HP Engage One Pro Magnetic Stripe Reader User Guide

M49143-001

RMN: HSN-NL02

First Edition: December 2020

Document Part Number: M49143-001

Product notice

This user guide describes features that are common to most models. Some features may not be available on your computer.

To access the latest user guides, go to http://www.hp.com/support, and follow the instructions to find your product. Then select **Manuals**.

Software terms

By installing, copying, downloading, or otherwise using any software product preinstalled on this computer, you agree to be bound by the terms of the HP End User License Agreement (EULA). If you do not accept these license terms, your sole remedy is to return the entire unused product (hardware and software) within 14 days for a full refund subject to the refund policy of your seller.

For any further information or to request a full refund of the price of the computer, please contact your seller.

Contents

1. Introduction

The HP Engage One Pro Magnetic Stripe Reader (MSR) can read 1, 2, or 3 tracks of magnetic stripe information. When connected to the host, the magnetic stripe reader is completely compatible with SPI (Serial Peripheral Interface). The raw data and decoded data go to the host via SPI. Also, firmware can be upgraded via SPI.

The MSR supports both unencrypted and encrypted data output. When encryption is not turned on, the decoded data can be formatted with preamble, postamble, and terminator characters to match the format expected by the host.

2. Specifications

General	
Card Speed	3 to 75 ips (7.6 to 190.5 cm/s)
Electrical	
Power Supply	3.0 to 3.6 VDC
I/O Voltage Range	2.7 to 3.6 VDC
Current	
Active Power Supply Current	5
mA Standby Power Supply Current	0.03 mA
Environmental	
ESD	+4kV discharge to head
Operating Temperature	0° C to 55° C
Storage Temperature	-40° C to 70° C
Humidity	-10% to 90% non-condensing
Mechanical	
Weight	5.67 grams
Cable Length	125 +/- 6.4 mm

Note: During the analog components' wake up, a few capacitors are charged up, and the wake-up inrush current can go up to 40 mA for no more than 5 µsec.

Note 2: During the chip power up, the internal regulator can introduce 80 mA current for 50 µsec.

Note 3: HP recommends that you incorporate the ability to separately control power to the MSR. During the firmware update procedure, there is a short time (a few seconds) during which, if power is removed from the device, firmware loading can fail. The host software can cycle the power of the MSR to start the device again. Then, the host needs to talk to the unit within ~500 msec to continue loading firmware.

For normal operation, HP does not recommend turning off the power of the unit. Also, do not turn off the power within 2 seconds after receiving MSR data.

Mounting

To mount the MSR to the HP Engage One Pro:

1. Remove the frame covering the MSR slot.
2. Connect the HP Engage One Pro system cable to the MSR.
3. Insert the MSR and secure it with two screws.
4. Reinstall the frame covering the MSR slot.

3. SPI Operation

This section describes SPI (Serial Peripheral Interface), the SPI bus interface timing, communication protocol, timeouts, and data output format. The following table shows the signals used in the SPI interface. Note that the connector is an eight-pin Molex 51021-0800.

PIN #	Signal	Description
1	SPCK	Serial Clock Input
2	MISO	Sender Input, Receiver Output
3	MOSI	Sender Output, Receiver Input
4	DAV	Data Available (output)
5	NCS	Chip Select, Active Low
6	VIN	Voltage Input
7	GND	Logic Ground
8	Head Case GND	Chassis Ground

SPI Data Transmission

A *serial peripheral interface* (SPI) is an interface that enables the serial exchange of data between two devices, one called a sender and the other called a receiver. The host (sender) generates the clock signal (SPCK) to trigger data exchange on the SPI bus.

During each SPI clock cycle, data are transmitted in both directions at the same time (full duplex transmission):

- On the MOSI line, the sender sends a bit and the receiver reads it.
- On the MISO line, the receiver sends a bit and the sender reads it.

The SPI bus transmits data in 8-bit data groups, sending data one bit at a time, from MSB to LSB. An example of bit transmission for byte A and byte B (of two-byte quantity AB) would be as follows:

A(bit 7) A(bit 6) … A(bit 0) B(bit 7) B(bit 6) … B(bit 0).

Clock polarity and phase

The clock polarity and phase have four different options with respect to the data. The serial clock input frequency can go up to 1M bps.

When clock polarity = 0, the base value of the clock is 0.

For clock phase = 0, data are read on the clock's rising edge (low to high transition) and data are changed on a falling edge (high to low transition).

For clock phase = 1, data are read on the clock's falling edge and data are changed on a rising edge.

