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Description

The invention concerns memory cards, and more particularly those which are used as means of prepayment in installations of distribution of products or of services.

A typical example of a memory card to which the present invention can be applied is the prepaid telephone card, which one purchases for a certain monetary value; this value is memorised directly or indirectly in the card and is decremented as and when it is used. The invention applies however also in other situations where account units are recorded in the card and are decremented or incremented as and when they are used; these units can have a monetary value or not. In the rest of the description, one will use systematically the example of the prepaid telephone card for it is the example the most eloquent to expose the advantages of the invention.

In a previous embodiment of a prepaid card, one uses as means of storage of the prepaid commercial value a non-volatile electrically programmable and electrically non-erasable memory.

In that embodiment, the non-volatile electrically programmable memory (memory EPROM) contains P memory cells; each cell corresponds to an elementary account unit of the commercial value. The cells are initially blank; during use, a card reader associated to the distribution of products or

services provides successive pulses of programming of the P cells one after the other, as and when they are distributed. The residual value of the card corresponds to the number of cells not yet programmed. When all the cells are programmed, the prepaid credit is exhausted.

In another embodiment, the memory is erasable electrically (memory EEPROM). Attention will be paid more especially to this latter example which better highlights the advantages of the invention. The memory comprises P cells each corresponding to an account unit. Furthermore a counter is provided for, a register containing a fixed number Z corresponding to an overall commercial value $Z \times P$ of the card expressed in account units, and a comparator for comparing the content of the counter and that of the register. When the P cells of the memory have been programmed, the counter is incremented by one unit, and the cells are all erased simultaneously, then programmed again successively one after the other. The content of the counter increments itself after each consumption of P account units. When the content of the counter reaches the value specified in the register, the comparator delivers an end-of-credit signal which prevents to continue to use the card. Thus, through the fact that the memory is erasable electrically, one has made a card of which the credited value is $Z \times P$ although the memory has only P cells.

Of course, the counter is incremented by a circuit

internal to the card; it is not accessible on the external terminals of the card, for fraud would then be possible.

In practice, one can conceive for example that the cards contain a memory of 50 cells ($P = 50$), and one sells in commerce cards of 50, 100, 150, etc. account units.

The erasable character of the memory is used to conserve a limited number of memory cells (P cells) while still having large possibilities of choice of the commercial value of the card ($P \times Z$). The manufacturer of the integrated circuit of the card will have only one circuit to conceive, and the only thing he will have to do to assign one commercial value or another to the card will be to program differently the content of a register (in practice a read-only memory) defining the number Z .

One knows furthermore (patent FR-A-2 503 423) systems of rechargeable cards, in which the P cells of the memory are erased after having all been programmed, these systems necessitating however means of anti-fraud security to prevent fraudulent recharging. One also knows (patent DE A 34 32 557) systems rechargeable a limited number of times, using a number of successive recharging counter.

The present invention proposes principally to use the erasable character of the memory to render the card rechargeable, that is to say so that the user who has exhausted his credit may go and purchase a supplementary quantity of account units without change of card.

Another aim of the present invention is to permit that when

the card contains only a small number of account units, these units be not lost for the user, including when he recharges this card.

According to the invention, one proposes a memory card serving as means of counting units, organised to count up to $N \times P$ units organised in N pages of P units each, the card comprising a memory zone of which each cell represents an account unit, the programming of this cell in a given state representing the counting of a unit, the card comprising a page counter and an incrementation circuit internal to the card to increment the page counter by one unit after each complete programming of a page of P cells, characterised in that it comprises a recording counter of which the content represents a total credit of Z pages of units, and a comparator to emit an end-of-credit signal when the content of the page counter reaches that of the recording counter, which means that the said comparator emits the said signal of end-of-credit when the page counter indicates that Z pages have been consumed, the recording counter being arranged to be incremented as from the exterior of the card.

