Title: SMART CARD AND READER/WRITER FOR DETECTING AN OPERATING VOLTAGE OF THE SMART CARD

Abstract: Many different types of smart card are available today and these operate at different operating voltages. This presents a problem in that if a particular type of smart card which operates at a given voltage is used with an incompatible reader/writer unit that operates at a different voltage, then damage to the smart card is sustained. It is difficult for the reader/writer unit to determine the correct operating voltage for a smart card without damaging the smart card. To address this problem, means for encoding information about a smart card’s operating voltage is provided on the smart card. The encoding means is positioned on the smart card, relative to an interface to integrated circuits on the smart card, in such a way that the encoded information is accessible to a reader/writer unit before damage to the smart card can occur. The encoding means is positioned on the smart card such that it is more peripheral than the interface to integrated circuits supported by the smart card. The encoding means preferably comprises a row of electrically conducting pins positioned along a leading edge of the smart card. Some or all of these pins are electrically connected to a single pin with a ground potential. The number and position of the ground potential pins is used to encode information about the operating voltage of the smart card.
5 **Field of the Invention**

The invention relates to smart cards and to reader/writer units for reading data from and/or writing data to smart cards.

**Background of the invention**

10 The term “smart card” is used to refer to a sheet of material which contains or supports a chip or integrated circuit; the sheet of material is usually sized and shaped in a similar manner to a credit card although any suitable size and shape may be used. The chip or integrated circuit is arranged to store information in such a manner that this information may be accessed or input using a suitable reader/writer unit. For example, smart cards are used today to provide telephone cards, pre-payment cards, identity cards and security cards.

Many different types of smart cards are available and many of these operate at different voltages. For example, conventional smart cards, such as those conforming to International Standard ISO 7816, are traditionally operated at 5 volts. However, where smart card systems are battery operated, the smart cards are often operated at 3 volts. As well as this, advances in semiconductor technology have enabled smart cards which operate at 1.8 volts and below to be provided.

When a smart card is inserted into a reader/writer device during use, the voltage applied to the smart card in order to read from or write to that smart card, must be within the allowed operating voltage range. Otherwise damage to the circuitry embedded in the smart card results. This is a particular problem for improved smart cards which operate over a relatively restricted range of voltages. For example, improved smart cards with enhanced memory capacity as described in our co-pending UK and International Patent Applications: PCT/GB00/00109; WO00/14677; GB0001062.9; and GB 2341707.
Previously, smart cards of a particular type have typically only been suitable for use with reader/writer units of a corresponding type. That is, the user is aware that his or her smart card is only suitable for use with particular reader/writer units and should not be used with other incompatible systems in case of damage. Alternatively, the smart card is so sized and shaped that it only operates with reader/writer units of a particular type. However, with increase in use of different types of smart cards the likelihood of errors occurring increases. Users may insert smart cards of a particular type into incompatible reader/writer units and damage the smart cards in the process.

A particular problem is that once a smart card is inserted into a reader/writer unit it becomes subject to any operating voltages applied by the reader/writer unit. That is, it is difficult for the reader/writer unit to assess the required operating voltage of the smart card without the possibility of damaging the smart card in the process.

Conventional smart cards, such as those conforming to International Standard ISO 7816, are used for secure data storage but are limited in the amount of data that can be stored on the smart card. In order to conform with the ISO standard, integrated circuits within a smart card should be located under contact areas on the surface of the smart card. Also, the interface of conventional smart cards, such as those conforming to the ISO standard, are limited with respect to the speed with which information can be read from that smart card. Our co-pending UK and International patent applications listed above describe an improved smart card which has enhance memory capacity and an improved interface such that data can be quickly read from or written to the improved smart card.

In the international standard and conventions agreed for Smart Card protocols, in particular ISO7816 parts 1-6, a serial data interface as defined in the ISO7816 standard is used for accessing data from integrated circuits on the smart card. This arrangement is only satisfactory for the limited amount of data transfer necessary to carry out the security code functions and limited data transfers in conventional Smart Card applications. For example, library access cards, telephone cards and identification
cards. Also, when data is accessed from a conventional smart card using the ISO7816 standard, the control data for operation of the smart card protocol must also be communicated between the smart card and a smart card reader. This means that not only is the data transfer rate limited by the interface design but also the actual data transfer rate (not including control data) is limited by the need for the control data.

It is accordingly an object of the present invention to provide a smart card which overcomes or at least mitigates one or more of the problems noted above. Another object of the present invention is to provide a smart card reader/writer which overcomes or at least mitigates one or more of the problems noted above.