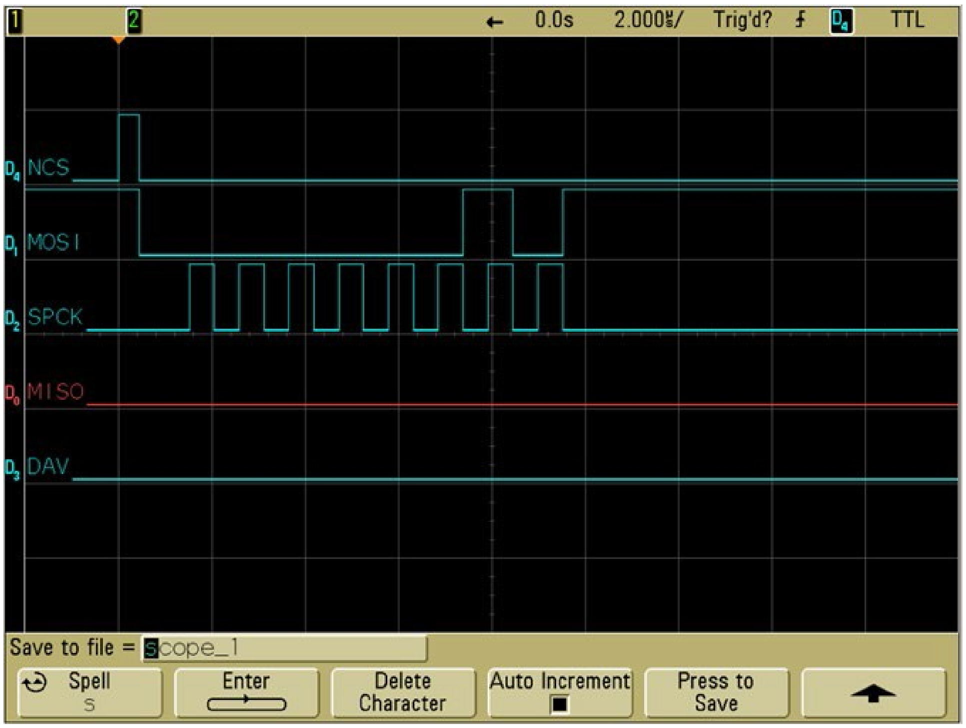
When clock polarity = 1, the base value of the clock is 1.

For clock phase = 0, data are read on clock's falling edge and data are changed on a rising edge.

For clock phase = 1, data are read on clock's rising edge and data are changed on a falling edge.

The signal is required to read card data from the device. The device default uses clock phase = 0 and clock polarity = 0. Custom defaults for device clock phase and polarity are available upon request.

The following picture shows an example of regular TM4 SPI firmware with clock polarity = 0 and clock phase = 0. The data are read on the rising edge of the clock and changed on the falling edge. On MOSI line, the host sends out data of 00000010, or 02h (0x02).



Sender Input, Receiver Output (MISO)

The MISO signal is the serial data output sent from for the device. It is also the data line that is received by the host. When the device is not active (Chip Select is high), the MISO becomes high impedance (disconnected). The MISO signal is in an indeterminate state after the device is power-cycled or reset for a maximum of 1 second. This signal should be ignored during this time.

Sender Output, Receiver Input (MOSI)

The MOSI signal is the serial data input for the device and serial data output for the host. This signal is sent from the host (sender) to the device (receiver). The signal might not be required after some device parameters such as the device key has been set and saved. Set the signal to be high if it is not being used.

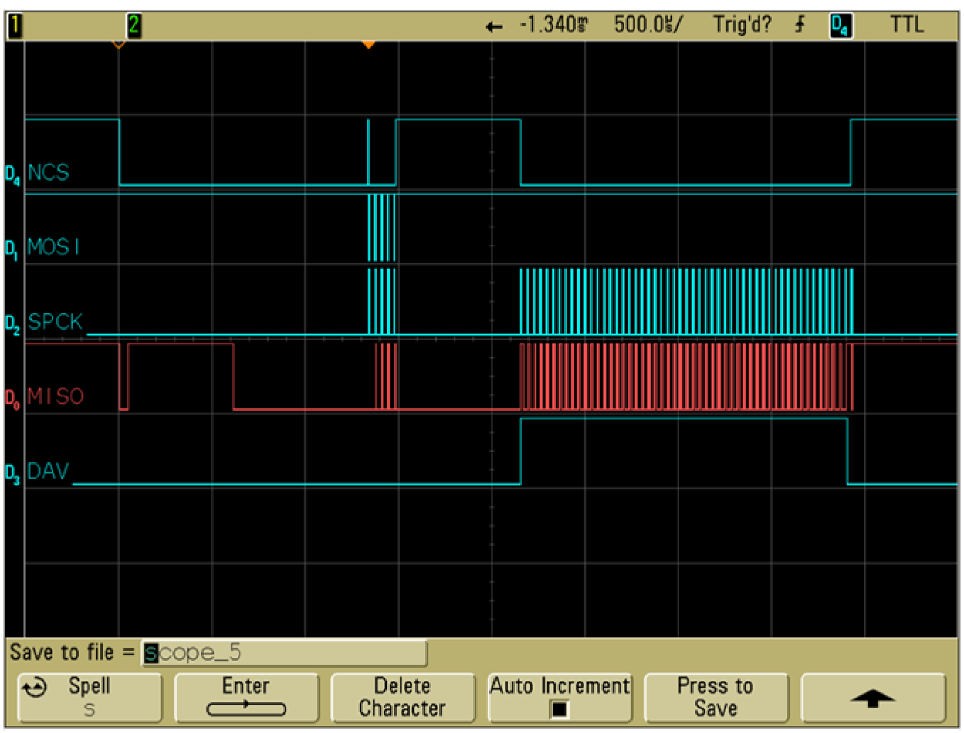
Data Available Output (DAV)

The DAV signal is low where there is no data to be transmitted. When the DAV signal is high, it indicates that there is data available for output. The host and then sends out the clock signal to read the data. After all the data is transmitted, the device sets the DAV signal low again.

