

The invention relates to memory cards and more particularly to those used as a prepayment means in vending machines or installations for the distribution of services.

A typical example of the memory card to which the present invention can be applied is the prepaid telephone card purchased for a certain sum of money; this value is memorized directly or indirectly in the card and reduced as and when the card is used. The invention is also applicable, however, in other situations in which counting units are recorded in the card and increased or reduced according to the use made of the card; these units may or may not have a monetary value. In the rest of the description the example of the prepaid telephone card will be used systematically, being that by which the advantages of the invention are most clearly illustrated.

In a former version of the prepayment card and means used for the storage of the prepaid commercial value is a non-volatile memory electrically programmable but not electrically erasable.

In this system the electrically programmable non-volatile memory (EPROM) contains P memory cells; each cell corresponds to an elementary counting unit of the commercial value. The cells are initially virgin; during their use a card reader associated with the distribution of products or services supplies successive programming pulses of the P cells one after the other, as and when the distribution is effected. The residual value of the card corresponds to the number of cells not yet programmed. When all the cells have been programmed the prepaid credit is exhausted.

In another version the memory is electrically erasable (EEPROM memory). It is to this latter example that special attention will be paid, as it brings out the advantages of the invention more clearly. The memory comprises P cells, each corresponding to one counting unit. The system includes a counter, a register containing a fixed number Z corresponding to a total commercial value $Z \times P$ of the card, expressed in counting units, and a comparator

serving to compare the contents 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 and then successively reprogrammed one after the other. The content of the counter is incremented each time P counting units have been consumed. When the content of the counter reaches the value specified in the register the comparator emits an end-of-credit signal which prevents any continued use of the card. Thus, thanks to the fact that the memory is erasable electrically, a card has been produced of which the credited value is $Z \times P$ even though the memory only has P cells.

Needless to say, the counter is incremented by a circuit inside the card; it is not accessible at the external terminals of the card, as fraud would then be possible.

In practice it is conceivable, for example, that the cards could contain a memory of 50 cells ($P = 50$) and cards of 50, 100, 150 etc. counting units be on sale.

The erasability of the memory is utilized in order to limit the number of memory cells (P cells) and nevertheless retain ample possibilities where the choice of the commercial value of the card is concerned ($P \times Z$). The manufacturer of the integrated circuit of the card will only have to design one single circuit, and all he will have to do to allocate one commercial value or another to the card will be to vary the programming of the content of a register (in practice a read-only memory) defining the number Z.

Systems are also known (French Patent A-2 503 423) which consist of rechargeable cards in which the P memory cells are erased after they have all been programmed, these systems nevertheless necessitating anti-fraud security devices to prevent fraudulent recharging. Systems are likewise known (German Patent A 34 32 557) which are rechargeable a limited number of times, using a counter for the number of successive recharging operations.

The main object of the present invention is to utilize the erasability of the memory for the purpose of

rendering the card rechargeable so that, in other words, a user who has exhausted his credit can purchase an additional number of counting units without changing his card.

A further object of the present invention is to ensure that when this card no longer contains more than a small number of counting units these latter need not be lost to the user, even when he has the card recharged.

The invention proposes a 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 of which each cell represents a counting of one unit, the card comprising a page counter and an incrementation circuit 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 of which the content represents a total credit of Z pages of units, and a comparator 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-circuit signal when the page counter indicates that Z pages have been commenced, the recording counter being arranged to be incremented from outside the card.

Instead of the manufacturer having to make different cards for the respective commercial values, only one single card is required, and it is by the initial charging and subsequent rechargings of the card that the credit value will be recorded on it.

This solution is mainly applicable if the memory is erasable electrically; it is here that the invention is of greatest value, as it makes the best possible use of the erasable nature of the memory; the solution is nevertheless also applicable if the memory is not erasable, the N zone then containing N pages of P cells; the page counter is incremented each time a complete page has been consumed, and the rechargings consist of the operation of incrementing the recording counter in order to increase the number of pages of

P cells which can be programmed, the limit of the successive incrementations being reached when the content of the recording counter reaches the value N.