Summary of the Invention

Many different types of smart card are available today and these operate at different operating voltages. This presents a problem in that if a particular type of smart card which operates at a given voltage is used with an incompatible reader/writer unit that operates at a different voltage, then damage to the smart card is sustained. It is difficult for the reader/writer unit to determine the correct operating voltage for a smart card without damaging the smart card. To address this problem, means for encoding information about a smart card's operating voltage is provided on the smart card. The encoding means is positioned on the smart card, relative to an interface to integrated circuits on the smart card, in such a way that the encoded information is accessible to a reader/writer unit before damage to the smart card can occur. The encoding means is positioned on the smart card such that it is more peripheral than the interface to integrated circuits supported by the smart card. The encoding means preferably comprises a row of electrically conducting pins positioned along a leading edge of the smart card. Some or all of these pins are electrically connected to a single pin with a ground potential. The number and position of the ground potential pins is used to encode information about the operating voltage of the smart card.
According to a first aspect of the present invention there is provided a smart card operable at one or more operating voltages and comprising:

- a sheet of supporting material;
- one or more integrated circuits supported by said sheet;
- an interface to said integrated circuits provided on said sheet;
- means for encoding information about at least one of said operating voltages; said means being positioned on said sheet of supporting material such that it is more peripheral than said interface.

This provides the advantage that because of the location of the means for encoding information, the operating voltage of the smart card can be determined by a smart card reader/writer unit before the smart card integrated circuits are accessed.

According to another aspect of the present invention there is provided a smart card reader/writer suitable for reading data from or writing data to a smart card, said smart card reader comprising:

- a housing arranged to accept a smart card in use;
- interface means adapted to communicate data with one or more integrated circuits on said smart card;
- means for accessing encoded information from said smart card about at least one of said operating voltages; and wherein the position of said means for accessing encoded information relative to said interface means is such that in use, when a smart card is accepted into said housing, said means for accessing encoded information is activated before said interface means.

This provides the advantage that information about an operating voltage of the smart card is accessed by the reader/writer unit before the integrated circuits themselves on the smart card are accessed. In this way damage to the smart card can be prevented by only operating the smart card if it has an operating voltage compatible with the reader/writer unit.
According to another aspect of the present invention there is provided a method of reading data from or writing data to a smart card using a smart card reader/writer as described immediately above said method comprising the steps of:

- inserting said smart card into said smart card reader/writer housing;
- accessing encoded information from said smart card about an operating voltage of said smart card; and
- accessing integrated circuits on said smart card only if said operating voltage of the smart card is compatible with the reader/writer unit.

This provides the advantage that a smart card is only operated if its operating voltage is compatible with the reader/writer unit. In this way damage to the smart card is prevented without the need for the user to check compatibility of the smart card and reader/writer unit.

**Brief description of the drawings**

15 Figure 1a is a plan view of a smart card with means to enable an operating voltage of the smart card to be detected.

Figure 1 is a plan view of an improved smart card.

Figure 2 is a general schematic diagram indicating the electrical connections of an improved smart card interface.

20 Figure 3a is a plan view of an improved smart card which has two interfaces.

Figure 3b is a side view of the improved smart card of figure 3a.

Figure 4 is a schematic diagram of an improved smart card interface.

Figure 5 is a schematic diagram of an improved smart card interface with octagonal ground planes.

25 Figure 6 is a schematic diagram of an improved smart card interface with circular ground planes.

Figure 7 is a plan view of a smart card reader/writer part of which is cut away to show an improved smart card in the card reader/writer.
Figure 7a is a cross-section along line A-A' of Figure 7.

Figure 7b is a cross-section along line B-B' of Figure 7.

Figure 8 is a general schematic diagram of the smart card reader/writer of Figure 7.

**Detailed description of the invention**

Embodiments of the present invention are described below by way of example only. These examples represent the best ways of putting the invention into practice that are currently known to the Applicant although they are not the only ways in which this could be achieved.

The term "smart card reader/writer" is used to refer either to a unit for reading information from a smart card, a unit for writing information to a smart card or a unit which is suitable for both these purposes.

Figure 1a is a plan view of an improved smart card 20 with means to enable an operating voltage of the smart card to be detected. The smart card may be any type of smart card, including an improved smart card as described in our co-pending patent applications mentioned above, and including ISO 7816 smart cards. The smart card comprises a sheet of supporting material such as a thermoplastics card within which integrated circuits are embedded (not shown). The improved smart card 20 has a contact means which comprises two contact areas or pads 29, 30. However, it is not essential to use two contact areas or pads 29, 30. For example, a single contact area could be used. These contact area(s) also represent the interface to integrated circuits.

In a preferred embodiment the integrated circuits are located only under the contact areas or pads. By including two contact areas or pads 29, 30 the available area under which integrated circuits can be located is increased. In the case that the smart card 20 is an improved smart card as described in our co-pending UK and PCT patent applications, additional integrated circuits are provided as compared with an ISO 7816 smart card, in order to increase the memory capacity available.

In addition to the contact areas or pads 29, 30 above the integrated circuits means is provided for encoding information about an operating voltage of the smart card.
20. In one example, this means for encoding information comprises a plurality of electrically conducting regions. In the example illustrated in Figure 1A these comprise eight pins labelled 21 to 28. It is not essential to use eight pins; any other suitable number of connections may be used.

