SM501 and SM501K Contactless Smartcard Reader Handbook

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Applicability

This handbook applies to the SM501 and SM501K Contactless Smartcard Readers

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Chapter 1

Introduction

The **SM501 and SM501K Contactless Smartcard Readers** are designed to read the codes contained in “Mifare” smartcards and to pass these codes to a host system.

The **SM501K** has an integrated keypad. As well as reading cards, it also passes data entered on the keypad to the host system.

The Readers consists of a printed circuit assembly and keypad mounted inside a plastic enclosure. They require a DC power supply.

Data output

Each Reader provides a choice of Wiegand, Mag Stripe or BCLINK format data output for the card data (and the PIN data on the **K** model).

Reading Smartcard data

By setting a jumper, the Reader can be configured to read one of three areas of data from the Smartcard:

- Read chip serial number from any Mifare card
- Read Girovend information only from Girovend cards
- Read Cotag information only from Cotag cards

Setting up the Reader

You configure the Reader using jumpers as desribed in chapter 2.

Chapter 2

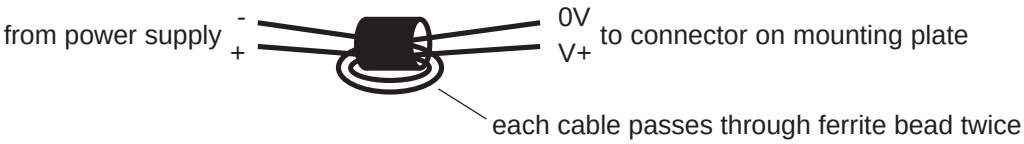
Installing

Mounting, connecting and setting up

Mount the Reader in a suitable position near the door approximately 1.2m from the floor. The Reader can be installed outside in a sheltered position.

The Reader has a mounting plate with two oval mounting holes which are suitable for most installations - you first need to break open the mounting holes using a screwdriver. There are also four round holes in the mounting plate which will align with a standard wall box of the type used, for example, for light switches.

1. If the Reader is fixed to the mounting plate, undo the four screws which are in each corner, then place the mounting plate in position on the wall or door frame and mark the position of the two mounting holes. Note: the mounting plate must be positioned with its connector at the top left.
2. Drill the two mounting holes. The holes accept 3.5mm machine screws or No 6 wood screws.
3. The connections are made to the connector on the mounting plate. Pass the cable through the large hole in the centre of the mounting plate. Note: the two power supply cables must be passed twice through the hole in the ferrite bead supplied with the Reader before they are joined to the connector, as shown in the following diagram:



4. Make the connections shown in the following table as required:

Name	Function
V+	Power supply +V (+ve) unregulated DC
	max 36.0V, min 10.0V, 250mA max
0V	Power supply 0V (-ve),
	(also ground reference for data output)
Amber	Either: Amber LED control - 0V for amber LED
	Or: BCLINK data interface Rx
Horn	Horn - 0V to sound
Red	Either: Red LED control - 0V for red LED
	Or: BCLINK data interface address

Name	Function
Green	Either: Green LED control - 0V for green LED
	Or: Single wire LED control
	0V for green LED, +5V for red LED
	(0V also switches off amber LED)
D0	Data zero for Wiegand output
	Data for Mag Stripe output
	BCLINK data interface Tx
D1	Data one for Wiegand output
	Clock for Mag Stripe output
DA	Data Available for Wiegand or Mag Stripe output

Note: do not apply a voltage greater than +5V to the horn input or the LED inputs

4. Route the cable tidily, then screw the mounting plate to the wall or door frame. Make sure all braid and loose filaments of wire are cut right back or insulated with tape or sleeving.