The signal can be used for the host to determine if the device has data ready to transmit. However, the signal should be ignored right after (1 second maximum) the power cycle or a reset, as it would be in an indeterminate state.

In the case when the DAV signal is not used, the host needs to poll the device periodically to determine if it has data to transmit. The host needs to toggle SCL to get card data from MISO. The first non-IDLE byte indicates the start of valid card data. IDLE is FF.

The following graph shows the command and response for Review Version command. The last signal shown in the graph is the DAV signal:



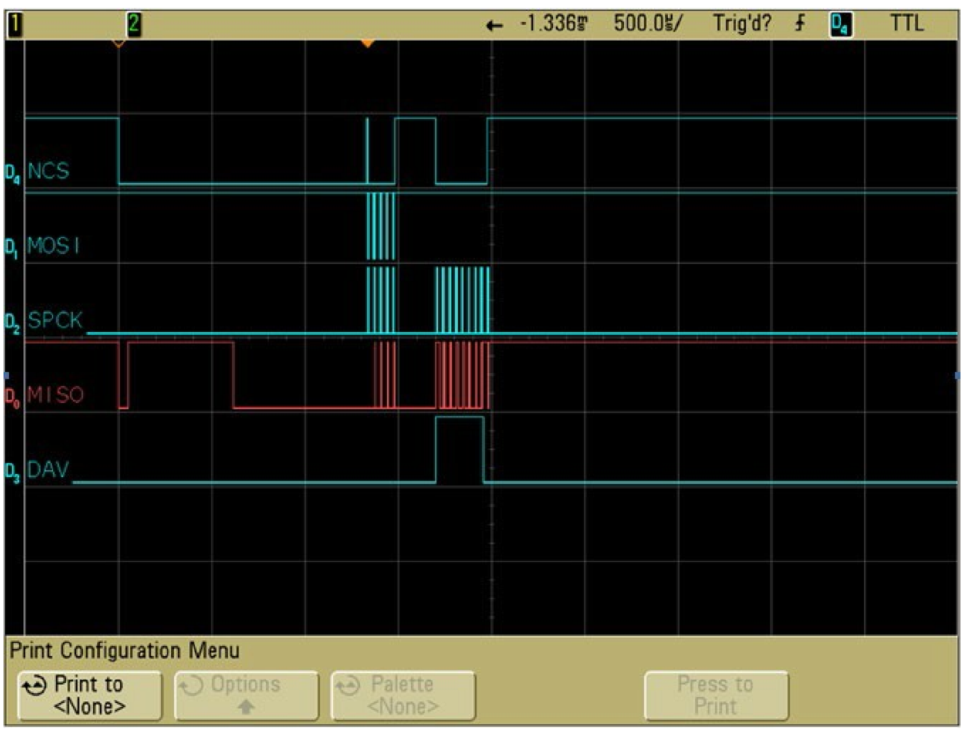
After the command is received and the response is ready, the DAV would be set too ***high*** for the host to receive response. After the response is received, the DAV would be ***low***, indicating there is no more data to be transmitted.

After receiving a command, typically within less than 20ms, response is ready and DAV set to ***high***. For some specific commands, the delay may be longer.

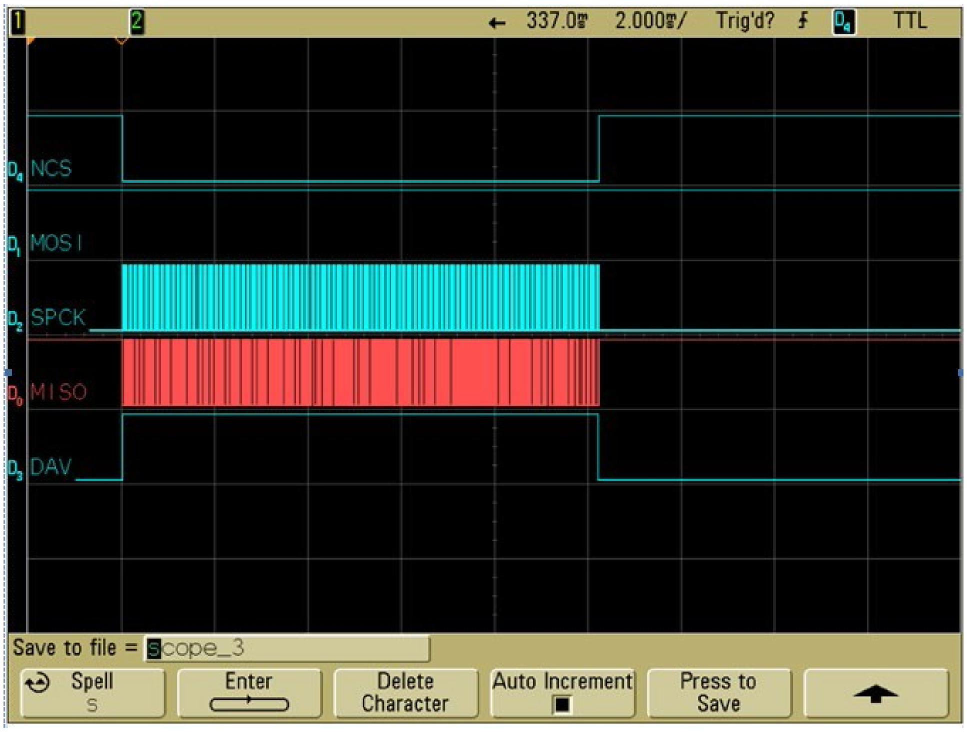
After the last byte of response is sent, the DAV is pulled low. If user polls DAV status to check whether there are data available, we suggest using 100µs polling interval and throw away any data when DAV is low.