Instead of the manufacturer's having to manufacture different cards in function of its commercial value, one single card can be manufactured, and it is by the initial charging and the later rechargings of the card that the credit value will be recorded in the card.

This solution is applicable principally if the memory is erasable electrically; it is there that the invention

assumes all its value for it makes the best use of the erasable character of the memory; but the solution is applicable also if the memory is not erasable, the memory zone containing then N pages of P cells; the page counter is incremented at each consumption of a complete page, and the recharging consists in incrementing the recording counter to increase the number of pages of P cells which can be programmed, the limit of successive incrementations being reached when the content of the recording counter reaches the value N.

In the more interesting case of an erasable memory, the memory zone contains P cells, that is to say that it corresponds to one single page of account units. When the P cells of the card have been programmed, a page counter incrementation signal is delivered (this signal is established in the interior of the card), and the P cells are erased; the successive programming of the P cells can then start again. When the content of the page counter reaches that of the recording counter, an end-of-credit signal is emitted, invalidating the subsequent functioning of the card and prohibiting for example the erasure of the P cells.

The card can then be recharged by incrementation of the recording counter, in the limit of its counting capacity. But the card can also be recharged before the end-of-credit signal is emitted; if there remain account units available in the memory, they will not be lost since the recharging acts on the recording

counter and not on the programming of the memory cells.

Preferably, the page counter and also the recording counter are strictly irreversible, that is to say that not only do they count in only one direction, but further they do not return to zero when they have reached their maximum counting capacity.

Given that the recording counter is accessible as from the external connection terminals of the card, it is very desirable, and sometimes indispensable, to provide for a security of access to this counter to prevent a fraud. The invention proposes a system of exploitation of cards with a particularly simple security, under the form of two registers in the card. The first register, register of identification, contains an identification number of the card, for example a serial number entered as from the origin in the card; this number is accessible in reading but its content is not in principal modifiable; the register may be constituted as from a read-only memory or an electrically programmable memory with floating gate. The second register contains a validation code which is the result of a calculation algorithm with the intervention both of the content of the first register and the content of the recording counter. The calculation of the validation code is made by the card recharging machine which reads the serial number of the card, which reads or which knows the new content of the recording counter, and which writes the result of the algorithm under the form of a validation code in the second register. The

verification of the validation code is made in the card reader at the time the card is used: the reader reads the serial number, the content of the credit counter and the content of the validation register. It verifies that there is compatibility between these three contents taking into account the encoding algorithm used.

Among the advantages of the invention, one will note that the card is compatible with the non-rechargeable cards such as described above : it will be easy to foresee that the future applications function indiscriminately with rechargeable or non-rechargeable cards.

Other characteristics and advantages of the invention will appear from the reading of the detailed description which follows and which is made with reference to the appended drawings in which the single figure represents schematically the integrated circuit of the memory card according to the invention.

The figure represents the architecture of the integrated circuit of the rechargeable memory card according to the invention. On this figure are represented only the parts specifically concerned by the invention; notably are not represented the circuits which handle the transmissions of signals between the card and the card reader or between the card and the apparatus of recharge of account units.

One will note furthermore that various signal input or output terminals have been represented on the figure. However, certain terminals

represented as terminals physically or electrically separated could be regrouped in the practical embodiment; indeed, it is important to minimise the number of input/output terminals of the card, and it is frequent to provide multiplexing of different signals on common terminals to achieve this objective.

The example of the figure corresponds to a prepaid telephone card, rechargeable, using an erasable electrically and electrically programmable memory (memory EEPROM).

The integrated circuit comprises a memory zone EEPROM designated by the reference MEM. This zone comprises P cells each corresponding to an account unit. The memory can be constituted under matrix form with row and/or column addressing decoders, or again under the form of registers, for example of shift registers, etc.

