Xico Data Formats
For Magnetic Stripe Card Readers and Encoders

Introduction

Various models of Xico magnetic stripe card readers and encoders are supplied with proprietary data format algorithms in addition to the two "standard" data formats specified in the ISO/IEC 7811 International Standard. These Xico Data Formats remove the restrictions imposed in the ISO Standard to yield the flexibility required in custom and closed-system applications of magstripe card technology. These additional Xico Data Formats are described in Section 1 below. For convenient reference, the two ISO Standard data formats are presented first.

Properly speaking, the term “data format” refers to the rules which define the bit-string of logic 0s and 1s to be encoded in the flux reversal pattern on the magnetic stripe, and therefore, refers only to encoders. A basic reader (called a Bit & Strobe reader) simply decodes the flux reversal pattern into a logic bit-string and therefore need not know the encoding data format. However, most magstripe readers today are expected to reformat the bit-string into ASCII data before transmission, and for this, the reader must obviously know the encoding data format. In addition, a reader may be required to process the read data under specified rules to produce a modified output. Such bit-string manipulations by a reader are more properly called reader “Output Formats.” The various Xico Output Formats are described in Section 2 below.

1. Encoder Data Formats

ISO BCD Data Format

This data format is usually referred to as "ISO BCD," or just "BCD," and sometimes as "ABA." It is also sometimes referred to as "Track 2 Format," which should be avoided since any data format (and any data density) can be used on any track location on a magstripe card.

The ISO BCD Data Format consists of a 16-character set of 4-bit patterns as shown in the table below. The specified framing characters for Start Sentinel (;) and End Sentinel (?) are shown.

The data is actually encoded on the magnetic stripe as a 5-bit pattern where the fifth bit is an odd character parity bit for error checking on read. The End Sentinel is followed by an LRC Character for longitudinal error checking on read. The three so-called framing

characters (Start Sentinel, End Sentinel, LRC) are ordinarily automatically inserted by an encoder and automatically deleted before data transmission by a reader.

The ISO BCD Data Format is used on Track #2 and Track #3 of ISO Standard ID-1 magstripe cards such as credit and debit cards, ATM cards, and many other cards which follow this standard. This is a specification imposed by the ISO/IEC 7811 Standard and is not a limitation of magstripe technology.

The essential restriction in this data format is that the End Sentinel (?) may not be used as a data character. Hence, the ISO BCD Data Format cannot be used to encode hexadecimal data. This restriction is removed in the Xico MOD BCD Data Format discussed below.

ISO BCD CHARACTER SET

Bits b_4 b_3 b_2 b_1	Character	Bits b_4 b_3 b_2 b_1	Character
0 0 0 0	0	1 0 0 0	8
0 0 0 1	1	1 0 0 1	9
0 0 1 0	2	1 0 1 0	:
0 0 1 1	3	1 0 1 1	;
0 1 0 0	4	1 1 0 0	<
0 1 0 1	5	1 1 0 1	=
0 1 1 0	6	1 1 1 0	>
0 1 1 1	7	1 1 1 1	?

Bit b_5 is an odd character parity bit.
; is the Start Sentinel.
= is the Field Separator.
? is the End Sentinel.

ISO ALPHA Data Format

This data format is usually referred to as "ISO ALPHA," or just "ALPHA," and sometimes as "IATA." It is also sometimes referred to as "Track 1 Format," which should be avoided as noted above.

The ISO ALPHA Data Format consists of a 64-character set of 6-bit patterns as shown in the table below. The framing characters for Start Sentinel (%) and End Sentinel (?) are shown. The data is actually encoded as a 7-bit pattern with an LRC character following the End Sentinel for error checking purposes during a read as described for the BCD format above.

The ISO ALPHA Data Format is used on Track #1 of ISO Standard ID-1 magstripe cards such as credit and debit cards, ATM cards, and many other cards which follow this standard. Again note that this use of the ALPHA format is a specification imposed by the ISO/IEC 7811 Standard and does not represent a requirement imposed by magstripe technology.

As with ISO BCD, the essential restriction in the ISO ALPHA format is that the End Sentinel (?) may not be used as a data character. This loss of one character in the data set places restrictions on encryption algorithms, security codes, and error correction codes used in the data field. This restriction is removed in the Xico MOD ALPHA Data Format discussed below.