5. Set the jumpers on the Reader to provide the functions you require, as described in the following tables:

INTERFACE

Jumper JU1	Function
1	32 bit Wiegand
2	34 bit Wiegand
3	10 character Mag Stripe
4	26 bit Wiegand
5	37 character Mag Stripe

DATA

Jumper JU2	Function
1	Read chip serial number from any Mifare card
2	Read Girovend information only from Girovend cards
3	Read Cotag information only from Cotag cards
4	not used
5	not used

LED CONTROL

Jumper JU3	Function
1	Internal - LED and horn inputs are disabled
2	Single wire LED control -
	0V on GREEN input for green LED,
	+5V on GREEN input for red LED
3	External - LEDs and horn can be controlled using the
	RED, GREEN, AMBER and HORN inputs - 0V to activate
5	BCLINK

6. Locate the Reader on the mounting plate with the LEDs at the top left and press it home - the Reader cannot be pushed fully home unless it is the correct way round.

7. Tighten the screws, then insert the little plastic plugs supplied with the Reader into the screw-holes so that the screws cannot be seen and the case looks neat. (Note that the plastic plugs cannot be removed without damaging them - four spare plugs are supplied with each Reader.)

8. Power up the Reader and test it: hold a smart card close to the outline of the card engraved on the face of the Reader - the Reader should bleep when the card is read and the host should receive the card data output. Each key-press should give an amber flash and the host should receive PIN data.

Chapter 3

Setting up

Jumper settings

You set the following functions using jumpers on the Reader:

- The protocol used by the Reader for data output (Wiegand, Mag Stripe or BCLINK)
- The type of data to be read from the Smartcard (chip serial number, Girovend, Cotag)
- Function of LEDs and horn

Distributor Code

In Girovend and Cotag modes, you can teach the Reader a Distributor Code. (In Girovend mode the “System Code” is the Distributor Code.)

When you power up the Reader, there is a 4 second configuration period which is signified by the green LED being lit. If you present a card within this period, the Reader learns the Distributor Code from the card and bleeps for 2 seconds. After learning a Distributor Code, the Reader will ignore all cards with the wrong Distributor Code.

Interface 5

Interface 5 can be re-programmed using a configuration card to give the data output that you require: contact Technical Support in Cambridge for details.

Data output selection (jumper JU1)

Using jumper JU1, you can choose from three Wiegand and two Mag Stripe (ABA) data outputs as shown in the table below:

	Interface 1	Interface 2	Interface 3	Interface 4	Interface 5*
Interface type	Wiegand	Wiegand	ABA	Wiegand	ABA
Bit length	500µs	500µs	1.5ms	500µs	1.5ms
Pulse width	100µs	100µs	500µs	100µs	500µs
Number of bits/characters	32	34	10	26	37
Data hold implemented**	No	No	No	No	No
D0 active high/low	low	low	low	low	low
D1 active high/low	low	low	low	low	low
DA active high/low	low	low	low	low	low
Repeat data delay	2s	2s	2s	2s	2s
Read hold off time***	1s/5s	1s/5s	1s/5s	1s/5s	1s/5s
Following for ABA formats only :-					
Number of leading zero bits			8		8
Number of trailing zero bits			8		8

*This interface can be redefined by presenting a Cotag programmed smartcard during the configuration period - contact Technical Support in Cambridge for details.

**If Data Hold is implemented, the amber LED will not work.

***The hold off time is 1 second on the **SM501** Reader, and is 5 seconds on the **SM501K** Reader. If a key is pressed within the 5 seconds hold off time on the **SM501K** Reader, the hold off time is reset to 2 seconds from the time the key was pressed. Pressing another key within the 2 seconds hold off time resets the hold off time again, so that it is always 2 seconds after the last key was pressed.

Note: if JU3 is set to position 5 for BCLINK data output, the position of JU1 has no effect.

Data type selection (JU2)

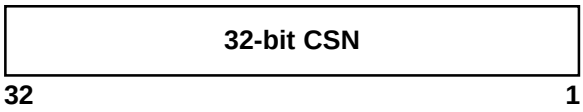
Jumper JU2	Function
1	Read chip serial number from any Mifare card
2	Read Girovend information only from Girovend cards
3	Read Cotag information only from Cotag cards

Data output in “chip serial number” mode

In the following diagrams, data is transmitted from left to right.