Chip Select

SPI interface allows connecting several SPI devices while the sender selects each of them with NCS (Chip Select, Active Low). The device only responds to SPCK and MOSI signals after an NCS is pulled low. For the first byte of each command sent to the MSR, NCS needs to be pulled low for 1 millisecond before the clock line. Because the MSR is always in deep sleep mode when in idle status, this 1 millisecond delay is required to allow the MSR wake up from sleep mode.



When the user swipes a card, no delay is required. The following is the waveform for MSR output:



Voltage Input and Ground

The VIN signal is the power input for the device and has an operating range of 3.0 to 3.6 volts DC. The GND signal is logic ground. The head case GND signal is chassis ground, which is connected to the head case. For optimum ESD protection, this signal should be connected to earth ground.

Communication

When the host has a frame to send, it pulls the NCS line low, waits 1 millisecond, then clocks it out. When the device has a frame to send, it raises its data available (DAV) signal and waits for the host to pull the NCS line low, then clock in the frame. The host normally clocks out IDLE characters to clock in a frame from the device. Because the device typically loads its one transmit buffer with IDLE byte when it has nothing to transmit, the first byte clocked out from the device after the DAV signal is asserted could be IDLE instead of a valid byte. If this is the case, simply discard this byte.

To detect whether the device has a frame to send, the host can either monitor the DAV signal or, optionally, periodically clock in up to two bytes from the device to see if the device has sent a valid data. Up to two bytes should be clocked in instead of just one because the first byte could be an IDLE byte that was loaded into the device's transmit buffers before the device had anything to send. The host should look at each byte it clocks in to see if it is a valid byte. If a valid byte is found, then the subsequent bytes contain the frame.

4. Configuration

The MSR must be appropriately configured to your application. Configuration settings enable the reader to work with the host system. Once programmed, these configuration settings are stored in the reader's non-volatile memory (so they are not affected by the cycling of power).

In TriMag IV, ACK is 0x5A.

Command Structure

Commands sent to the MSR

Setting command:

```
<STX><S>[<FuncID><Len><FuncData>…]<ETX><CheckSum>
```

Read Status command:

```
<STX><R><FuncID><ETX><CheckSum>
```

Special Function command:

```
<STX>[<FuncID><Len><FuncData>…]<ETX><CheckSum>
```

Response from the MSR

Setting command:

```
Host           The MSR
    Setting    →
    Command
←       > if OK
    or
←   <NAK> if Error
```

Read Status command:

```
Host                     The MSR

   Read Status Command →
←   <ACK> and <Response> if OK
   or
←   <NAK> if Error
```

Special Function command:

```
Host                    The MSR

   Special Function →
   Command
←  <ACK>and <Response> if OK
   or
←  <NAK>if Error
```

The format is defined as follows:

<STX>	02h
<S>	Indicates setting commands. 53h
<R>	Indicates read status commands. 52h
<FuncID>	One-byte Function ID identifies the
<Len>	One-byte length count for the following data
<FuncData>	Data block for the function
<ETX>	03h
<CheckSum>	Check Sum: The overall Modulo 2 (Exclusive OR) sum (from <STX> to
<ACK>	06h
<NAK>	15h

Communication timing

The power up time for TMIV the MSR is 600ms. The typical delay for the reader to respond to a command is 20ms; the maximum delay for the reader to respond can be as much as 40ms. Caution must therefore be taken to maintain an appropriate delay between two commands.

Default settings

The MSR is shipped from the factory with the default settings already programmed. In the following sections, the default settings are shown in **bold**.

For a table of default settings, see Appendix A.

General selections

This group of configuration settings defines the basic operating parameters of the MSR.

Change to default settings

Command: <STX><S><18h><ETX><CheckSum>

This command does not have any <FuncData>. It returns all settings for all groups to their default values.

MSR reading settings

Enable or disable the MSR. If the reader is disabled, no data is sent out to the host.

Command: <STX><S><1Ah><01h><MSR Reading Settings><ETX><CheckSum>

MSR Reading Settings:

- 0: Disabled
- 1: Enabled

Decoding method settings

The MSR can support four kinds of decoded directions.

Command: <STX><S><1Dh><01h><Decoding Method Settings><ETX><CheckSum>

Decoding method settings:

- 0: Raw Data Decoding in both directions, sent out in HP mode.
- 1: Decoding in Both Directions. If the encryption feature is enabled, the key management method used is DUKPT.
- 2: Moving stripe along head in direction of encoding. If the encryption feature is enabled, the key management method used is DUKPT.
- 3: Moving stripe along head against direction of encoding. If the encryption feature is enabled, the key management method used is DUKPT.
- 4: Raw Data Decoding in Both Directions, sent out in other mode. If the encryption feature is enabled, the key management method used is fixed key.