The plurality of electrically conducting regions 21 to 28 are positioned substantially along one or more edges of the smart card 20. These regions are also positioned such that in use, when the card is inserted into a reader/writer unit, the regions 21 to 28 are inserted before the integrated circuit interface 29, 30 of the smart card. That is, the electrically conducting regions 21 to 28 are more peripherally located on the smart card than the interface to the integrated circuits within the smart card. In the example shown in Figure 1A the pins 21 to 28 are positioned along only one edge of the smart card 20 which is referred to as the leading edge of the smart card, because this edge is inserted into a reader/writer first.

The smart card is designed for use with a reader/writer unit which comprises a row of sensors which are arranged to sense or monitor the potentials of the electrically conducting regions 21 to 28 on a smart card in use. For example, the sensors comprise mating contacts which are arranged such that contact is made with the regions 21 to 28 on the smart card, when the smart card is inserted into the reader/writer unit and before the normal ISO 7816 contacts are established. Alternatively, connectionless sensors are used. In this case, the sensors in the reader/writer unit are able to sense or monitor the electric potential of the regions 21 to 28 on the smart card without contact being established between the sensors and the regions.

The electrically conducting regions 21 to 28 are arranged in a manner which indicates, or encodes the operating voltage of the smart card itself. For example, in a preferred embodiment, the electrically conducting regions 21 to 28 are pins, some of which are connected to ground potential. The pattern of which pins are ground connected and which are not is used to indicate the operating voltage of the smart card.
Those pins which are ground connected may be ground connected in any suitable manner. In a preferred embodiment, this is achieved by connecting each of the pins that are to be grounded to a single pin which is connected to ground potential during use. Preferably, this single pin is located at the end of a row of pins. In the example illustrated in Figure 1a, pins 21, 24 and 28 are connected to a pin at the end of the row which is connected to ground potential in use.

As the smart card is inserted into a smart card reader/writer, the reader/writer applies a "ground" to the pin on the smart card to which some or all of the other pins are connected. The smart card reader/writer then checks the other pins within the encoding means on the smart card to see which of these is also connected to "ground". Thus, by determining which of the electrically conducting regions or pins on the card are connected to "ground", the correct operating voltage is determined before the integrated circuits are accessed in order to effect reading/writing to the smart card. By the time an electrical connection is made the reader/writer determines and applies the correct operating voltage for that card to the interface to the integrated circuits.

The greater the number of pins provided in the encoding means, the more accurately the operating voltage may be determined. For instance, using four pins at the edge of the card, and using one of these as the ground connection, the three remaining pins give \(2^3 = 7\) possible voltages. Using 8 pins gives \(2^7 = 128\) possible voltages. The accuracy of voltage detection needed depends on the operating voltage range of the inserted smart cards. If the smart cards being used tolerate a range of voltages, then the accuracy needed to determine the applied voltage is less.

It is probable that the applied voltage for battery operated systems will be multiples of the individual battery voltages, and that hence the adopted voltages for all types of systems will reflect this. Thus, for instance, for Nickel-Cadmium Rechargeable Batteries (NiCads), the operating voltages will be multiples of 1.2 volts; i.e. 1.2 volts, 2.4 volts, 3.6 volts, 4.8 volts, and higher. For non-rechargeable batteries and for lead-acid
types, the operating voltage is typically 1.5 volts and hence this gives multiples of 3.0 volts and 4.5 volts and higher.

A reader/writer unit for use with the smart cards described above is also provided. Figures 9, 9a and 9b illustrate an example of such a reader/writer unit and these figures are described in more detail below with reference to an example in which improved smart cards with enhanced memory capacity are used. However, it is not essential for the reader/writer unit to be adapted to operate with such improved smart cards; the reader/writer unit may operate with any suitable type of smart card which comprises encoding means for encoding information about an operating voltage of the smart card.

Details about the improved smart card which is the subject of our co-pending patent applications mentioned above is now given.

Figure 1 is a plan view of an improved smart card 101 which comprises a sheet of supporting material 102 such as a thermoplastics card within which integrated circuits are embedded (not shown). The improved smart card 101 has a contact means 103 which comprises two contact areas or pads 104, 105. These contact areas also represent the interface means. In a preferred embodiment the integrated circuits are located only under the contact areas or pads. By including two contact areas or pads 104, 105 the available area under which integrated circuits can be located is increased. Additional integrated circuits are provided as compared with an ISO 7816 smart card, in order to increase the memory capacity available.

One of the contact areas 104 comprises a serial data interface such as those conforming to the ISO 7816 standard. The other contact area 105 comprises a parallel data interface as described below. It is also possible to use more than one parallel data interface by positioning extra parallel data interfaces on the support surface 102 around serial data interface 104.

Figure 2 shows example electrical connections within each contact area 104, 105 in more detail. Each contact area 104, 105 comprises a ground connection a, b, and
these are connected to one another. For this reason it is advantageous to position the contact areas 104, 105 next to one another, but this is not essential.