ISO ALPHA CHARACTER SET

	Bits b_6 b_5			
Bits b_4 b_3 b_2 b_1	0 0	0 1	1 0	1 1
0 0 0 0	SP	0	@	P
0 0 0 1	!	1	A	Q
0 0 1 0	"	2	B	R
0 0 1 1	#	3	C	S
0 1 0 0	$	4	D	T
0 1 0 1	%	5	E	U
0 1 1 0	&	6	F	V
0 1 1 1	'	7	G	W
1 0 0 0	(	8	H	X
1 0 0 1	)	9	I	Y
1 0 1 0	*	:	J	Z
1 0 1 1	+	;	K	[
1 1 0 0	,	<	L	\
1 1 0 1	-	=	M	]
1 1 1 0	.	>	N	^
1 1 1 1	/	?	O	_

Bit b_7 is an odd character parity bit.

% is the Start Sentinel
^ is the Field Separator
? is the End Sentinel

Xico Multi-Message ALPHA/BCD Data Formats

The Xico Multi-Message ALPHA and Multi-Message BCD Data Formats are used to encode an ISO-framed data block two or more times on a single track with each framed data block separated by ten (10) clocking bits. Each data block complies with the relevant ISO Data Format with the obvious proviso that the total encoding must fit on the length of the card.

The Xico Multi-Message Data Formats are particularly useful for insertion readers in applications where a valid read must be obtained on card insertion. The principal human factors limitation on such applications is that some people stop the card partially inserted and then push it the rest of the way in. This will prevent a valid read of a card encoded its full length with a single data block. The use of multiple data blocks makes it extremely unlikely that a user will stop on every data block and thereby fail to get a valid read.

XICO MOD BCD Data Format

This Xico Modified BCD Data Format is referred to in Xico literature as "XICO MOD BCD," or just "MOD BCD." It permits the use of the full 16-character set of ISO BCD in the data field. The ISO BCD framing characters (Start Sentinel, End Sentinel, LRC) and parity rules are used *with the exception that* the End Sentinel has an even character parity bit, rather than odd, as in ISO BCD.

The XICO MOD BCD Data Format permits the encoding and reading of hexidecimal data while retaining the features of character parity and LRC functions to catch read errors. Note that the characters used for serial transmission of data to an encoder and from a reader are the ASCII representations of the characters in the BCD Character Set (0 thru ?), and not the HEX Character Set (0 thru F).

An encoder equipped with XICO MOD BCD Data Format is used to encode and read-verify cards for use in readers equipped with the XICO BIT Output Format discussed below.

XICO MOD ALPHA Data Format

This Xico Modified ALPHA Data Format is referred to in Xico literature as "XICO MOD ALPHA," or just "MOD ALPHA." It permits the use of the full 64-character set of ISO ALPHA in the data field. The ISO ALPHA framing characters (Start Sentinel, End Sentinel, LRC) and parity rules are used *with the exception that* the End Sentinel has an even character parity bit, rather than odd, as in ISO ALPHA.

The XICO MOD ALPHA Data Format permits the encoding and reading of alphanumeric data employing encryption algorithms, security codes, and/or error correction codes which normally require a complete character set. The characters used for serial transmission of data to an encoder and from a reader are the ASCII representations of the characters in the ALPHA character set (SP thru _).

XICO HEX Data Format

The XICO HEX Data Format permits the direct encoding of a bit-string of logic zeros and ones without the use of framing characters or parity bits. The encoded bit-string is preceded by clocking bits, as set on the encoder, and followed by clocking bits to the end of the encoding. The XICO HEX Data Format allows the user to specify every bit encoded on the card, i.e. an arbitrary bit pattern, and hence, to use a proprietary data format known only to the user.

For convenience, the characters used for serial transmission to the encoder of the data to be encoded are the ASCII representations of the HEX Character Set (0-F).

The output from a XICO HEX Data Format reader, including the read-after-write circuit of an encoder, uses the XICO HEX Output Format discussed in Section 2. Note that this means that the first bit of the first HEX character encoded above must be a "1" bit for the HEX character string returned by the encoder read-verify function to match the HEX character string sent to the encoder.