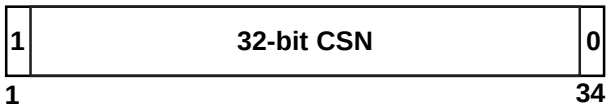
If chip serial number (CSN) mode is selected the data output for each interface is as follows:

Interface 1



32-bit chip serial number, most significant bit first.

Interface 2



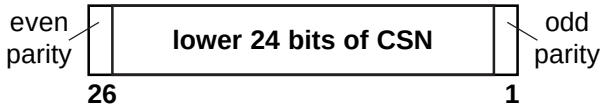
Start bit 1, 32-bit chip serial number, stop bit 0, least significant bit first.

Interface 3

BCCCCCCCCCC**FL**$_{rc}$

c - 32-bit chip serial number converted to decimal and output as ten ASCII characters

Interface 4



Lower 24 bits of chip serial number with leading even parity bit and odd trailing parity bit, most significant bit first.

Interface 5

Interface 5 can be re-defined using a configuration card. If it is left in its default setting, the data output is as follows:

B0000000000000000000000CCCCCCCCCC C0000000**FL**$_{rc}$

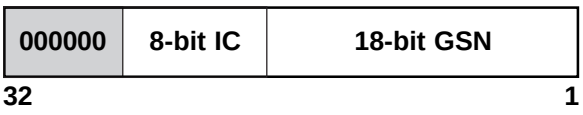
c - 32-bit chip serial number converted to decimal and output as ten ASCII characters

Data output in “Girovend” mode

In the following diagrams, data is transmitted from left to right, and the shaded areas are zeros.

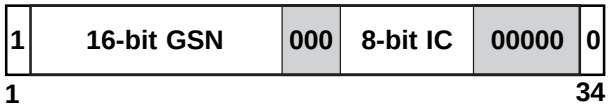
If Girovend mode is selected the data output for each interface is as follows:

Interface 1



6 zeros, 8-bit Girovend installation code, 18-bit Girocard serial number, most significant bit first.

Interface 2



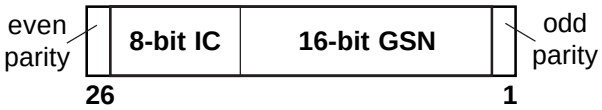
Start bit 1, lower 16 bits of 18-bit Girocard serial number, 3 zeros, 8-bit Girovend installation code, 5 zeros, stop bit 0, least significant bit first.

Interface 3

B00nnnnnnnn**FL**$_{rc}$

n - 26-bit number converted to decimal and output as 8 ASCII characters. The most significant 8 bits of the 26-bit number are the 8-bit Girovend system code. The least significant 18 bits of the 26-bit number are the 18-bit Girocard serial number.

Interface 4



8-bit Girovend installation code, lower 16 bits of 18-bit Girocard serial number, with leading even parity bit and odd trailing parity bit, most significant bit first.

Interface 5

Interface 5 can be re-defined using a configuration card. If it is left in its default setting, the data output is as follows:

B00sss000000000000000000ccccc c0000000**FL**$_{rc}$

s - 8-bit Girovend system code converted to decimal and output as 3 ASCII characters.

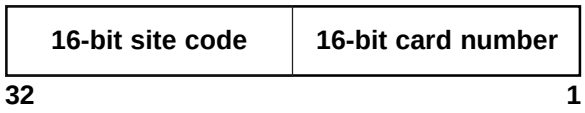
c - 18-bit Girocard serial number converted to decimal and output as 6 ASCII characters.

Data output in “Cotag” mode

In the following diagrams, data is transmitted from left to right.

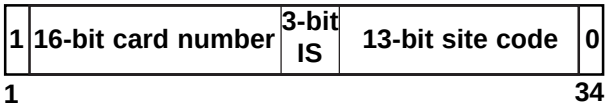
If Cotag mode is selected the data output for each interface is as follows:

Interface 1



16-bit site code, lower 16 bits of card number, most significant bit first.

