

APPARATUS AND METHOD FOR WIRELESS CHARGING

FIELD OF THE INVENTION

- 5 The invention generally relates to electronics, in particular, non-contact power/energy transfer.

BACKGROUND OF THE INVENTION

- 10 With the advent of wireless communications, a myriad of handheld or portable devices has surfaced on the market on a global scale. At any one time, a consumer could be in ownership of a number of devices, such as laptops, mobile phones, personal digital assistants, shavers or electrical toothbrushes and game consoles in which these devices are still individually powered or charged via
15 electrical contacts through the mains. Suitable levels of power have to be individually converted using such means.

- As vendors have different or varied means of achieving power conversion, this implies a great deal of inconvenience when each individual or consumer carries
20 a multitude of power adaptors wherever they travel to.

- Apart from consumer electronics, the biomedical industry has taken great strides into applying wireless technologies into their domains. Applications such as medical telemetry use wireless technologies to convey information from within the
25 human body to external devices, giving medical practitioners a much improved apprehension of the internal workings and condition of the patient.

- For example, there is a need for miniaturized, reliable and hermetically sealed rechargeable sources for highly integrated and size limited, low power implantable
30 devices in applications such as drug delivery, glucose sensing, functional electrical stimulation, retinal prosthesis and endoscopy. These are just few of a multitude of biomedical applications whereby non-contact power transfer would be very suitable in powering these implants in an environmentally "green", safe, reliable and non-intrusive manner without much interference to other wireless platforms in use. This is
35 partly due to the well-established fact that magnetic fields interact weakly with most

surrounding materials. Magnetic fields can also be deemed relatively safe for such transmission usage as it also interacts very weakly with biological organisms.

Earlier attempts have been made to realize energy or power transfer via inductive coupling. One example is that seen in Braun Oral B Plak Control toothbrush whereby inductor coils on both primary and secondary devices are axially aligned to achieve an effective energy transfer. There is a need to provide a more convenient method of charging devices.

SUMMARY

The invention is an arrangement of two magnetic cores parallel to each other to generate a magnetic field for wireless charging.

One embodiment of the invention is an apparatus for wireless charging a device comprising a first and second magnetic cores, each having conductive windings, for generating a first and second magnetic fields, wherein the magnetic cores are positioned adjacent to each other.

Preferably, the magnetic cores are oriented with opposing polarities parallel to each other for forming a closed circuit with the generated magnetic fields.

Preferably, there is a third magnetic core having conductive winding and two opposing polarities for generating a third magnetic field, wherein the third magnetic core is positioned adjacent to the second magnetic core and parallel to the third magnetic core.

Preferably, the second and third magnetic cores are oriented with opposing polarities parallel to each other to form a closed circuit with the generated second and third magnetic fields.

Preferably, the magnetic cores are positioned apart.

Preferably, the apparatus includes a casing for containing the magnetic cores.

Still preferably, the magnetic cores are positioned in the casing and the magnetic cores are equidistant from the opposing sides of the casing.

- 5 Preferably, the apparatus is operatively connected with an AC/DC power adaptor to receive electrical power for providing electrical power to the windings.

Preferably, the apparatus is operatively connected with resonant converters to receive electrical power for providing electrical power to the windings.

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Preferably, the apparatus further includes an impedance sensing means for detecting a device for wireless charging.

- 15 Preferably, the apparatus further includes an infra red sensor for detecting a device for wireless charging.

Preferably, the apparatus is adaptable to operate with any electronic device.

- 20 In another embodiment, an apparatus for wireless charging a device comprising a plurality of magnetic segments, each magnetic segment having a first and second magnetic cores, each having a conductive winding, for generating a magnetic field, wherein the magnetic cores are positioned adjacent to each other and a casing for containing the magnetic cores.

- 25 Preferably, the magnetic cores are oriented with opposing polarities parallel to each other for forming a first closed circuit with generated magnetic fields.

