according to Claim 1 wherein said conductive spikes include a plurality of pointed ends positioned at said opening.

3. A meter according to Claim 2 wherein said conductive spikes are connected to an electrical ground.

4. A meter according to Claim 3 wherein said meter includes a battery and said conductive spikes are connected to said battery.

5. A meter according to Claim 4 wherein said battery includes a negative terminal and said conductive spikes are connected to said negative terminal.