Interface 2



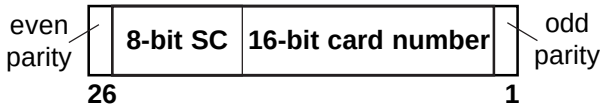
Start bit 1, lower 16 bits of card number, 3-bit issue state, lower 13 bits of site code, stop bit 0, least significant bit first.

Interface 3

B00CCCCCCCCFL_{rc}

c - Least significant 26 bits of card number converted to decimal and output as 8 ASCII characters.

Interface 4



Lower 8 bits of site code, lower 16 bits of card number, with leading even parity bit and odd trailing parity bit, most significant bit first.

Interface 5

Interface 5 can be re-defined using a configuration card. If it is left in its default setting, the data output is as follows:

Bsssss00000ccccccccccccccccccc ci000000**FL**$_{rc}$

s - 16-bit site code converted to decimal and output as 5 ASCII characters.

c - 64-bit card number converted to decimal and output as 20 ASCII characters.

i - 3-bit issue state converted to decimal and output as 1 ASCII character.

LED control and BCLINK selection (JU3)

Jumper JU3	Function
1	Internal - LED and horn inputs are disabled
2	Single wire LED control - 0V on GREEN input for green LED, +5V on GREEN input for red LED horn input is disabled
3	External - LEDs and horn can be controlled using the RED, GREEN, AMBER and HORN inputs - 0V to activate
5	BCLINK

LED control

Use the **1** setting if you want the Reader alone to control the LEDs as follows:

- The red LED is on when no smartcard is in range.
- When the Reader reads a valid smartcard, the red LED goes off, the green LED goes on, and the horn beeps. The green LED goes off and the red LED on again after the hold off time.

The **2** setting requires external control of the green LED indication from the host, but the Reader controls red and amber LED indications. This provides single-wire control of the LED indication from the host. It works as follows:

- The red LED is on when no smartcard is in range.

- When the Reader reads a valid smartcard, the red LED stays on and the amber LED comes on. The amber LED remains on for the period of the hold off time.

- If the GREEN input on the connector is pulled low (0V) while the amber LED is on, both red and amber LEDs go off and the green LED comes on, and the hold off time is cancelled.

- The green LED stays on until the GREEN input returns high (+5V), when the green LED goes off and the red LED comes on again.

Use the **3** setting when the drives for LED indications and horn are supplied by the host system. The LEDs follow the inputs labelled RED, GREEN and AMBER on the connector: +5V for off, 0V for on. The horn follows the Horn input: +5V for off, 0V for on. Note that, even when the LEDs and horn are driven externally, the amber LED will flick for 100ms whenever a key is pressed on the **SM501K** Reader, and the horn will beep for 100ms whenever a card is read on either Reader.

BCLINK

Set JU3 to position 5 if you want to transmit data from the Reader in BCLINK format. This setting overrides all settings of JU1.

Chapter 4

Operation

Once you have set up all the options described in chapter 3, “Setting up”, normal operation simply consists of presenting your card to the Reader, entering your PIN on the keypad if the Reader is type **SM501K,** and awaiting the response. The Readers are always used in conjunction with a host system which controls the door lock mechanism (or any other equipment in different applications) and takes decisions about when to activate it.

LEDs

Internal LED control

Under internal control (LEDs driven by Reader), the indicator LEDs work as follows:

- The red LED is on when no smartcard is in range.
- When the Reader reads a valid smartcard, the red LED goes off, the green LED goes on, and the horn beeps. The green LED goes off and the red LED on again after the hold off time*.

Single wire LED control

Under single wire control (red and amber LEDs driven by Reader, green LED driven by host), the indicator LEDs work as follows:

- The red LED is on when no smartcard is in range.
- When the Reader reads a valid smartcard, the red LED stays on and the amber LED comes on. The amber LED remains on for the period of the hold off time*.
- If the GREEN input on the connector is pulled low (0V) while the amber LED is on, both red and amber LEDs go off and the green LED comes on, and the hold off time* is cancelled.
- The green LED stays on until the GREEN input returns high (+5V), when the green LED goes off and the red LED comes on again.