Preferably, each pair of adjacent magnetic segments are oriented with the magnetic fields in opposite directions.

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Preferably, the apparatus is operatively connected with an AC/DC power adaptor to receive electrical power for providing electrical power to the windings.

- 35 Preferably, the apparatus is operatively connected with resonant converters to receive electrical power for providing electrical power to the windings.

Preferably, the apparatus further includes an impedance sensing means for detecting a device for wireless charging.

- 5 Preferably, the apparatus further includes an infra red sensor for detecting a device for wireless charging.

Preferably, the apparatus is adaptable to operate with any electronic device.

- 10 Another embodiment of the invention is a method for wireless charging a device, the method comprising providing a first and second magnetic cores having conductive windings and two opposing polarities, positioning the magnetic cores adjacent to each other and providing electrical power to the first and second conductive windings.

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Preferably, the method further includes orienting the first and second magnetic cores with opposing polarities parallel to each other for forming a first closed circuit with the generated magnetic fields.

- 20 Preferably, the method further includes providing a third magnetic core having conductive winding, positioning the third magnetic core adjacent to the second magnetic core and providing electrical power to the third conductive winding.

- 25 Preferably, the method further includes orienting the second and third magnetic cores with opposing polarities parallel to each other for forming a second closed circuit with the generated magnetic fields.

Preferably, the method detects the device for wireless charging.

- 30 Preferably, the method further includes determining if the battery voltage level of the device is below a first threshold, charging the device when the battery voltage level is below the first threshold, determining if the charging is complete, and terminating the charging when the charging is complete.

When the battery voltage level is above the threshold, the power supply is decreased.

- Preferably, the low dropout voltage is determined if it is above a second threshold. If
5 the low dropout voltage is below the second threshold voltage, the power supply is increased.

BRIEF DESCRIPTION OF THE DRAWINGS

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Figure 1 illustrates one embodiment of the invention with two magnetic cores.

Figure 2 illustrates one embodiment of the invention with three magnetic cores,

- 15 Figure 3 illustrates one embodiment of the invention being an array of magnetic segments, each segment having two magnetic cores.

Figure 4 illustrates a schematic of an AC to DC power adaptor.

- 20 Figure 5 illustrates a schematic of a single-ended, forward fly-back resonant converter with demagnetising circuit.

Figure 6a illustrates a top view of one magnetic segment.

- 25 Figure 6b illustrates a side view of one magnetic segment.

Figure 7 is a process diagram illustrating one embodiment of the invention.

- Figure 8a is a schematic of integrating a microcontroller on the secondary segment
30 circuitry with IR transmitter.

Figure 8b is a schematic of integrating a microcontroller on the primary segment circuitry with IR receiver.

Figure 9a is a layout of IR transmitters, magnetic cores and peripheral control circuitry on the secondary segment.

Figure 9b is a schematic of secondary coils and full bridge rectifying circuits.

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Figure 10a is a schematic of a primary segment implemented without a microcontroller

Figure 10b is a schematic of a secondary segment implemented without a microcontroller

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Figure 11 is a schematic representation of a USB shoot-through circuit to facilitate external USB connections

Figure 12 is an illustration of implementation of wireless connectivity solutions

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Figure 13 is an illustration of a controller attached with a secondary segment sitting on a primary segment mat

Figure 14 is a block diagram illustrating how the USB host controller is integrated in the secondary segment circuitry

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Figure 15 is an embodiment illustrating a method of fastening or joining an array of primary segments.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Single Magnetic Segment

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Figure 1 illustrates one embodiment of the invention. The apparatus 10 comprises two conductive windings of magnetic cores 12, 14 electrically connected in series and placed parallel to one another as seen in Figure 1 and this forms a primary magnetic segment. The windings can be orientated in any direction including diagonally. The magnetic cores are positioned adjacent to each other.