CAL DMV Data Formats

The California Department of Motor Vehicles uses custom data formats on Tracks #1 and #3 of its DL/ID Cards. Track #2 on the DL/ID Card uses ISO BCD Data Format.

The two custom formats are as follows:

CAL DMV #1 Data Format

- 6-bit Alpha Character Set
- No parity bit
- Start Sentinel is % (05H)
- End Sentinel is ? (1FH)
- End Sentinel not permitted as data

CAL DMV #3 Data Format

- 6-bit Alpha Character Set
- No parity bit
- Start Sentinel is ! (01H)
- End Sentinel is ? (1FH)
- End Sentinel is permitted as data

The 6-bit Alpha Character Set is the one used in the ISO Alpha Data Format. Note that the provision in CAL DMV #3 Data Format permitting the End Sentinel to also be used as a data character has no impact on the encoder, but does require the reader to test for the true End Sentinel. Without the odd parity bit, this test can be ambiguous.

AAMVA Data Formats

The American Association of Motor Vehicles Administrators adopted recommended data formats for the three tracks on Driver Licenses and Identification Cards on 9 September 1992, and most states, except California, follow the AAMVA rules for their DL/ID Cards.

AAMVA uses the ISO ALPHA Data Format on Track #1, the ISO BCD Data Format on Track #2, and the ISO ALPHA Data Format on Track #3, with the additional provision that the End Sentinel may be used as a data character on Track #3. This has no impact on the encoder, but does require the reader to test for the true End Sentinel on Track #3. With the odd parity bit, this test is unambiguous.

JIS II Data Format

The JIS II Data Format is used to encode the single track on the magnetic stripe at the top front of a Japanese financial card (the JIS I Data Formats are identical to those of ISO/IEC 7811). The JIS II Data Format uses a 7-bit 128-character set, which is basically the 7-bit ASCII Table with some entries representing Japanese characters. The Format uses an even character parity bit and an even–bit LRC character. The JIS II track is wider than the ISO track, roughly covering ISO Tracks #1 and #2, and is encoded at 210 BPI density. The full specifications are given in JIS X-0201.

2. Reader Output Formats

A Data Format specifies how the encoder "formats" the data it is supplied into a bit-string for encoding on the magnetic stripe and specifies how the reader "reformats" the bit-string to recover the original data. However, a reader may further process this data to yield an output based on, but not identical with, the original data. Xico Reader Output Formats which involve processing the read data under rules additional to those in the encoding Data Format are presented below.

XICO HEX Output Format

The XICO HEX Output Format is an output transmission protocol used by a reader when it has no data format algorithm to guide it in processing its read bit-buffer. In HEX Output Format transmission, the reader transmits its read buffer in HEX Character (0 thru F) representations of 4-bit nibbles, starting with the first one-bit encountered in the read buffer.

Note that some XICO readers operate with multiple Data Formats in an automatic reformat mode, where the reader tests each of the Data Formats on the read buffer to see if one of them is satisfied. Some of these readers perform a default transmission of the read buffer in XICO HEX Output Format if none of the Data Formats is satisfied.

XICO BIT Output Format

The XICO BIT Output Format permits the encoding and read recovery of an arbitrary length data bit-string of logic zeros and ones while retaining character parity and LRC functions to catch read errors. The BIT Output Format is for use in readers only so that the reader output is the desired arbitrary bit-string. Cards for such readers must be encoded using the XICO MOD BCD Data Format discussed in Section 1 or its equivalent. The BIT Output Format is used in Format #1 and #3 of Xico's Suffix BP readers.

The following two-step algorithm is used to determine the BCD data string to be encoded on the card:

> **Step #1: Bit-String Length.** The first two BCD characters following the Start Sentinel specify the Bit-String Length, which can range from 1 to 255 bits. In terms of the BCD couplet, this is the range from "01" to "??", which is the BCD equivalent of the Hexadecimal range from "01" to "FF."
>
> **STEP #2: Bit-String Data.** The BCD characters representing the Bit-String Data are determined by dividing the Bit-String into 4-bit characters, starting at the end of the Bit-String and working backwards to the beginning of the Bit-String, completing any partial 4-bit character at the beginning with leading 0-bits.