*The hold off time depends on which type of Reader you are using; see the section on the hold off time later in this chapter.

External LED control

Under external control (LEDs driven by host), the indicator LEDs follow the RED, AMBER and GREEN terminals on the connector.

All LED control modes

In all of the above LED control modes, the amber LED flicks on or off (depending on its current state) for 100ms whenever a key is pressed on the **SM501K** Reader.

Horn

The horn bleeps for 100ms whenever the Reader reads a valid smartcard.

If External LED Control is selected, the horn can be controlled externally using the Horn terminal on the connector.

PIN data

The **SM501K** Reader outputs PIN data whenever a key is pressed, irrespective of whether it has read a card.

Using cards

The Readers are designed for use with a hand-held card. Present the face of the card near the Reader and wait for the horn to beep.

Looking after a card

- Don't let the card get too hot - for example if left in a car on a sunny day. The operating temperature range for the card is -20 to +50°C.
- Don't deliberately bend the card and take care not to sit on it in your pocket.
- To clean the card, use a damp cloth. Don't use any solvents and don't immerse it in anything.

Hold off time

When the Reader reads a valid card, it will not read a card again until the hold off time has elapsed.

The standard data ouputs which are available using jumper JU1 all give a hold off time of 1 second for the **SM501** Reader, and 5 seconds for the **SM501K** Reader.

If a key is pressed within the 5 seconds hold off time on the **SM501K** Reader, the hold off time is reset to 2 seconds from the time the key was pressed. Pressing another key within the 2 seconds hold off time resets the hold off time again, so that it is always 2 seconds after the last key was pressed.

Repeat Data Delay (RDD)

When the Reader reads data from a card, it sends card data to the host. After it has done this, it will not send the same card data to the host again until the RDD time has elapsed. This prevents the system becoming overloaded with lots of data from one card being read over and over again.

The standard data ouputs which are available using jumper JU1 all give a repeat data delay of 2 seconds. Note that if the hold off time is longer than the RDD (as with the standard data outputs on the **SM501K** Reader), the RDD has no effect.

Chapter 5

Data output

The **SM501 and SM501K** Readers offer a choice of Wiegand or Magnetic Stripe or BCLINK interface to communicate with a host system. You select the interface you require using the jumpers on the Reader, see chapter 3.

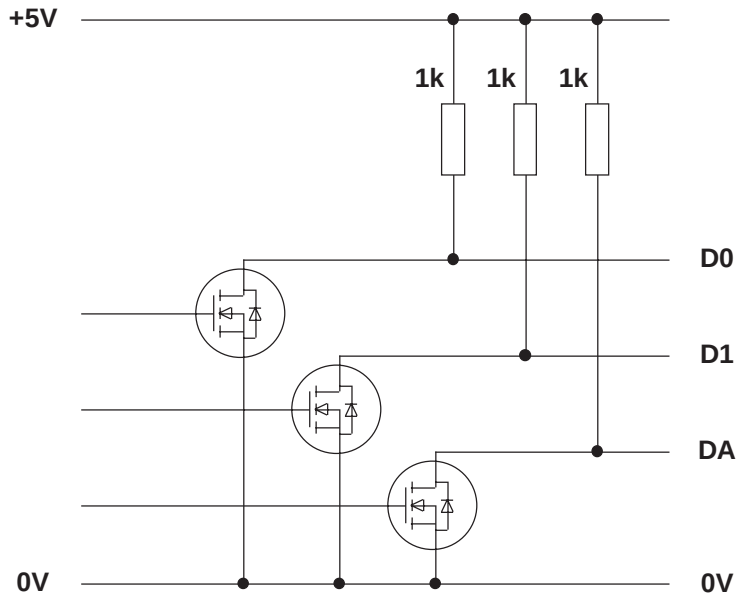
Electrical characteristics of outputs from the Reader

The Wiegand interface uses the data lines D0, D1 and DA.