One has represented on the figure a terminal DB of access to the card, by which arrive debit pulses; these pulses are issued, during use of the card in a public telephone booth, from the telephone line itself. Each pulse has for effect to program a cell of the memory MEM, and the address of the cell to program is incremented at each pulse for programming successively all the cells not yet programmed of the memory. The programming circuits of prepayment memory cards are known and will not be described in more detail. One has simply indicated on the figure the presence of a PGC programming circuit between the terminal DB and the memory MEM.

A circuit DET of detection of the end of programming of the memory MEM is provided for; it provides a signal when the last cell (pth cell) is programmed. A circuit EFF of overall erasure of the whole memory MEM is also provided for; it erases the P cells of the memory when it receives the order from the detection circuit of end of programming of a complete page of P units.

One further remarks on the figure two counters CPP and CPC and a comparator COMP for comparing the contents of the two counters.

The counters are irreversible: they count in only one direction (for example incrementation only) and they do not return to zero or to a prior content when they reach the maximum of their capacity. They can count in binary mode or BCD or any other mode.

The first counter, CPP, is the counter of pages of account units consumed; it is incremented by the detection circuit DET (that is to say by a circuit internal to the card) after each programming of a complete page of account units.

The second counter, CPC, is the recording counter or credit counter. Its content is charged as from the exterior of the card, more precisely by a credit recharging machine. This is why one has represented a link between the credit counter CPC and an external recharging terminal CR. As stated above, this terminal is represented as an autonomous terminal, but it could be merged with another, for example with the terminal DB since the recharging of credit will not be done during use in a telephone booth.

One can suppose that the initial content charged in the counter CPC is Z; it is the content on leaving the factory or after an initial passage in a credit recharging machine. The initial content of the page counter CPP is zero. When the card is used, the cells of the memory M will be programmed one by one in function of the consumption of telephone units (determined by the reception of the debit pulses on the terminal DB). When the P cells have been programmed, the counter CPP is incremented by one unit and the memory is completely erased. And so on until the page counter CPP reaches the value Z recorded in the recording counter CPC. The comparator COMP then emits an end-of-credit signal on an external terminal ST of the card. This signal stops for example the telephone communication or performs any other action, including on the internal functioning of the card. It can in particular inhibit the erasure of the memory, erasure which should take place at the time when the counter CPP reaches the value Z.

If the card is then introduced into a credit recharging machine, this machine can increment the counter by M units, for example up to a value $Y = Z + M$. The user pays for this incrementation, for example proportionately to this incrementation, or with a sliding scale tariff. He has then a new credit of $(Y - Z)P$ account units. The functioning of the card is then exactly the same as precedingly.

The card is no longer rechargeable when the recording counter has reached its maximum capacity N.

The recharging of the card can be done as has been stated even when the credit is not exhausted, for example when the page counter marks a content Z' inferior to the content of the recording counter and when only a part P' of the P cells of the memory has been programmed. The credit remaining $(Z - Z' - 1)P + P - P'$ remains usable and the card recharged up to an instructed value Y comprises a total credit $(Y - Z')P - P'$ whatever Z' and P' may be.

One has further represented on the figure two registers serving to ensure the security of the recharging of the card in the case where the integrated circuit of the card is a simple wired logic circuit using no microprocessor which could ensure this security.

The first register, RID, is a register of identification of the card. It may include for example a serial number of the card, or a batch number, or any fixed code number. The more the identification code is proper to the card the more the security is ensured; in other words, the security is very high if two distinct cards have practically no chance of having the same code. This first register RID is for example made under the form of a read-only memory (ROM) or an electrically programmable register with floating gate. It is accessible in reading as from an external terminal ID, in such a manner that the card reader being used or the credit recharging machine may read the code that it contains.

The second register, RVL, is a validation register. It contains a validation code permitting to verify the absence of fraud. It is accessible in

reading by the card reader or the credit recharging machine. It is accessible in writing by the credit recharging machine alone. An external access terminal VL has been represented; this could be the same terminal as the terminal ID with an appropriate multiplexing of signals. The register is constituted by an erasable electrically and reprogrammable memory.