The BCD "data" characters transmitted to the encoder consist of the two BCD Bit-String Length characters followed by the BCD Bit-String Data characters. Note that the characters used for serial transmission of this data to the encoder, and the return transmission of read-verify data from the encoder, are the ASCII representations of the characters in the BCD Character Set (0 thru ?).

The XICO BIT Output Format extends the applicability of standard magstripe cards to a wide range of access control systems which employ other card technologies, such as Wiegand-Effect, barcode, and magnet-buttons. This permits magstripe readers to be used interchangeably with the readers for the other technologies. The magstripe cards can be re-encoded when employee status changes. Permanently encoded magstripe cards are also available if desired.

Read Buffer Output Format

This is a multi-format mode in which the buffered Read data is first checked for several valid formats then transmitted as an unmodified bit-string starting with the first one-bit. The data is preceded by a 4-bit Header as given below. For a valid Format, the bit-buffer is shipped forward. If there is no valid Format, the bit-buffer is shipped backwards from the end of the buffer, which will always give the shortest bit-string. This is Format #2 in Xico's Suffix BP readers.

Header-bits	Format
0000	Valid ISO BCD Data Format
0001	Valid XICO MOD BCD Data Format
0010	Valid JIS Type II Data Format
0100	Valid ISO Alpha Data Format
1000	None of the above formats are valid

Bank Card Output Format

This is Format #4 in Xico's Suffix BP readers which yields a 32-bit output from the first eight BCD digits in the bank card account number. It is for use with the Track #2 data encoded on standard credit and debit cards (VISA, MasterCard, etc.).

The eight (8) BCD Characters following the ISO Start Sentinel are transmitted as a continuous bit-string (i.e., without the parity). The card data is checked for framing and parity errors. No transmission occurs unless the first character following the ISO Start Sentinel is either a 4 or a 5. The 4-bit BCD characters are transmitted MSB first.

26-Bit ISO/Wiegand Output Format

This output is for reading a card encoded with the ISO BCD Data Format. It accepts, as valid, cards encoded with a minimum of five (5) and a maximum of seven (7) BCD characters between the Start Sentinel and the End Sentinel. The card data is checked for framing and parity errors. The first one to three decimal digits are converted to an 8-bit binary number Site Code, and the last four decimal digits are converted to a 16-bit binary number Card Code. The 26-bit output is a 1-bit followed by the Site Code, followed by the Card Code, and terminated with an even parity bit for the Card Code. The binary numbers are transmitted MSB first. This is Format #5 in Xico's Suffix BP readers.

32-Bit ISO/Wiegand Output Format

This output permits the use of cards encoded in ISO BCD Data Format in which the first nine digits (such as the Social Security Number) are used to yield a 32-bit output. It accepts, as valid, cards encoded with a minimum of nine (9) BCD characters following the Start Sentinel. Read data is checked for framing and parity errors. The first five (5) BCD characters are converted to a 16-bit binary number, and the next four (4) BCD characters are converted to a second 16-bit binary number. The binary numbers are transmitted MSB first. This is Format #6 in Xico's Suffix BP readers.

26-Bit JIS/Wiegand Output Format

This output is for reading a card encoded with the JIS II Data Format. It accepts, as valid, cards encoded with minimum of five (5) and a maximum of seven (7) ASCII characters between the Start Sentinel and the End Sentinel. The card data is checked for framing and parity errors. The first one to three decimal digits are converted to an 8-bit binary number Site Code, and the last four decimal digits are converted to a 16-bit binary number Card Code. The 26-bit output is a 1-bit followed by the Site Code, followed by the Card Code, and terminated with an even parity bit for the Card Code. The binary numbers are transmitted MSB first. This is Format #7 in Xico's Suffix BP readers.

32-Bit JIS/Wiegand Output Format

This output permits the use of cards encoded in JIS II Data Format, wherein the first nine decimal characters are used to yield a 32-bit output. It accepts, as valid, cards encoded with minimum of nine (9) ASCII characters between the Start Sentinel and the End Sentinel. Read data is checked for framing and parity errors. The first five (5) decimal characters are converted to a 16-bit binary number, and the next four (4) decimal characters are converted to a second 16-bit binary number. The binary numbers are transmitted MSB first. This is Format #8 in Xico's Suffix BP readers.