All outputs are driven by open drain drivers which can each sink up to 250mA. When a driver is off, its output is pulled up to +5V (the regulated logic voltage on the board) by a 1k resistor (and also by whatever is connected at the host end).

The polarities of the three data outputs (D0, D1 and DA) are individually selectable (active-high or active-low) using a configuration card: contact Technical Support in Cambridge for details.

The diagram below shows the logical implementation of the outputs used for the Wiegand interface.



Data Hold input

The Reader can be configured to use the AMBER LED input as a Data Hold input ($\overline{H}$). This can be used by the host to buffer up to five data message in the Reader until the host is ready to read them. This enables the data lines from two Readers to be connected in parallel, the host polling each in turn by releasing its Data Hold input, reading the data, then asserting the Data Hold input again. If you do not read the messages quickly enough and the message buffer becomes full, new messages will be thrown away.

Wiegand interface

Connections

The pin connections for the Wiegand interface are as follows:

0V (ground)

D0 (logic 0)

D1 (logic 1)

DA (data available)

Electrical characteristics

The interface provides three outputs: logic zero data (D0), logic one data (D1) and data available (DA).

Data transfer is performed by pulsing the D0 line to indicate a logic zero and by pulsing the D1 line to indicate a logic one. The voltage of the data lines is +5V or 0V.

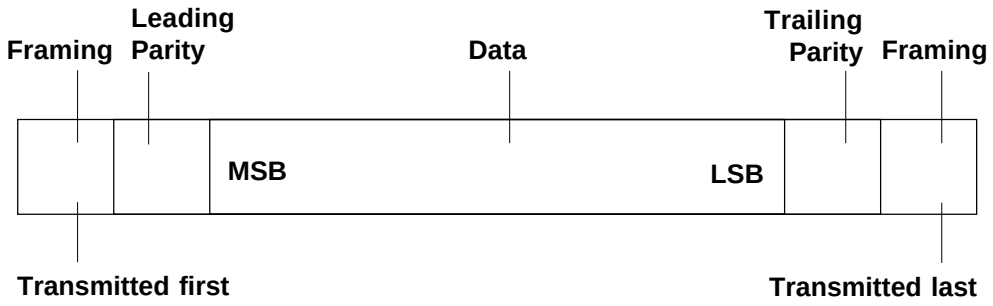
The Data Available output (DA) is provided to tell the host system it must read a data message from the Reader. DA becomes active 1ms before data is sent and is released 1ms after the data has been sent.

Data format

There are three aspects to the format of the data message, all of which can be varied, depending on the interface setting you use:

- Framing bits at the start and finish of the message.
- Any parity bits which may be used.
- The data from the card.

The following diagram shows a typical message structure.



Framing bits are usually either not used or confined to start and stop bits which have a fixed state. Some applications require a more complicated sequence of framing bits, usually at the start of the message.

Parity bits are used to check the integrity of the data message. Parity may be odd or even and it may be calculated from the data only or from the data and some framing bits.

Card data

Data from the card can be any number of bits including any parity check bits which may be stored in the card code. The interface selected determines whether the data is sent most significant bit first or least significant bit first.

PINpad data

Data from a PINpad is sent whenever a key is pressed, providing the Reader is not already sending a card data message, in which case it sends the PINpad data afterwards. PINpad data has 8 data bits. The first four bits are the inverse of the PINpad key, the second four bits are the PINpad key. For example, if the data is 1010 0101, the key pressed was 5. If the data is 0100 1011, the key pressed was #. (Hex 0 to 9 corresponds to keys 0 to 9, hex A is * and hex B is #.)

Magnetic Stripe

A Magnetic Stripe interface is provided which simulates the output of a magnetic card reader.