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Preferably, the magnetic cores are oriented with their opposing polarities parallel to each other. This arrangement generates a circular or elliptical magnetic field 16 when the windings are electrically powered. This magnetic field is in the same plane as the magnetic cores. Further, the magnetic field is rotational and can be polarized in either clockwise or anti-clockwise directions as depicted by the field lines. This primary magnetic segment is such that the first magnetic core 12 represents the primary side of a conventional transformer and the second magnetic core 14 as the secondary side of the transformer. The magnetic field lines arches from one magnetic core to the other depending on the orientation of the windings on the respective cores.

The leakage inductance or eddy current of the primary magnetic segment is induced on a secondary magnetic segment, resulting in power or energy transfer to the secondary magnetic segment. The secondary magnetic segment is a secondary circuit or receiving coil in communication with the battery of an electronic device. The power or energy transferred to the secondary magnetic segment is then converted or rectified for powering or charging the battery.

The primary magnetic segment or charging mat that is scalable for expansion dependent on the size and/or number of devices to be charged or powered.

Preferably, the magnetic cores are positioned apart from each other to allow heat from the magnetic cores to be dissipated to the ambient space. The space can be utilized for other peripheral circuitries.

Figure 2 shows another embodiment where a conductive winding of a third magnetic core 20 is positioned adjacent to any of the first or second magnetic core. Preferably, the third magnetic core 20 is positioned with its polarities opposing and in parallel to the polarities of the second magnetic core 14. Accordingly, this arrangement results in an additional circular or elliptical magnetic field 22.

Preferably, a casing 24 is provided for the apparatus to allow devices for charging to be placed on the casing for charging and for ease of handling the apparatus.

Preferably, the magnetic cores are positioned equidistant from the sides of the casing. As shown in Fig 2, the distances D1, D2 are the same as each other and D3, D4 are the same as each other. This is to ensure when the two primary magnetic segments are positioned adjacent and equidistant from each other, the casing forms a line of symmetry between them. This facilitates an even and distributed magnetic field set-up when multiple primary magnetic segments are utilised for expansion.

Magnetic segment configuration

- 10 Figure 3 illustrates multiple primary magnetic segments 10 joined together in all directions to form a larger charging or powering surface area to facilitate charging for more than one device simultaneously. The multiple primary magnetic segment forms a wireless mat for wireless charging.
- 15 In the prior art, a large surface formed from a primary magnetic segment requires more power. Therefore the applied voltage and components used in the power electronics circuits require a higher rating. In this invention, the combination and layout of multiple magnetic segments can lower the rating due to the distributed nature of the layout. Advantageously, the power consumption for each magnetic
- 20 segment is brought to a minimal optimum, thereby reducing the heat dissipation in the whole assembly. The dashed lines 30 depict the direction of magnetic field lines.

Preferably, adjacent primary magnetic segments are arranged with the orientation of the generated magnetic field in opposite directions. Figure 3 illustrates a plurality of

25 primary magnetic segments arranged with their magnetic fields orientated clockwise and anti-clockwise alternately. Primary magnetic segments 31, 33, 35, 37 and 39 are oriented clockwise and the others 32, 34, 36 and 38 are anti-clockwise. This ensures that the vector sum of the fields is not zero at any point on the wireless mat.

30 Adaptor/DC in the same unit

In another embodiment, an environmental friendly or "Green" AC to DC power adaptor 40 in accordance to the Energy Star rating's criteria is designed to supply the DC power to the wireless mat. A device having an Energy Star rating meets the

35 strict energy efficiency guidelines set by the United States Environmental Protection

Agency and the United States Department of Energy. This power adaptor allows power to be used efficiently for a no-load condition. This power adaptor is capable of drawing less than 0.3W when there is no load. This results in extremely low power consumption under no-load or standby conditions and in full compliance to qualify as an environmental friendly or "Green" product amidst current energy scarcity and consumption issues.