Figure 3a is a plan view of a smart card which has one interface means 301 positioned at one end of the support sheet and another interface means 302 positioned at the other end of the support sheet. Also, the interface means 301, 302 are on opposite sides of the support sheet as shown in Figure 3b. In this case, two encoding means 303 are provided on the smart card in order that the operating voltage of the smart card can be determined by a reader/writer unit no matter which of the interface means 301, 302 are to be used.

The improved smart card described herein augments the 'Smart' interface as in ISO 7816. The improved smart card enables parallel data transfers between a Credit Card sized (86mm x 54mm) standard card and a host reader. This increases data transfer through the interface by at least eight times the speed of existing serial interfaces (such as those conforming to ISO 7816 standard), for the same clock speed at the interface.

The improved smart card gives a sampling rate at one byte instead of the conventional one bit per clock serial data transfers of smart cards conforming to ISO 7816 standard. This enables the improved Smart Card to carry out more complex assignments and broadens the generic use of the improved smart card as an information source.

In one embodiment, the improved smart card also contains increased storage capacity as compared with the 256 bytes to 8k bytes (typical) of data storage capacity normally available in a Smart Card. This enables the improved smart card to act as a replacement for text books, catalogues containing pictures, audio tapes, CD ROMs, PCMCIA memory cards, floppy disks, camera cards and other optical, magnetic, and electronic media for data storage.

When the storage capacity within the improved smart card is increased it is particularly advantageous to reduce data transfer times between the Smart Card and
host reader. This is achieved using a parallel interface which enables a faster data transfer rate to be accomplished using the existing serial clock rate. If required, a higher clock rate can also be used which further increases the data transfer rate. In this case, the ISO 7816 protocol clock speeds may not be met, but this is acceptable for non ISO applications.

In one example, the improved smart card has similar external dimensions as a conventional Smart Card and utilizes the contact pad protocols of the ISO 7816 standard to position the serial port interface. In addition an adjacent interconnected contact pad is provided to allow transmission of parallel information.

In one example, the serial data interface consists of an ISO 7816 eight pin interface and the parallel data interface comprises a further eight pin interface. The resulting interface means consists of sixteen pins in total, and occupies an area of double the width of the normal ISO 7816 interface.

A ground connection at pin 5 (see Figure 2) of the serial data interface is extended across via the centre of the serial data interface contact area 104 to the centre of the parallel data interface contact area 105. Detection of a ground connection at the centre of the parallel data interface contact area 105 distinguishes the improved smart card from a normal ISO 7816 interface. This does not affect the integrity of the ISO 7816 interface connections.

The new eight pins (9 to 16 in Figure 2) comprising the parallel data interface are connected to the data bus of memory circuits (integrated circuits) internal to the Smart Card. Thus, once data transfer has been initiated, the data can be transferred one byte (eight bits) at a time compared to the one bit at a time over the serial connection at pin 7 (see figure 2) of the normal ISO 7816 interface. The data transfer in both cases is synchronous with the data clock, which is present at pin 3 (see figure 2) of the normal ISO 7816 interface.

As the actual data accessed from the smart card data is embedded within the serial data protocols of the ISO 7816 standard, the true user-data transfer rate is
considerably slower than the possible serial clock rate. Once data transfer has been initiated, the interface means 103 transfers data at eight times the serial clock rate. Thus user-data transfer is at a much greater rate than the normal ISO 7816 standard allows, and the integrity of the ISO 7816 standard is not compromised.

The existing ISO 7816 standard pin numberings and functions of the normal interface are retained in the serial data interface. The additional pins of the parallel data interface are numbered 9 through to 16, and correspond to data bits 1 through to 8 of the data bus connections (i.e. an eight-bit wide data bus). The new pins of the parallel data interface are numbered in the same fashion as the pins 1 through to 8 of the serial data interface. Thus pin 9 of the Second Part is adjacent to pin 4 of the First Part, and pin 13 of the Second Part is adjacent to pin 8 of the First Part. (See Figure 2).

The serial data interface can be arranged to provide a means of authentication. That is, on use of the improved smart card, a smart card reader first communicates with the smart card via the serial data interface and checks security details stored in that smart card (for example a personal identification number). Then, once authentication is successfully completed, data on the smart card can be accessed via the parallel data interface. Similarly, new data can be written to the smart card via the parallel data interface.