With the bidirectional method, the user can swipe the card in either direction and still read the data encoded on the magnetic stripe. Otherwise, the card can only be swiped in one specified direction to read the card. Raw Decoding just sends the card's magnetic data in groups of 4 bits per character.

The head reads from the first byte of each track, starting from the most significant bit. The data start to be collected when the first 1 bit is detected. No checking is done except to verify that the track has, or does not have, magnetic data.

Samsung Pay encoding/decoding

Special track decoding considerations apply to Samsung Pay interactions. Samsung Pay/MST (LoopPay) sends out a magnetic signal to a magnetic head. So MCUs might receive identical magnetic signals on all tracks. However, Samsung Pay devices send out Track1 and Track2 data consecutively, making it possible to disambiguate the tracks.

If the reading device receives identical MSR data for multiple tracks, MSR processing ignores Track2 and Track3 data if the card data is ISO 7-bit encoded, treating it as Track1 data . If the data are 5-bit encoded, it is received as Track2 data only.

If MSR receives single track data corresponding to ABA, IATA, or ISO 4909, but not in the expected track, the data will be ignored to avoid capturing track data as an incorrect type. The processor will not move data from one track to another.

Review settings

Command: `<STX><R><1Fh><ETX><CheckSum>`

This command does not have any <FuncData>. It activates the review settings command. The MSR sends back an <ACK> and <Response>.

<Response> format:

The current setting data block is a collection of many function-setting blocks <FuncSETBLOCK> as follows:

`<STX><FuncSETBLOCK1>…<FuncSETBLOCKn><ETX><CheckSum>`

Each function-setting block <FuncSETBLOCK> has the following format:

<FuncID><Len><FuncData>

This format is defined as follows:

- <FuncID> is one byte identifying the settings for the function.

- <Len> is a one-byte length count for the following function-setting block <FuncData>
- <FuncData> is the current setting for this function. It has the same format as in the sending command for this function.
- <FuncSETBLOCK> are in the order of their Function ID<FuncID>

Review firmware version

Command: `<STX><R><22h><ETX><CheckSum>`

This command gets the device firmware version.

Review serial number

Command: `<STX><R><4Eh><ETX><CheckSum>`

This command gets the device serial number.

Message formatting selections (only for Security Level 1 & 2)

Terminator setting

Terminator characters are used to end a string of data in some applications.

Command: `<STX><S><21h><01h><Terminator  Settings><ETX><CheckSum>`

<Terminator Settings>: Any one character, 00h is none; default is **CR** (0Dh).

Preamble setting

Characters can be added to the beginning of a string of data. These can be special characters for identifying a specific reading station, to format a message header expected by the receiving host, or any other character string. Up to fifteen ASCII characters can be defined.

Command: `<STX><S><D2h><Len><Preamble><ETX><CheckSum>`

The format is defined as follows:

- <Len>= the number of bytes of preamble string
- <Preamble> = {string length}{string}

Note: String length is one byte, maximum fifteen <0Fh>.

Postamble Setting
The postamble serves the same purpose as the preamble, except it is added to the end of the data string, after any terminator characters.

Command: `<STX><S><D3h><Len><Postamble><ETX><CheckSum>`

The format is defined as follows:

- <Len> = the number of bytes of postamble string
- <Postamble> = {string length}{string}

Note: String length is one byte, maximum fifteen <0Fh>.

Track n prefix setting
Characters can be added to the beginning of a track data. These can be special characters to identify the specific track to the receiving host, or any other character string. Up to six ASCII characters can be defined.

Command: `<STX><S><n><Len><Prefix><ETX><CheckSum>`

The format is defined as follows:

- <n> = 34h for Track1; 35h for Track2 and 36h for Track3
- <Len> = the number of bytes of prefix string
- <Prefix> = {string length}{string}

Note: String length is one byte, maximum six.

Track n Suffix Setting
Characters can be added to the end of track data. These can be special characters to identify the specific track to the receiving host, or any other character string. Up to six ASCII characters can be defined.

Command: `<STX><S><n><Len><Suffix><ETX><CheckSum>`

The format is defined as follows:

<n> = 37h for Track1; 38h for Track2 and 39h for Track3

<Len> = the number of bytes of suffix string

<Suffix> = {string length}{string}

Note: String length is one byte, maximum six.

Magnetic track selections (only for Security Level 1 & 2)

There are up to three tracks of encoded data on a magnetic stripe. This option selects the tracks that will be read and decoded.

Command: `<STX><S><13h><01h><Track_Selection Settings><ETX><CheckSum>`

Track selection settings:

- 0: Any Track
- 1: Require Track1 Only
- 2: Require Track2 Only
- 3: Require Track1 & Track2
- 4: Require Track3 Only
- 5: Require Track1 & Track3
- 6: Require Track2 & Track3
- 7: Require All Three Tracks
- 8: Any Track1 & 2
- 9: Any Track2 & 3

Note: If any of the required multiple tracks fail to read for any reason, no data for any track is sent.

Track separator selection

This option allows the user to select the character to be used to separate data decoded by a multiple-track reader.

Command: `<STX><S><17h><01h><Track_Separator><ETX><CheckSum>`

<Track_Separator> is one ASCII Character. The default value is **CR**, 0h means no track separator.