Figure 4 shows the power adaptor circuit which can be operatively connected to the wireless mat. During a nominal load operation, the circuit switches at one of the available frequencies. When the current set-point falls below a preset value, which may be due to the reduction in the output demand, the circuit enters a skip-cycle mode. This reduces the power loading, thus improving the efficiency of the power consumption. By skipping unneeded switching cycles, it drastically reduces the power wasted during light loads conditions. Further, if the Pulse Width Modulation ("PWM") controllers 42 used in the circuit have an inbuilt self supply, an auxiliary winding 44 can further decrease the standby power to extremely low levels by invalidating this dynamic self supply feature.

In this power adaptor circuitry, the PWM current mode controller chip used is NCP 1014. This chip is a complete current-mode control solution together with a high voltage power metal-oxide-semiconductor field-effect transistor ("MOSFET") in a monolithic structure.

Single-ended, Forward Fly-back Resonant Converter with Demagnetising circuit

Figure 5 shows the circuitry 50 for a forward fly-back resonant converter which can be operatively connected to the wireless mat. The circuit operates as both a fly-back converter and a forward converter. The mode of operation depends on the orientation of the secondary magnetic segment. When the energy is transferred during the turn-on period, it operates in the forward mode. When the energy is transferred during turn off period, the circuit operates in the fly-back mode. During the forward there will be stored energy in the magnetic primary. An effect called staircase saturation will occur which may cause the circuit to fail. A demagnetizing

circuit 52 as shown is used that allows the stored magnetic energy to be recovered and feedback to the input supply.

5 Preferably, the circuitry includes an impedance sensing block 54. This is for detecting a device for wireless charging.

Device detection and Identity Verification

10 In another embodiment, an electronic device is detected for wireless charging by infra red ("IR") sensors which are IR receivers and transmitters. An example of this embodiment is illustrated in Figures 6a and 6b. Figure 6a shows a top view of the placement of IR receivers 60 for a primary magnetic segment 62 and a corresponding secondary magnetic segment 64 and Figure 6b shows a side view. IR sensors 60 are placed in each corner and side of the primary magnetic segment 62.

15 A recess 66 for each IR receiver is indented into the casing 68 of the primary magnetic segment to facilitate lateral and longitudinal coverage of the IR receivers 60 and IR transmitters 70 mounted on the primary magnetic segment 62 and secondary magnetic segment 64 respectively. The secondary magnetic segment 64 is in communication with the battery of the electronic device. These IR sensors are

20 connected to a logic control circuitry that increases or switches on the magnetic field via frequency and/or voltage means to power or charge the battery through the secondary magnetic segment. Such a mechanism simplifies the electronic device detection solution, thereby reducing unnecessary power generation and its resulting losses.

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Further, the IR sensors can be used for identification purposes. Only secondary magnetic segments having IR transmitters which can be identified by the IR sensors can be charged. Non-proprietary secondary magnetic segments without the IR transmitters which can be identified by the IR sensors cannot be detected for power

30 or energy transfer.

The detection or communication means is not restricted only to IR systems. Other options include light emitting diodes ("LED"), radio transceivers such as Zigbee, Z-Wave etc, optocouplers, mechanical or electronic oscillators, audio transceivers,

35 ultrasonic transceivers and other means of load sensing circuits. The

communications or detection means can also be in the form of proprietary communication protocols existing in the host system which this wireless charging system is integrated in. This reduces the bill of materials ("BOM") and also system complexity, costs and performance of the overall integrated system.

5

IR Communication Protocol

Preferably, the primary magnetic segment pulses magnetic energy while waiting for an electronic device to be placed on it for charging. Once the electronic device is placed on the mat, the IR system communicates or detects via a series of pulses to determine whether the power generated by the primary magnetic segment should be increased, decreased, maintained or terminated. The form of signaling is not restricted to pulse trains as other forms of pulse and non-pulse signaling methods can also be implemented.