Connections

The pin connections for the Magnetic Stripe interface are as follows:

0V (ground)

D0 (data)

D1 (strobe)

DA (present)

Electrical characteristics

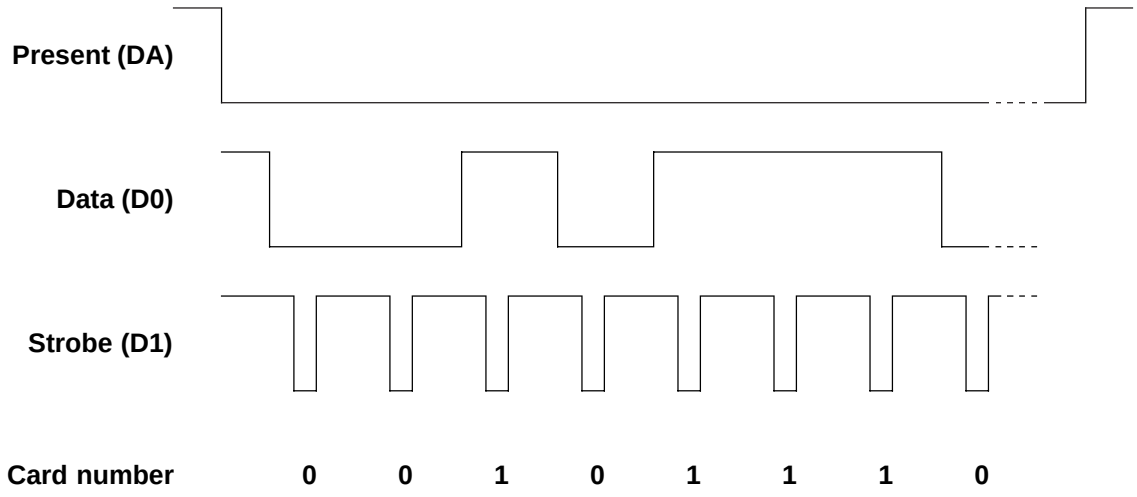
The interface provides three outputs: Present, Data and Strobe.

Present is a signal given by a magnetic card reader indicating that a card has been inserted in the slot. On the Readers, this signal becomes active just before data is sent and is released after the data has been sent.

Data is a signal whose level reflects the value of the bit in the code.

Strobe is a series of clock pulses. Data can be sampled on either the rising edge or the falling edge of the Strobe signal.

The following diagram should make clear the action of all three signals in a data transfer. In this example, the Data line (D0) is high for a one and low for a zero:



PINpad data

Data from a PINpad is sent whenever a key is pressed, providing the Reader is not already sending a card data message, in which case it sends the PINpad data afterwards. PINpad data has 8 data bits. The first four bits are the inverse of the PINpad key, the second four bits are the PINpad key. For example, if the data is 1010 0101, the key pressed was 5. If the data is 0100 1011, the key pressed was #. (Hex 0 to 9 corresponds to keys 0 to 9, hex A is * and hex B is #.)

Whenever a key is pressed, the Strobe output pulses 8 times, and the Data output should be sampled at each Strobe pulse to give the 8 data bits corresponding to the key that was pressed. Note that PINpad data is not output as an ASCII character.

Custom interfaces

It is possible to configure your own interface: contact Technical Support in Cambridge for details.

Chapter 6

Card data format

Chip serial number mode

This mode will work with any Mifare contactless smartcard regardless of the data content and security keys used.

The Reader will read the first card it finds at the antenna and output the chip serial number as its data.

The chip serial number is a number programmed into the card at the time of manufacture which is guaranteed to be unique regardless of the source or application of the card.

Girovend mode

This mode enables you to use cards that have been pre-programmed by Girovend to work with their cashless vending systems.

The Girovend cards are programmed in accordance with the Mifare application directory standard.

The Girovend cards contain a public access sector which contains, among other things, an 8 bit “installation code”, an 8 bit “system code” and an 18 bit “serial number”.

The Reader treats the system code in the same way as a Cotag Distributor Code, and treats the installation code in the same way as a Cotag Site Code, and treats the serial number in the same way as a Cotag Card Number.