In the most important case of an erasable memory there are P cells in the memory zone, which thus corresponds to one single page of counting units. When the P cells of the card have been programmed a page counter incrementation signal is emitted (this signal being established inside the card) and the P cells are erased; the successive programming of the P cells can then be recommenced. When the content of the page counter becomes equal to that of the recording counter an end-of-circuit signal is emitted, invalidating the further functioning of the card and preventing, for example, the erasure of the P cells.

The card can then be recharged by incrementation of the recording counter, within the limits of the counting capacity of this latter. But the card can also be recharged before the end-of-circuit signal is emitted; if any available counting units are left 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.

The page counter and also the recording counter are preferably made strictly irreversible, which means not only that they count in one single direction but also that they do not re-zero on reaching their maximum counting capacity.

As the recording counter is accessible from the external connection terminals of the card, it is highly desirable and at times indispensable to provide a safety device to prevent access to this counter and thus prevent fraud. The invention proposes a system for the operation of cards with a particularly simple security system in the form of two registers in the card. The first register, an identification register, contains a card identification number, e.g. a serial number which was entered in the card from the beginning; this number is accessible for reading but not in principle modifiable; the register may be formed from a read-only memory or from an electrically programmable

memory with floating grid. The second register contains a validation code which is the result of a calculation algorithm taking account both of the content of the first register and of that of the recording counter. The calculation of the validation code is effected 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 in the form of a validation code in the second register. The verification of the validation code is carried out in the card reader at the moment when the card is used; the reader reads the serial number, the content of the credit counter and that of the validation register. It verifies the compatibility of these three contents, taking account of the coding algorithm used.

Among the advantages of the invention it will be noted that the card is compatible with the non-rechargeable cards such as described in the foregoing: it will be easy to see that future applications function equally well whether the cards are rechargeable or non-rechargeable.

Further characteristics and advantages of the invention will emerge from a reading of the detailed description which now follows and which is given by reference to the accompanying drawing, in which the one single diagram is a schematic illustration of the integrated circuit of the memory card according to the invention.

The drawing illustrates the architecture of the integrated circuit of the rechargeable memory card according to the invention. This diagram only shows the parts to which the invention specifically relates; the main items omitted are the circuits controlling the transmission of signals between the card and the card reader or between the card and the apparatus for the recharging of counting units.

It will also be noted that various input or output terminals have been shown in the drawing. In the practical construction of the invention, however, certain terminals shown as physically or electrically separate terminals could

be re-grouped; it is important, in fact; to keep the number of input/output terminals of the card to a minimum, multiplexings of different signals at common terminals being frequently adopted with this end in view.

The example shown in the drawing corresponds to a rechargeable prepaid telephone card, with the use of an electrically erasable memory, and electrically programmable (EEPROM) memory.

The integrated circuit comprises an EEPROM memory zone identified by the reference letters MEM. This zone comprises P calls, each of which corresponds to a counting unit. The memory may take the form of a matrix with decoders for addressing in lines and/or columns, or take the form of registers, such as shift registers etc.

The drawing includes a card access terminal DB, via which the debit pulses are received; these pulses have come from the telephone line itself while the card has been in use in a telephone call box. Each pulse has the effect of programming one cell of the memory MEM, and the address of the cell to be programmed is incremented at each pulse, so that all the still unprogrammed cells in the memory will be programmed in succession. Circuits for programming prepayment memory cards are already known and will not be described in detail. The drawing simply shows the presence of a PGC programming circuit between the terminal DB and the memory MEM.

A circuit DET is provided for the detection of the end of the programming of the memory MEM; it supplies a signal when the last call (p^{th} call) has been programmed. A circuit EFF for the total erasure of the entire memory MEM is likewise provided; it erases the P calls of the memory when it receives the order to this effect from the detection circuit for the end of the programming of a complete page of P unit.

The drawing will also be seen to include two counters CPP and CPC and a comparator COMP to compare the contents of the two counters.

The counters are irreversible; they only count in one direction (e.g. incrementation only) and do not return to zero or to a previous content on reaching the maximum of their capacity. They may count in the binary mode or BCD or in any other mode.