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Still preferably, threshold voltage and/or current ranges and limits are set to determine whether the power generated by the primary magnetic segment should be increased, decreased, maintained or terminated. The determination is performed by voltage and/or current sensing mechanisms. Charge controllers can also be used to determine charging and/or terminating status.

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Figure 7 is a process diagram illustrating one embodiment of the invention which is the process of wireless charging an electronic device having a battery.

In Step 701, the primary magnetic segment detects whether there is any electronic device for charging by sending a signal. If there is no electronic device detected, Step 702 continues to send the signal. If an electronic device is detected, Step 703 determines whether the battery voltage level is below a predetermined threshold. If the battery voltage level is not below the predetermined threshold, Step 704 sends a signal to decrease the power.

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If the battery voltage is below a predetermined threshold, or after Step 704, Step 705 determines whether the low dropout ("LDO") voltage is above the threshold. If the LDO voltage is not above the threshold, Step 706 sends a signal to increase the power.

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If the LDO voltage is above the threshold, or after Step 706, Step 707 determines whether the charging has completed. If the charging is completed, Step 708 sends a signal to terminate the charging.

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Additional Features

The primary magnetic segment can be embedded into any electronic devices powered from an electric mains. Examples of such electronic devices are mp3
10 players, dvd players, set-top boxes. In such applications, additional features or intelligences can be added to the functionality of both primary or/secondary magnetic segments. The secondary magnetic segments are embedded into electronic devices to be charged or powered by a battery.

15 After charging, the primary magnetic segment can send a signal to the secondary magnetic segment to switch it off or activate other task sequence.

Another feature is the primary magnetic segment running a preassigned task sequence when it detects the presence of secondary magnetic segments. Examples
20 of such tasks are:-

- activating an alarm clock on a bed side charging table when devices embedded or in communication with a secondary magnetic segment is placed on the primary magnetic segment
- switching on mobile phone to silent/vibration/off mode upon detecting
25 the presence of secondary magnetic segments (e.g. mobile phone – at bedside table)
- switching off all devices when a remote controller having a secondary magnetic segment is placed on the primary magnetic segment.

30 If the primary magnetic segment is standalone, when it detects that the device battery in communication with the secondary magnetic segment is full, it cuts off the power and stop the charging.

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Controller for Identity (“ID”) verification

Figures 8a and 8b illustrates a microcontroller 80 integrated in the primary magnetic segment 82 and secondary magnetic segment 84. This allows a detection and communication feature to be implemented to ensure that both the primary and secondary magnetic segments are using compatible technologies. This prevents unauthorized third party accessories which are incompatible with one authentic segment. Incompatible segments may cause hazardous results such as an explosion or fire. In an example of the implementation, if an incompatible secondary magnetic segment with a non-proprietary secondary winding or other forms of winding, the primary magnetic segment or wireless mat will not power up.

In an example of ID verification, the verification is done by encoding a unique signal pattern within the magnetic field during startup of the primary magnetic segment. Using a cross correlation technique, this signal pattern will be decoded and matched by the secondary magnetic segment. Only a compatible secondary magnetic segment can receive charge or power transmitted.

Multiple magnet segments and Multiple Bridges – Distributed rectifiers

In this embodiment, the receiving circuit or secondary magnetic segment is illustrated in Figure 9a. Four magnetic cores 92 with windings are positioned horizontally, two are positioned in series, spaced apart and parallel from the other two. Another four 94 are placed vertically, a pair is spaced apart from the other pair. This arrangement facilitates relatively good and sufficient pick-up of flux leakage via inductive coupling from the primary magnetic segments. The number of magnetic cores with windings on the secondary magnetic segment is not restricted to these numbers but cores can be added or removed to increase pick-up dependent on the device's form factor and power requirements. Therefore, the optimum coupling of energy from the primary magnetic segment to the secondary magnetic segment is largely determined by the number and size of magnetic cores, available space on the device and the device's power requirements. In addition, the shape of the magnetic cores is not restricted to square or rectangular forms, it can be in any other form such as circles or arcs. The space 96 is meant for embedding control and other peripheral circuits for the secondary magnetic segment.