When reading cards, the Reader will interrogate all the cards currently in range of the antenna one by one until a card is found which contains Girovend data. If the installer code matches that learnt by the Reader (see the section at the beginning of chapter 3 for details of teaching the Reader a Distributor Code) then it outputs the system code and serial number via the currently selected data interface.

If the installer code does not match that learnt by the Reader, the Reader will keep interrogating the rest of the cards.

Cotag mode

This mode uses smartcards which have been programmed with Cotag's own data, see below for details.

The Cotag cards are programmed in accordance with the Mifare application directory standard.

A Cotag programmed card may contain one or more sectors of information which may be either access control data or configuration data. Every sector contains the distributor code.

When reading cards the reader will interrogate all the cards currently in the range of the antenna one by one until a card is found which contains Cotag data. If the Distributor Code matches that learnt by the Reader (see the section at the beginning of chapter 3 for details of teaching the Reader a Distributor Code) then the Reader reads and processes each sector which is present .

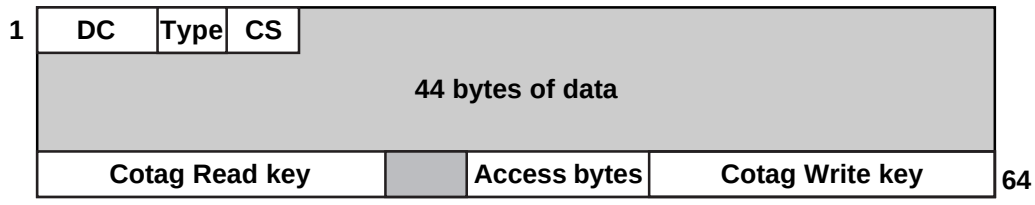
Information contained in a Cotag smartcard

This section should be read with a good understanding of the structure of the data in a Mifare contactless card, particularly the structure of the MAD (Mifare Application Directory). (For this information, see the Mifare standardisation note entitled "MIFARE Application directory MAD".)

Note: all numbers stored in a Cotag sector are stored most significant byte first (this is is different from most other data in the card).

A Cotag programmed card may contain between one and three sectors of information. Each sector has the Cotag AID (Application Identifier) in the relevant position in the MAD. (Cotag's AID is $4837, that is: the $37th access control application ($48 = access control)

The sectors all have the following structure:



DC - Distributor code

Type - Type of sector - can be one of the folowing values
- 0 - Access control sector
- 1 - Configuration sector
- 2 - Configuration extension sector

CS - Checksum correction byte - this is calculated so that the EOR of the first 48 bytes of the sector = $AA.

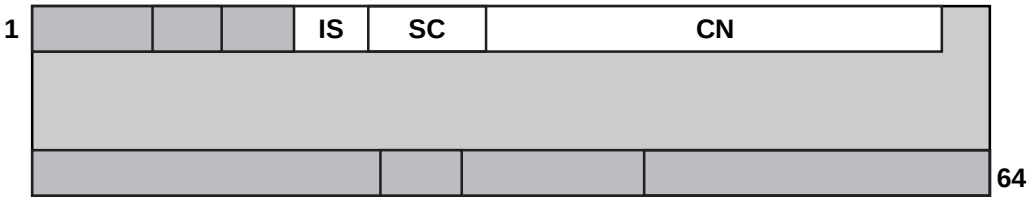
Data - This is the 44 bytes of sector data - its use use is dictated by the sector type and is described in detail below.

- Cotag Read key - Cotag's own secret read key.
- Cotag Write key - Cotag's own secret write key.
- Access bytes - See GEMPLUS "Contactless Serial Readers Reference Manual" for a description of this area.

Sector type 0 - Access control

If this sector is present it must be the highest numbered Cotag sector on a card (that is, it must come after any configuration sectors).

The data contained in this type of sector has the following structure:



IS - 3 bit Issue state of card (0 - 7)

SC - 16 bit Site code of card (0 - 65,535)

CN - 64 bit Card number of card (0 - 281,474,976,710,655)

Other sector types

Other sector types are defined which enable you to configure Reader interface type 5. Contact Technical Support in Cambridge for details.