Figure 1 shows the position and proportions of the interface means 103 relative to the Smart Card 101. The position of the serial data interface, for example an ISO7816 standard interface 104 is shown in Figure 1. Adjacent to this, and maintaining the same contact separation as the contacts of the serial data interface 104, is the parallel interface 105. This comprises a further eight contacts, the minimum contact pad proportions and dimensions of which conform to the detail dimensions of the contact pin connections of ISO7816, but are positioned adjacent to the existing interface serial interface 104. The serial and parallel data interfaces 104, 105 comprise the interface means 103.
Figure 2 shows the electrical connections of the interface means 103. Pins 1 to 8 conform to the ISO7816 standard and have the same numbering and pin functions. Pins 9 to 16 correspond to the parallel data bits one to eight respectively. The existing 'ground' contact at pin 5 of the serial data interface 104 is extended through the physical centre of the serial data interface 104 - see figure 2, Pin 'a', to the physical centre of the parallel data interface - see figure 2, Pin 'b'. The contact pad areas 'a' and 'b' represent the minimum areas which must be available as 'ground' connections to the centres of interfaces 104, 105. Thus pin 5 of the existing ISO7816 interface is electrically and mechanically connected to pins 'a' and 'b' of interfaces 104 and 105.

The interface reader (not shown) makes an external 'ground' connection at pin 5, as in a conventional Smart Card reader. Detection of a 'ground' at pin 'a' only indicates a conventional Smart Card has been inserted into the reader. Detection of a 'ground' at pins 'a' and 'b' indicates an improved smart card has been inserted.

The smart card 101, conventionally is a flat planar rectangular surface, of nominal thickness 0.3mm to 1.00mm. In current usage the ISO standard requires the longitudinal axis to be inserted into a reader port. The electrical apparatus as described herein is not restricted to the convention and may be inserted into an appropriately engineered transverse axis port.

Figure 3 shows various positions that interface means 103 may be located on the smart card 101. It is possible to position an interface means 103 at either or both ends of the card and on one or both sides or faces of the card. It is possible, with two opposing read heads, to read both sides of a card at the same time, or contiguously. The preferred positions are with one interface means 103 at each end of the card, on opposing sides. This requires only a single read head. Thus the card is inverted longitudinally to utilize the second interface.

Figures 4, 5, & 6 show different physical implementations of the contact areas of the interface means 103. Figure 4 depicts an interface means 103 constructed in rectangular form, about a central rectangular 'ground' plane. Figure 5 depicts an
interface constructed about octagonal centres of the 'ground' planes in the two contact areas 104, 105, using connector pins having angled edges. Figure 6 depicts an interface constructed about circular centres of the 'ground' planes in the two contact areas 104, 105, using connectors having curved edges.

The improved smart card is constructed, for example, by bonding the integrated circuits to the back of the contact pads and epoxy bonding the integrated circuits into a milled out recess in the sheet of supporting material as in known uses of smart cards such as phone cards. Any other suitable method of construction may be used. An alternative method of construction may comprise a flexible PCB with memory and control circuits. Internal dies of integrated circuits are used and are attached direct to the flexible PCB. The whole PCB is then encapsulated between two outer layers of the smart card 717 forming a laminate and thus providing protection for the PCB whilst allowing a limited degree of flexibility. Electrical contact pads are provided on the external surface of the smart card. This construction method enables more memory dies to be incorporated within the smart card to increase the memory capacity of the smart card.

It is not essential to use semiconductor devices to provide the memory within the smart card. Alternative types of memory device can be used, such as the recently developed 3D memory storage system which uses metal alloys and gives vast increases in memory capacity for small amounts of storage space. Integrated circuits may still be used in conjunction with the 3D memory storage system to control access to that memory system.

In the examples described above the improved smart card comprises an interface means with a first serial data interface and a second parallel data interface. For example, the serial data interface comprises an 8 pin port conforming to the ISO7816 standard and communicates with a smart chip located under that 8 pin port on the smart card. The parallel data interface also comprises an 8 pin port (byte-wide), for example. This is located adjacent the serial 8 pin port and communicates with memory chips.
located under that 8 pin port. However, it is also possible to configure the second data interface as a serial rather than a parallel data interface. In this case the 8 pin port of the second data interface is configured in a similar way as that for the ISO7816 port. Table 2 below lists the electrical connections that would be used for the 16 pins in the case that both ports are serial. Table 1 below lists these same connections in the case that one serial and one parallel port are used. The type of memory incorporated within the improved smart card determines the configuration of the port. The interface electronics is required to validate data transfers and to communicate with the appropriate pins for the memory type being used.

It is possible, for example, to utilise the extra eight pins, configured as a serial port, to house a further 'Smart' chip if necessary. There are few practical advantages to doing this, as Smart chips do not contain large amounts of memory. However, with the growing use of Mobile Phone technology in applications such as remote collection and storage of electronic mail (e-mails), and for electronic transactions (e-commerce), there is a need for increased memory in Mobile Telephones. Some manufacturers are starting to include two SIMs (Subscriber Identity Modules) in their telephones. While this configuration could also be achieved under one platform with the Improved Smart Card, there are greater benefits in using a card with much larger memory capacity, with the memory access controlled by a single 'Smart' chip.