Another feature of this secondary magnetic segment 97 is that each column or row of magnetic segments consists of a pair of magnetic cores with bridge rectifiers connected to each one of them as shown in Figure 9b. This distributed nature of
5 rectifying power or energy inductively coupled from the leakage flux reduces ratings of the components used, in particular, those in the rectifying block. Also, leakage flux pick-up can take place at most if not all corners of the device with no constraint on device orientation when placed on the primary magnetic segments.

10 IR transmitters 98 are placed for device detection and identification purposes as seen in Figure 9a. This provides an elegant, hardwired form of identification without any form of software interrogation. Additional identification functionalities can be incorporated such as using a combination of microcontrollers and sensors that can be embedded into the primary and secondary segments in a non-intrusive way.

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Secondary Receiver Circuit

In Figure 10a, the control circuitry of the primary magnetic segment is shown. There is at least one IR sensor 100 connected in parallel to detect the presence of at least
20 one electronic device on the primary magnetic segment. When the primary magnetic segment detects the presence of a device, the impedance of the IR receivers changes and this in turn produces a proportionate voltage on the voltage detector. The voltage detector, dependent on the threshold voltage setting, switches the transistor Q1 on to direct current flow via R1 and R3, to the current controlled
25 oscillator and this lowers the switching frequency of the power switch, thereby increasing the power coupling.

In another instance, the absence of the device or a fully charged device would deliver yet another proportionate voltage to the voltage detector to switch off Q1,
30 thereby, directing current flow through R1 and R2 to the current controlled oscillator to increase the switching frequency so as to reduce the power coupling, i.e. standby mode. A capacitor, C1 between R2 and R3, eases the transition from high to low frequency switching.

Figure 10b shows the schematic of circuits in the control circuits on the secondary magnetic segment. The rectified voltage from the secondary magnetic segment as described in an earlier embodiment is regulated by a Low Dropout Regulator (LDO). Voltage detector 1 is triggered to switch on Q1 when the rectified voltage is below a voltage threshold. With Q1 switched on, Q2 is also switched on to power up the IR transmitter, sending a signal to the IR receivers on the primary magnetic segments to power up. Voltage detector 2 serves a similar purpose as voltage detector 1 on the LDO's output voltage.

10 Charge selector for USB shoot through

Figure 11 shows the connections between the secondary magnetic segment 110, a shoot-through circuit 112, an electronic device 114 and an external universal serial bus ("USB") connection 116. Usually an electronic device has limited proprietary connecting ports. When a secondary magnetic segment is connected to the electronic device at the only proprietary connecting port, a user is unable to connect other accessories to the electronic device. This description, in particular, refers to USB connections but is not restricted to only USB connections and could encompass other proprietary connections.

As such, a shoot-through circuit 112 is placed in between the regulated output voltage from the secondary magnetic segment 110 to the electronic device. This circuit also accommodates an additional or multiple connections for USB or other proprietary connections dependent on the type of portable/handheld device.

Wireless connectivity solutions – Bluetooth, FM

Figure 12a and 12b are a perspective and a side view of the secondary magnetic segment adaptor 120 used with an electronic device 122. The electronic device sits with its back resting on the adaptor 120 via a physical connection. The connection is formed by a connector 124 interfacing the electronic device 122 and secondary segment adaptor 120. This physical connection is proprietary which means that it is dependent on the type of connection used in the device.

As shown in Figures 12a and 12b, the secondary magnetic segments circuitry 126 sits on the back of the adaptor 120. There is also space 128 for circuitries relevant to radio circuits or wireless connectivity solutions such as FM radio, Bluetooth and Zigbee and the like. The addition of radio circuits takes into account that the device
5 does not have any form of wireless connectivity functions.