Start/End sentinel and Track2 account number only

The MSR can be set to either send, or not send, the Start/End sentinel, and to send either the Track2 account number only, or all the encoded data on Track2. (The Track2 account number setting does not affect the output of Track1 and Track3.)

Command: <STX><S><19h><01h><SendOption><ETX><CheckSum> SendOption:

- 0: Do not send start/end sentinel and send all data on Track2
- 1: Send start/end sentinel and send all data on Track2
- 2: Don't send start/end sentinel and send account # on Track2
- 3: Send start/end sentinel and send account number on Track2

5. Security settings

Select key management type

Command: <STX><S><58h><01h><Key Management Type><ETX><CheckSum>

Available key management types are as follows:

- 0: Fix key management
- 1: DUKPT Key management

External authenticate command (Fixed Key only)

Before a security related command is executed, an authentication process is required to make sure the device key used is correct. For example, authentication is generally required whenever encryption is enabled/disabled or the device key is changed. After the authentication process has finished successfully, the same process would not be needed again until the device is restarted.

First, the host would get a data block which is generated by encrypting a random 8-byte data using TDES algorithm.

The host then decrypts the data block using TDES algorithm using the current device key.

The host initiates an External Authenticate Command to verify the decrypted 8 bytes of random data

The device checks to see if the data matches the random data generated. If the data are the same, authentication process is successful. If it fails, the host must start the authentication process again until it succeeds before any security related featured can be changed.

Retrieve encrypted challenge command

Host to device:

Command: <STX><R><74h><ETX><CheckSum>

Device to host:

Command: `<ACK><STX><8 bytes of TDES-encrypted random data><ETX><CheckSum> (success)`

`<NAK> (fail)`

Send external authenticate command from host to device
Command: `<STX><S><74h><08h><8 bytes of original random data><ETX><CheckSum>`

Device to host:

`<ACK> (success)`

`<NAK> (fail)`

Encryption settings

Enable or disable the The MSR Encryption output in ID TECH protocol. If encryption is disabled, original data will be sent out to the host. If it enabled, encrypted data will be sent out to the host.

Command: `<STX><S><4Ch><01h><Encryption Settings><ETX><CheckSum>`

Available encryption settings are as follows:

- 0: Encryption Disabled
- 1: Enable TDES Encryption
- 2: Enable AES Encryption

Review KSN (DUKPT key management only)
Command: `<STX><R><51h><ETX><CheckSum>`

This command gets the DUKPT key serial number and counter.

Review security level
Command: `<STX><R><7Eh><ETX><CheckSum>`

This command gets the current security level.

Encrypt external data command
This command encrypts the data passed to the MSR and sends back the encrypted data to the host. The command is valid when the security level is set to 3 or 4.

Host to device:

Command: `<STX><41h><Length<Data to Be Encrypted><ETX><CheckSum>`

The format is defined as follows:

<Length> is the 2-byte length of <Data to Be Encrypted> in hex, represented as <Length_L> and <Length_H>.

Device to host:

Command: `<ACK><STX><Length><Encrypted Data>[SessionID]<KSN><ETX><LRC> (success)` or `<NAK> (fail)`

The format is defined as follows:

<Length> is the 2-byte length of <Encrypted Data>[SessionID]<KSN> in hex, represented as<Length_L> and <Length_H>.

[SessionID] is only used at security level 4; it is part of the encrypted data. No data in this field at security level 3.

<KSN> is a 10 bytes string, in the case of fix key management, use serial number plus two bytes null characters instead of KSN.

After each successful response, KSN increments automatically.

Encrypted output for decoded data

Encrypt functions

When a card is swiped through the Reader, the track data is encrypted via TDES (Triple Data Encryption Algorithm, aka, Triple DES) or AES (Advanced Encryption Standard) using fixed key management or DUKPT (Derived Unique Key Per Transaction) key management. DUKPT key management uses a base derivation key to encrypt a key serial number that produces an initial encryption key (IPEK), which is injected into the MSR before deployment. After each transaction, the encryption key is modified per the DUKPT algorithm so that each transaction uses a unique key. Thus, the data will be encrypted with a different encryption key for each transaction, as a safeguard against replay attacks. DUKPT is described by ANSI X9.24-1:2009; for details, refer to that spec.

Security related function ID

Security related function IDs are listed in the following table. Their functions are described in other sections.

Characters	Hex Value	Description
PrePANID	49	First N Digits in PAN, which can be clear data
PostPANID	4A	Last M Digits in PAN, which can be clear data
MaskCharID	4B	Character used to mask PAN
EncryptionID	4C	Security algorithm
SecurityLevelID	7E	Security Level (Read Only)
Device Serial Number ID	4E	Device Serial Number (Can be write once. After that, can only be read)
DisplayExpirationDataID	50	Display expiration data as mask data or clear data
KSN and Counter ID	51	Review the Key Serial Number and Encryption Counter
Session ID	54	Set current Session ID
Key Management Type ID	58	Select Key Management Type

The following examples list possible settings of these new functions.