The Improved Smart Card and its associated reader/writer offer just such benefits. Due to its construction, it would be possible to supply the card in a form whereby the functioning contact pad area could be separated from the remainder of the card. That is the size of the improved smart card is reduced by removing most of the supporting sheet or card. The remaining small module may then be inserted into a small, shortened version of a reader/writer in exactly the same manner as that of conventional small telephone SIMs. This means that Mobile Telephones are instantly equipped with large, removable, and secure, memory means, enabling their use for many more
applications than are currently possible, such as remote downloading of MP3 music files, or E-mails with large file attachments.

Further details of a reader/writer for use with the improved smart card described above are now given.

Figure 7 shows a smart card reader/writer suitable for use with an improved smart card. The reader/writer has a housing 1004 which is rectangular and has a slot into which at least part of an improved smart card can be accommodated. Figure 7 shows an improved smart card 1001 which is inserted into a slot in the housing 1004. A card indicator switch 1002 is located in the housing in such a position that it is activated by a smart card when it is inserted into the housing. More such card indicator switches may be used but only one is shown in Figure 7. Supported by the housing 1002, on the interior surface of the housing, are a plurality of electrical contact pins 1003. In the example shown in Figure 7, sixteen such pins are used and these are positioned such that they contact corresponding contact regions (such as those illustrated in Figure 2) on an improved smart card 1001 when that card is inserted in the housing. Similarly two electrical contacts 1005 are provided for contacting the 0 volt or ground plane connection regions on the improved smart card. In Figure 7, reference numeral 1006 is used to refer to the contact region on the improved smart card itself. This corresponds to the contact region C in Figures 1 and 3A.
The smart card reader/writer also comprises a plurality of sensors 1100 supported on the housing 1004, on the interior surface of the housing arranged to access the encoding means on a smart card 1001. For example, these sensors comprise contact pads arranged to contact pins on the smart card 1001 which are part of the encoding means on the smart card. However, it is not essential to use contact pads. Any other suitable type of sensor may be used to detect the electrical potential of regions in the encoding means in the smart card. For example, contact-less sensors may be used.

Figure 7a is a cross-section along line A-A' of Figure 7 and Figure 7b is a cross-section along line B-B' of Figure 7. The same reference numerals are used to refer to corresponding components in Figures 7, 7a and 7b.

Figure 8 is a general schematic diagram of a smart card reader/writer suitable for use with the improved smart card described herein. The housing assembly of the reader/writer is indicated by reference numeral 1007 and an interface 1023 for communicating with the first serial data interface of the smart card is shown together with a second interface 1024 for communication with the second data interface of the smart card. For example, the first interface 1023 comprises an 8 pin connector for contacting an 8 pin ISO7816 port on the smart card that accesses a smart chip in the smart card. For example, the second interface 1024 comprises an 8 pin connector for contacting an 8 pin parallel port on the smart card that accesses a memory chip in the smart card.

A third interface 1101 is shown for communicating with the encoding means on the smart card. This third interface 1101 is connected to a central processing unit 1010.

The smart card reader/writer further comprises an electrical connection 1008 from the ISO port interface 1023 to a central processing unit 1010. There is also an electrical connection 1009 from the additional port interface 1024 to the same central processing unit 1010. The central processing unit comprises electronic circuitry to arbitrate and control the flow of data between the card reader/writer and devices to which the card/reader writer is connected. The central processing unit also controls operation of the
first two interfaces 1024 and 1023 depending on the operating voltage of a smart card inserted into the reader/writer in use.

When a smart card is inserted into the housing 1007 the encoding means 1100 on the smart card first comes into registration with sensors 1101 on the smart card reader/writer. The reader/writer applies a ground potential to one of the sensors 1101 and then determines which of the sensors are also at ground potential. This information is forwarded from the encoding means interface 1101 to the central processing unit 1010. The central processing unit has prior knowledge of the encoding scheme being used and is able to determine the operating voltage of the inserted smart card. If this operating voltage is compatible with the reader/writer the central processing unit allows access to integrated circuit interfaces on the smart card. If the operating voltage is not compatible with the reader/writer the central processing unit prevents use of the smart card and alerts the user. For example, the smart card may be automatically ejected from the reader/writer unit or a warning displayed to the user. In another embodiment, the reader/writer unit is operable at several different voltages. In that case, the central processing unit causes the reader/writer unit to adjust its own operating voltage to correspond with the operating voltage of the inserted smart card.

The smart card reader/writer is typically incorporated into another device such as a personal organiser, mobile telephone, personal computer or other apparatus. This other device is termed a “host” and an electrical connection 1011 is provided between the central processing unit 1010 and a port on that host 1012. For example, if the host is an electronic book, data read from the smart card is passed via connection 1009, central processing unit 1010, and connection 1011 to the host device.

More details about the reader/writer assembly are now given:

25 Physical Card reader/writer

The physical card reader/writer consists of a card reader/writer that conforms to the overall dimensions of similar card readers intended for ISO7816 Smart cards. It consists
of a physical card-holder with provision for a card conforming to ISO7816 to be inserted into a slot in said card holder, and with supporting material for sets of electrical contacts.