FM radio transceivers can be incorporated to facilitate transmission of audio signals from the device to FM receivers in vehicles and at home. It can also double up as an FM receiver if the device is without FM receiving function. Bluetooth transceiver chips
10 can also be included for wireless communication functions such as beaming audio signals from the device to a wireless headset. Zigbee transceivers can be utilized for sensing and communication networking of multiple devices, in this case, multiple primary charging mats and secondary devices for charging.

15 **Application of Wireless Charging to Game Controllers**

Apart from powering or charging portable electronic devices, this method of wireless energy transfer can be adapted to another mass consumer market product such as game controllers in the likes of XBOX 360, Sony PS3, Nintendo Wii and Sony PSP
20 etc. Figure 13 shows the cross-section view of a Sony PS3 game controller 130. It is placed on top of a primary magnetic segment 132 and magnetic fields lines 134 flowing out towards the page fringes to the other magnetic core 136. This fringing magnetic field is harnessed or received by the secondary segment, thereby charging the console 130.

25 In the case of charging the Sony PS3 controller, a USB host controller is required to communicate with the controller before charging is allowed as seen in Figure 14. In this instance, a host microcontroller is implemented in the secondary magnetic segment to communicate with the controller, thereby replicating the role of a Sony
30 PS3 console.

Application of Wireless Charging without battery

Another mass market application that wireless charging could be applicable is
35 "instant" charging with wireless charging. By integrating latest energy storage

technologies (e.g. super capacitors etc.) into the current invention, it is possible to reduce one of the major pollutants, battery.

5 Due to the increased demands for greener and more sustainable usage of resources, There have been efforts to reduce rubbish / toxic waste or waste that take a long time to break down.

Battery technologies (including rechargeable) is not the perfect solution for energy storage as it has a limited/short lifespan. The energy storage capability starts to
10 deteriorate once they leave the factory and has a typical optimal lifespan of one to two years. After two years, the capacity will be reduced by approximately 20% - 35% per year.

To minimize the environmental impact, there is another method of supply power
15 without the need for batteries, without impacting the usability of the device, It will reduce the dependence on one of the limited resources used to manufacture batteries (e.g. Lithium etc.), that is to replace batteries with energy storage components that can last the lifetime of the device, such as super capacitor etc.

20 **Fastening or Joining of Multiple Primary Segments**

In this section, a method of joining multiple primary segments is shown in Figure 15. In each primary segment, male connectors 150 and female connectors 152 are placed in pairs on all four sides of the segment. Each connector has two leads 154
25 but the number of leads can be increased dependent on requirements. This method of connection facilitates expansion of the charging surface by means of assembling multiple primary segments to form a single, larger primary segment so as to charge more devices. It also physically holds the primary segments together.

30 It is to be understood that the foregoing description of several preferred embodiments is intended to be purely illustrative of the principles of the invention, rather than exhaustive thereof, and that changes and variations will be apparent to those skilled in the art, and that the present invention is not intended to be limited other than expressly set forth in the following claims.

We claim

1. An apparatus for wireless charging a device comprising at least first and second magnetic cores, each having conductive windings, for generating first and second
5 magnetic fields, wherein the magnetic cores are positioned adjacent to each other.

2. An apparatus as claimed in claim 2 wherein the first and second magnetic cores are oriented with opposing polarities parallel to each other for forming a closed circuit with the generated magnetic fields.

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3. An apparatus as claimed in claim 1 or 2 further includes a third magnetic core having conductive winding and two opposing polarities for generating a third magnetic field, wherein the third magnetic core is positioned adjacent to the second magnetic core.

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4. An apparatus as claimed in claim 3 wherein the second and third magnetic cores are oriented with opposing polarities parallel to each other for forming a closed circuit with the generated second and third magnetic fields.

5. An apparatus as claimed in any of the preceding claims wherein the magnetic
20 cores are positioned apart.

6. An apparatus as claimed in any of the preceding claims further includes a casing for containing the magnetic cores.

25 7. An apparatus as claimed in claim 6 wherein the magnetic cores are positioned in the casing, the magnetic cores are equidistant from the opposing sides of the casing.