Characters	Default Setting	Description
PrePANID	04h	00h ~ 06h Allowed clear text from start of PAN Command format: 02 53 49 01 04 03 LRC
PostPANID	04h	00h ~ 04h Allowed clear text from end of PAN Command format: 02 53 4A 01 04 03 LRC
MaskCharID	'*'	20h ~ 7Eh Command format: 02 53 4B 01 3A 03 LRC
DisplayExpirationDataID	'0'	0: Display expiration data as mask data 1: Display expiration data as clear data
EncryptionID	'0'	0: Clear Text 1: Triple DES 2: AES Command format: 02 53 4C 01 31 03 LRC
SecurityLevelID	'1'	0 ~ 3 Command format: 02 52 7E 03 LRC
Device Serial Number ID	00, 00, 00, 00, 00, 00, 00, 00,	10 bytes number: Command format: Set Serial Number: 02 53 01 4E 09 08 37 36 35 34 33

	00, 00	32 31 30 03 LRC Get Serial Number: 02 52 4E 03 LRC
KSN and Counter ID	00, 00, 00, 00, 00, 00, 00, 00, 00, 00	This field includes the Initial Key Serial Number in the leftmost 59 bits and a value for the Encryption Counter in the right most 21 bits. Get DUKPT KSN and Counter: 02 52 51 03 LRC
Session ID	00, 00, 00, 00, 00, 00, 00, 00	This Session ID is an eight-byte string which contains hex data. This field is used by the host to uniquely identify the present transaction. Its primary purpose is to prevent replays. It is only used at Security Level 4 (not supported). After a card is read, the Session ID will be encrypted, along with the card data, supplied as part of the transaction message. The cleartext version of this will never be transmitted. New Session ID stays in effect until one of the following occurs: Another Set Session ID command is received. The reader is powered down. The reader is put into Suspend mode.
Key Management Type ID	'1'	Fixed key management by default. 0: Fixed Key 1: DUKPT Key

Security management

This MSR is intended to be a secure reader. Security features include the following:

- Can include Device Serial Number
- Can encrypt Track1 and Track2 data for all bank cards
- Provides clear text confirmation data including card holder's name and a portion of the PAN as part of the Masked Track Data
- Optional display of expiration data
- Security Level is settable

The reader features configurable security settings. Before encryption can be enabled, Key Serial Number (KSN) and Base Derivation Key (BDK) must be loaded; then encrypted transactions can take place. The keys must be injected by certified key injection facility (such as ID TECH). Contact ID TECH for more information about key injection services.

Level 0

Security Level 0 is a special case where all DUKPT keys have been used and is set automatically when it runs out of DUKPT keys. The supply of DUKPT keys is effectively 1 million, meaning that a new key can be generated, per swipe, for up to a million card swipes. After this limit has been reached, key injection will need to occur again before any more transactions can be done.

Level 1

By default, readers from the factory are configured to have this security level. There is no encryption process, no key serial number transmitted with decoded data. The reader functions as a non-encrypting reader and the decoded track data is sent out in default mode.

Level 2

Key Serial Number and Base Derivation Key have been injected but the encryption process is not yet activated. The reader will send out decoded track data in default format. Setting the encryption type to TDES and AES will change the reader to security level 3.

Level 3

Both Key Serial Number and Base Derivation Keys are injected and encryption mode is turned on. For payment cards, both encrypted data and masked cleartext data are sent out. (Users can select the data masking of the PAN area; the encrypted data format cannot be modified.) You can choose whether to send hashed data and whether to reveal the card expiration date. When encryption is turned on, Level 3 is the default security level.

6. Encryption Management

The encrypted swipe read supports TDES and AES encryption standards for data encryption. Encryption can be turned on via a command. TDES is the default.

If the reader is at or above security Level 3, for the encrypted fields, the original data is encrypted using the TDES/AES CBC mode with an Initialization Vector of all binary zeroes and the Encryption Key associated with the current DUKPT KSN.

Check card format

ISO/ABA (American Banking Association) card encoding method

Track1 is 7 bits encoding. Track1 is 7 bits encoding. Track2 is 5 bits encoding. Track3 is 5 bits encoding. Track1 is 7 bits encoding. Track2 is 5 bits encoding. Track2 is 5 bits encoding.

Additional check:

Track1 second byte is B.

There is only one '=' in Track2 and the position of '=' is between 13th ~ 20th character. Total length of Track2 should above 21 characters.

AAMVA (American Association of Motor Vehicle Administration) card encoding method

Track1 is 7 bits encoding. Track2 is 5 bits encoding. Track3 is 7 bits encoding.

7. Others (customer card)

MSR data masking

For cards that need to be encrypted, a combination of encrypted data and masked clear text data are sent.

Masked area

The data format of each masked track is ASCII.

The clear data include start and end sentinels, separators, first N, last M digits of the PAN, card holder name (for Track1).

The rest of the characters should be masked using mask character.

```
Set PrePANClrData (N), PostPANClrData (M), MaskChar (Mask
Character)
```

N and M are configurable and default to 4 first and 4 last digits. They follow the current PCI constraints requirements (N 6, M 4 maximum).

Mask character default value is '*'.

```
Set PrePANClrDataID (N)
```

The parameter range is 00h ~ 06h and the default value is 04h.

```
Set PostPANClrDataID (M)
```

The parameter range is 00h ~ 04h and the default value is 04h.

```
MaskCharID (Mask Character)
```

The parameter range is 20h ~ 7Eh and the default value is 2Ah

```
DisplayExpirationDataID
```

The parameter range is 0 ~1, and the default value is 0.