It differs from the conventional Smart card reader/writer in that it consists of a set of sixteen electrical contact pins, arranged such that said contact pins are in alignment with the sixteen contact pads on the Improved Smart Card when the card is pushed fully home into the locating slot. The conventional Smart card reader has only eight contact pins, and variations have only six contact pins, as two of the eight pins used in the ISO7816 standard configuration have yet to be assigned usage.

The first eight pins of the Improved Smart Card reader/writer are situated in exactly the same position as the eight pins of a conventional Smart card reader/writer. The extra eight pins of the Improved Smart Card reader/writer are situated adjacent to the first eight pins, towards the centre of the card. The sixteen interface pins are positioned such that they contact the sixteen contact pins/pads of the Improved Smart Card, when the card is inserted into the reader/writer slot and pushed fully home.

The physical card reader/writer may, or may not, also contain a set of two further contact pins arranged such that said two contact pins make contact with the extended 'Ground' contact pad running across the centre of said Improved Smart Card contact pad area. One contact pin may be positioned in the physical centre of the conventional eight-pin interface described in ISO7816. The second pin may be positioned in the physical centre of the additional eight-pin interface that constitutes the 'Improved' part of said Improved Smart Card.

Thus, the reader/writer arbitration, said Central Processing Unit, is able to discriminate whether a standard Smart card or an Improved Smart card is present. This may be achieved before the main sixteen interface pin connections are powered up and any data is transferred, by checking for a 'ground' connection at each of said two further pins. A 'ground' connection at the centre of the standard ISO port only, confirms a standard Smart card has been inserted into the reader/writer. A 'ground' connection at both the centre of the standard ISO port, and the centre of the additional eight-pin

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interface, confirms that an Improved Smart card has been inserted into the reader/writer. Thus the generic card type is determined, by checking for 'grounds' at the centre pad interface connections, before the card is physically powered.

The physical reader/writer also contains an additional pair of electrical contacts arranged in the form of a switch. Said switch contacts are normally 'open', (not in contact), with no card inserted in the reader/writer. When a card is inserted and pushed fully home, the switch contacts are closed together, making electrical contact. This connection is used by the reader/writer's electronics, to power up the connections to the card interface pins. This is done in a specific order, ensuring that power to the Voltage supply to the card is supplied first, followed by connections to the remainder of the pins. This ensures that none of the contacts of the card, especially the Improved Smart card, is powered up before the main supply to that card, ensuring that none of the circuitry within the card is reverse-biased, thereby preventing potential internal damage to the embedded circuitry.
### Table 1

**Electrical Connections illustrated in Figure 2 for parallel configuration**

The Electrical connections are:

- **Pin 1** - Vcc - typically +5 Volts.
- **Pin 2** - RST - Reset.
- **Pin 3** - CLK - Data Clock.
- **Pin 4** - NC - Not Connected - Reserved for future use.
- **Pin 5** - GND - Ground - 0 Volts.
- **Pin 6** - Vpp - Programming Voltage.
- **Pin 7** - I/O - Input / Output.
- **Pin 8** - NC - Not Connected - Reserved for future use.
- **Pin 9** - Data Bit 1 - Parallel Data - Least Significant Bit - LSB.
- **Pin 10** - Data Bit 2 - Parallel Data.
- **Pin 11** - Data Bit 3 - Parallel Data.
- **Pin 12** - Data Bit 4 - Parallel Data.
- **Pin 13** - Data Bit 5 - Parallel Data.
- **Pin 14** - Data Bit 6 - Parallel Data.
- **Pin 15** - Data Bit 7 - Parallel Data.
- **Pin 16** - Data Bit 8 - Parallel Data - Most Significant Bit - MSB.
- **Pin 'a'** - Ground - Electrically and Mechanically Connected to Pin 5.
- **Pin 'b'** - Ground - Electrically and Mechanically Connected to Pin 5.
### Table 2

**Electrical connections for serial configuration**

- **Pin 1** - Vcc - typically +5 Volts.
- **Pin 2** - RST - Reset.
- **Pin 3** - CLK - Data Clock.
- **Pin 4** - NC - Reserved for future use.
- **Pin 5** - GND - Ground - 0 Volts.
- **Pin 6** - Vpp - Programming Voltage.
- **Pin 7** - I/O - Input / Output.
- **Pin 8** - NC - Reserved for future use.
- **Pin 9** - NC - Reserved for future use.
- **Pin 10** - CTRL - Command & Control.
- **Pin 11** - CLK - Clock.
- **Pin 12** - NC - Reserved for future use.
- **Pin 13** - NC - Reserved for future use.
- **Pin 14** - MCS - Memory / Chip Select.
- **Pin 15** - I/O - Input / Output.
- **Pin 16** - NC - Reserved for future use.
- **Pin 'a'** - Ground - Electrically and Mechanically Connected to Pin 5.
- **Pin 'b'** - Ground - Electrically and Mechanically Connected to Pin 5.
Table 3

Examples of mapping different serial protocols (extra port configured to serial port)