The first counter CPP is the counter for pages of counting units consumed; it is incremented by the detection circuit DET (i.e. by an internal circuit of the card) each time a complete page of counting units has been programmed.

The second counter, CPC, is the recording counter or credit counter. Its content is charged by the outside of the card, or more precisely, by a credit recharging machine. This is why a connection has been shown between the credit counter CPC and an external recharging terminal CR. As stated in the foregoing, this terminal is shown as an autonomous terminal, but it could be made identical with another, such as the terminal DB, since the credit recharging operation will not be carried out while the card is being used in a telephone call box.

It may be assumed that the initial content charged in the CPC counter is Z; this is its content on leaving the factory or after an initial passage through a credit recharging machine. The initial content of the page counter CPP is zero. During the use of the card the memory cells M will be programmed one by one in accordance with the consumption of telephone unit (determined by the receipt of debit pulses at the terminal DB). When the P cells have been programmed the CPP meter is incremented by one unit and the memory is completely erased. This process continues 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 at an external terminal ST of the card. This signal stops the telephone communication, for example, or exerts any other action, including the internal functioning of the card. In particular, it may prevent the erasure of the memory, which should take place at the moment when the counter CPP reaches the value Z.

If the card is then inserted in a credit recharging machine the latter can increment the counter by M units, e.g. up to a value of $Y-Z+M$. For this incrementation the user pays either in proportion thereto for example, or at a diminishing tariff. A new credit of $(Y-Z)P$ counting units is then available to him. The card then functions in exactly the same way as before.

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

As already stated, the card can be recharged even when the credit has not been exhausted, e.g. when the page counter shows a content Z' less than the content of the recording counter and when only some of the P cells of the memory, i.e. P' , have been programmed. The residual credit $(Z-Z'-1)P + P-P'$ remains available for use, and the card recharged up to a recording Y contains an overall credit $(Y'-Z')P-P'$ whatever the value of Z' and P' .

The diagram also includes two registers serving to ensure the security of the card in a simple wired logic circuit not making use of the microprocessor which could ensure this security.

The first register, RID, is a card identification register. It may, for example, include a serial number of the card, a lot number or some fixed code number. The more the identification code is specific to the card, the greater the security provided; in other words, the degree of security is very high if there is practically no chance that two different cards will have the same code. This first register RID is provided, for example, in the form of a read-only memory (ROM) or an electrically programmable register with floating grid. It is accessible for reading from an external terminal ID, so that the card reader in use or the credit recharging machine can read the code which it contains.

The second register, RVL, is a validation register. It contains a validation code as a means of ascertaining that no fraud has been committed. It is accessible for reading by

the card reader or credit recharging machine. It is accessible for writing by the credit recharging machine only. An external access terminal VL has been shown, this could be the same as the terminal ID with a suitable multiplexing of signals. The register consists of an electrically erasable and reprogrammable memory.

The validation process is as follows: during the recharging of the card the recharging machine reads the content Z of the recording counter. It increments the counter until the desired new recording value Y is reached. Proceeding from the new content and from the identification code read in the register RID it establishes a validation code according to a clearly defined algorithm. This code is written into the validation register RVL.

When used in a card reader associated with a machine for the distribution of services (telephone call box) the reader commences by reading from the terminals CR, VL, ID, the contents of the recording counter and of the identification and validation registers. It verifies whether these three contents are compatible, taking into account the algorithm used by the recharging machine. For example, it reproduces the reverse algorithm from the content of the validation register or reproduces 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 no compatibility between the contents of the two registers and of the counter the card reader prevents the distribution of the service or product asked for by the user; it may also prevent the card from being returned to him.

The verification of the validation register does not necessarily imply the execution of the initial algorithm or of the reverse algorithm; in certain cases it may be confined to a more summary verification of calculations of parities 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, which are accessible via an address decoder. The verification of the card then proceeds via an addressing of these specific zones of the memory MEM, since it is these zones that have the function of the validation register RVL and identification register RID.

In particular, the invention will make it possible to produce high capacity telephone cards for people frequently needing to use public call boxes for long distance calls.



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-circuit 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.