The procedure of validation is the following: during the recharging of the card, the recharging machine reads the content Z of the recording counter. It increments the counter up to the new instructed value Y desired. As from the new content and from the identification code read in the register RID, it establishes a validation code according to a well-defined algorithm. This code is entered in the validation register RVL.

During the use in a card reader associated with a services distribution machine (telephone booth), the reader starts by reading on the terminals CR, VL, ID, the content of the recording counter, and of the identification and validation registers. It verifies that these three contents are compatible taking into account the algorithm used by the recharging machine. For example, it redoes the reverse algorithm as from the content of the validation register, or it redoes the same algorithm as the recharging machine and verifies that the result of the calculation coincides with the content of the validation register RVL.

If there is not compatibility between the contents of the two registers and of the counter, the card reader prohibits the distribution of the service or product requested by the user; it can also prevent the restoring of the card to the user.

The verification of the validation register does not necessarily imply the execution of the starting algorithm or of the reverse algorithm; it can in certain cases limit itself to a more brief verification of parity calculations, etc.

The identification and validation codes are not necessarily contained in registers directly connected to external terminals of the integrated circuit. They may be contained in specific zones of the memory MEM, these zones being accessible through an address decoder. The verification of the card passes then by an addressing of these specific zones of the memory MEM since it is these zones which have the function of validation RVL and of identification RID registers.

The invention will permit notably to easily make telephone cards of high capacity for the people who have much need to use public telephone booths for long-distance communications.

CLAIMS

1. Memory card serving as a means for the counting of units and organised to count up to $N \times P$ units organised in N pages of P units each, the card

comprising a memory zone (MEM) of which each cell represents a counting of one unit, the card comprising a page counter (CPP) and an incrementation circuit (DET) internal to the card and serving to increment the page counter of a unit after each complete programming of a page of P cells, characterised in that it comprises a recording counter (CPC) of which the content represents a total credit of Z pages of units, and a comparator (COMP) serving to emit an end-of-credit signal when the contents of the page counter equal the content of the recording counter, which means that the said comparator emits the said end-of-credit signal when the page counter indicates that Z pages have been commenced, the recording counter being arranged to be incremented from outside the card.

2. Memory card according to claim 1, characterised in that the memory zone is erasable electrically and comprises one single page of P cells and that in the card an erasure circuit (EFF) is provided for the purpose of erasing the programming of the P cells when the P cells have been programmed and then incrementing the page counter, after which the programming of the cells can recommence.
3. Memory card according to claim 2, characterised in

that the end-of-credit signal is transmitted to outside the card and is also used to prevent the erasure of the programmed cells.

4. Memory card according to any one of claims 1 to 3, characterised in that the page counter and the recording counter are irreversible, their content being unable to return to a previous content or to zero even when their maximum capacity has been reached.
5. Memory card according to any one of claims 1 to 4, characterised in that it comprises an identification register (RID), containing an identification number of the card, and a validation register (RVL) containing a validation code which is the result of a calculation algorithm taking account both of the content of the first register and the content of the recording counter, the validation register being capable of being read and entered from outside the card.
6. System for the operation of a memory card according to claim 5, comprising memory cards, card readers, associated product or service distribution installations, and credit recharging machines for the cards, characterised in that:
 - the card recharging machines comprise means for incrementing the content of the recording counter of the card by a quantity M

such that $Z+M$ remains less than or equal to N , where N represents the maximum capacity of the recording counter,

- the recharging machines comprise means for reading the content of the identification register of the card, to produce a validation algorithm from the content of the identification register and from the new content $Z+M$ of the recording counter and to write the result of the algorithm into the validation register of the card,
- the card readers comprise means for reading the content of the recording card, of the validation register and of the identification register, in order to verify the compatibility of these three contents as a function of the validation algorithm used and prevent the card from being used if any incompatibility is detected.