<table>
<thead>
<tr>
<th>Serial Improved Smart</th>
<th>MMC</th>
<th>SPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 9</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>Pin 10</td>
<td>CTRL</td>
<td>CMD (Command) Data In</td>
</tr>
<tr>
<td>Pin 11</td>
<td>CLK</td>
<td>CLK</td>
</tr>
<tr>
<td>Pin 12</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>Pin 13</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>Pin 14</td>
<td>MCS</td>
<td>RSV (Always 1) ChipSelect</td>
</tr>
<tr>
<td>Pin 15</td>
<td>I/O</td>
<td>DAT (Data I/O) Data Out</td>
</tr>
<tr>
<td>Pin 16</td>
<td>NC</td>
<td>NC</td>
</tr>
</tbody>
</table>
Claims

1. A smart card operable at one or more operating voltages and comprising:
   (i) a sheet of supporting material;
   (ii) one or more integrated circuits supported by said sheet;
   (iii) an interface to said integrated circuits provided on said sheet;
   (iv) means for encoding information about at least one of said operating voltages;
        said means being positioned on said sheet of supporting material such that it is
        more peripheral than said interface.

2. A smart card as claimed in claim 1 wherein said means for encoding comprises a
   plurality of electrically conducting regions.

3. A smart card as claimed in claim 2 wherein said electrically conducting regions
   comprise pins.

4. A smart card as claimed in claim 2 or claim 3 wherein some or all of said regions
   are provided at substantially the same potential.

5. A smart card as claimed in claim 4 wherein said potential is substantially a
   ground potential.

6. A smart card as claimed in claim 2 or claim 3 wherein some or all of said regions
   are each electrically connected to one of the regions.

7. A smart card as claimed any of claims 2 to 6 wherein said regions are positioned
   around at least part of the edge of the sheet of material.

8. A smart card as claimed in any of claims 2 to 7 wherein said regions are
   positioned substantially in a row.

9. A smart card as claimed in any preceding claim wherein said interface comprises
   a first serial data interface and at least one second data interface which may be
   serial or parallel arranged such that in use, data stored in said integrated circuits
   may be accessed via said serial or parallel data interface.
10. A smart card as claimed in any preceding claim wherein said integrated circuits are arranged to provide between 10 Kbytes and 128 Megabytes of data storage capacity.

11. A smart card as claimed in any preceding claim wherein said integrated circuit has a specified clock speed and wherein each of said second data interfaces is arranged to provide sampling rates of one or more bytes per unit of clock speed.

12. A smart card as claimed in any preceding claim wherein said sheet of supporting material is incorporated into a three dimensional structure selected from a cylinder, a sphere, and a cone.

13. A smart card reader/writer arranged to read data from or write data to a smart card as claimed in any of claims 1 to 12.

14. A smart card reader/writer as claimed in claim 13 which comprises means for accessing encoded information from said smart card about at least one of said operating voltages.

15. A smart card reader/writer as claimed in claim 14 wherein said means for accessing encoded information from said smart card comprises a plurality of sensors arranged to sense the voltages of each of a plurality of corresponding regions on said smart card.

16. A smart card reader/writer suitable for reading data from or writing data to a smart card, said smart card reader comprising:

(i) a housing arranged to accept a smart card in use;

(ii) interface means adapted to communicate data with one or more integrated circuits on said smart card;

(iii) means for accessing encoded information from said smart card about at least one of said operating voltages; and wherein the position of said means for accessing encoded information relative to said interface means is such that in use, when a smart card is accepted into said housing, said means for accessing encoded information is activated before said interface means.
17. A smart card reader/writer as claimed in claim 16 wherein said means for accessing encoded information comprises a plurality of sensors arranged to sense the voltages of each of a plurality of corresponding regions on said smart card.

18. A smart card reader/writer as claimed in any of claims 15 to 17 which is arranged to both read data from and write data to the smart card.

19. A method of reading data from or writing data to a smart card using a smart card reader/writer as claimed in any of claims 16 to 18 said method comprising the steps of:

(i) inserting said smart card into said smart card reader/writer housing;
(ii) accessing encoded information from said smart card about an operating voltage of said smart card; and
(iii) accessing integrated circuits on said smart card only if said operating voltage of the smart card is compatible with the reader/writer unit.

20. A method as claimed in claim 19 wherein said reader/writer is operable at a plurality of voltages and wherein said step (iii) comprises selecting one of the reader/writer unit's voltages which is compatible with the smart card.

21. A method as claimed in claim 19 or claim 20 wherein said step (ii) of accessing encoded information comprises sensing which of a plurality of regions on the smart card are provided at a specified potential.

22. A method as claimed in claim 21 which further comprises applying a ground potential to a region of the smart card.

23. A smart card substantially as described herein and with reference to any combination of Figures 1A to 6

24. A smart card reader/writer substantially as described herein and with reference to any combination of Figures 8 to 10.

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Fig. 8