8. An apparatus as claimed in any of the preceding claims operatively connected with an AC/DC power adaptor to receive electrical power for providing electrical
30 power to the windings.

9. An apparatus as claimed in any of the preceding claims operatively connected with resonant converters to receive electrical power for providing electrical power to the windings.

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10. An apparatus as claimed in any of the preceding claims further includes an impedance sensing means for detecting a device for wireless charging.

11. An apparatus as claimed in any of the preceding claims further includes an infrared sensor for detecting a device for wireless charging.

12. An apparatus as claimed in any of the preceding claims is adaptable to operate with any electronic device.

13. An apparatus for wireless charging a device comprising a plurality of magnetic segments, each magnetic segment having a first and second magnetic cores, each having a conductive winding, for generating a magnetic field, wherein the magnetic cores are positioned adjacent to each other and a casing for containing the magnetic cores.

14. An apparatus as claimed in claim 13 wherein the magnetic cores are oriented with opposing polarities parallel to each other for forming a closed circuit with the generated magnetic fields.

15. An apparatus as claimed in claim 13 or 14 wherein each magnetic segment further includes a third magnetic core, the third magnetic core is positioned adjacent to the second magnetic core.

16. An apparatus as claimed in claim 15 wherein the second and third magnetic cores are oriented with opposing polarities in parallel and forming a closed circuit with the generated second and third magnetic fields.

17. An apparatus as claimed in any of the preceding claims 13 to 16 wherein each magnetic segment is positioned equidistant from the adjacent magnetic segment.

18. An apparatus as claimed in any of the preceding claims 13 to 17 wherein each pair of adjacent magnetic segments are oriented with the magnetic fields in opposite directions.

19. An apparatus as claimed in any of the preceding claims 13 to 18 operatively connected with an AC/DC power adaptor to receive electrical power for providing electrical power to the windings.
- 5 20. An apparatus as claimed in any of the preceding claims 13 to 19 operatively connected with resonant converters to receive electrical power for providing electrical power to the windings.
21. An apparatus as claims in any of the preceding claims 13 to 20 further includes
10 an impedance sensing means for detecting a device for wireless charging.
22. An apparatus as claimed in any of the preceding claims 13 to 21 further includes an infra red sensor for detecting a device for wireless charging.
- 15 23. An apparatus as claimed in any of the preceding claims adaptable to operate with any electronic device.
24. A method for wireless charging a device, the method comprising
providing first and second magnetic cores having conductive windings and
20 two opposing polarities;
positioning the magnetic cores adjacent to each other; and
providing electrical power to the first and second conductive windings.
- 25 25. A method as claimed in claim 24 further includes orienting the magnetic cores with opposing polarities parallel to each other to form a first closed circuit with the generated magnetic fields.
26. A method as claimed in claim 24 or 25 further includes providing a third magnetic
30 core having conductive winding, positioning the third magnetic core adjacent to the second magnetic core providing electrical power to the third conductive winding.
27. A method as claimed in claim 26 further includes orienting the second and third magnetic cores with opposing polarities parallel for forming a closed circuit with the
35 generated second and third magnetic fields.

28. A method as claimed in any of the preceding claims 24 to 27 further includes detecting the device for wireless charging.

- 5 29. A method as claimed in any of the preceding claims 24 to 28 further includes
detecting the device;
determining if the battery voltage level of the device is below a first threshold;
charging the device when the battery voltage level is below the first threshold;
determining if the charging is complete; and
10 terminating the charging when the charging is complete.

30. A method as claimed in claim 29 wherein the battery voltage level is above the threshold, the method further includes decreasing the power supply.

- 15 31. A method as claimed in claim 29 or 30 further includes determining if the low dropout voltage is above a second threshold, wherein the low dropout voltage is below the second threshold voltage, increasing the power supply.

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