Level 1 and 2 data output format

Magnetic track basic decoded data format

```
Track1: <SS1><T1 Data><ES><Track Separator> Track2: <SS2><T2
Data><ES><Track Separator> Track3: <SS3><T3 Data><ES><Terminator>
```

The format is defined as follows:

SS1 (start sentinel Track1) = % SS2 (start sentinel Track2) = ;

SS3 (start sentinel Track3) = ; for ISO, % for AAMVA ES (end sentinel all tracks) = ?

Track Separator = Carriage Return Terminator = Carriage Return Language: US English

Magnetic track basic raw data format

```
Track1: <01><T1 Raw Data><CR> Track2: <02><T2 Raw Data><CR>
Track3: <03><T3 Raw Data><CR>
```

The format is defined as follows: The length of T1 Raw Data, T2 Raw Data, T3 Raw Data is 0x60 for each field. Pad with 0 if the original data length does not reach 0x60.

Language: US English

Definitions

Start or End Sentinel: Characters in encoding format which come before the first data character (start) and after the last data character (end), indicating the beginning and end, respectively, of data.

Track Separator: A designated character that separates data tracks.

Terminator: A designated character that comes at the end of the last track of data, to separate card reads.

DUKPT Level 3 data output enhanced format

For ISO cards, both masked clear and encrypted data are sent; no unmasked clear data will be sent. For other cards, only clear data is sent.

This mode is used when all tracks must be encrypted, or encrypted OPOS support is required, or when the tracks must be encrypted separately or when cards other than type 0 (ABA bank cards) must be encrypted or when Track3 must be encrypted. This format is the standard encryption format, but not yet the default encryption format.

Card data is sent out in the following format

<STX><LenL><LenH><Card Data><CheckLRC><CheckSum><ETX>

Value	Description
0	STX
1	Data Length low byte
2	Data Length high byte
3	Card Encode Type1
4	Track1-3 Status2
5	Track1 data length
6	Track2 data length
7	Track3 data length
8	Clear/masked data sent status 3
9	Encrypted/Hash data sent status 4
10	Track1 clear/mask data
	Track2 clear/mask data

Track3 clear/mask data

Track1 encrypted data

Track2 encrypted data

Track3 encrypted data

Session ID info for Level 4 (Level 4 not available)

Track1 hashed (20 bytes each) (if encrypted and hash Track1 allowed)

Track2 hashed (20 bytes each) (if encrypted and hash, Track2 allowed)

Track3 hashed (20 bytes each) (if encrypted and hash Track3 allowed) KSN (10 bytes)

`CheckLRC CheckSum ETX`

The format is defined as follows:

- <STX> = 02h
- <ETX> = 03h

See Appendix F for a real-world example.

Data length byte

LenL – Overall length of data, low bits LenH – Overall length of data, high bits

Card encode type

Value	Encode type description
80	ISO 7813/ISO 4909/ABA format
81	AAMVA format
83	Other
84	Raw; undecoded format

All tracks are encrypted and no mask data is sent. No track indicator ‘01’,

‘02’ or ‘03’ in front of each track.

85	JIS II; Only supported in some products
86	JIS I; Only supported in some products
87	JIS II; SecureKey and Secure MIR
91	Contactless Visa (Kernel 1)
92	Contactless SenderCard
93	Contactless Visa (Kernel 3)
94	Contactless American Express
95	Contactless JCB
96	Contactless Discover
97	Contactless UnionPay
90	Contactless Others
C0	Manual data entry enhanced mode (similar to ABA Track2)

Track status

MSR sampling and decode status

MB LB

B7	B6	B5	B4	B3	B2	B1	B0

B0 1: Track1 decode success (0: Track1 decode fail)

B1 1: Track2 decode success (0: Track2 decode fail)

B2 1: Track3 decode success (0: Track3 decode fail)

B3 1: Track1 sampling data exists (0: Track1 sampling data does not exist)

B4 1: Track2 sampling data exists (0: Track2 sampling data does not exist)

B5 1: Track3 sampling data exists (0: Track3 sampling data does not exist)

B6 0: reserved for future use

B7 0: reserved for future use

Track data length

This one-byte value indicates the number of bytes in the respective track masked data field. For ISO 7813 and ISO 4909 compliant Financial Transaction Cards:

Track1 maximum length is 79 alphanumeric characters. Track2 maximum length is 40 numeric digits. Track3 maximum length is 107 numeric digits.

Clear/masked data sent status

Bit 0 1: Track1 clear/mask data present
Bit 1 1: Track2 clear/mask data present
Bit 2 1: Track3 clear/mask data present
Bit 3 1: fixed key

Bit 4 0: TDES

Bit 5 0: No requirement to use IC

Bit 6 1: Pin Encryption Key

Bit7 1: Serial # present

Encrypted hash data sent status

Bit 0 1: Track1 encrypted data present
Bit 1 1: Track2 encrypted data present
Bit 2 1: Track3 encrypted data present
Bit 3 1: Track1 hash data present
Bit 4 1: Track2 hash data present
Bit 5 1: Track3 hash data present
Bit 6 1: Session ID present
Bit 7 1: KSN present

Track masked data

Track data masked with the MaskCharID (default is '*'). The first PrePANID (up to 6 for BIN, default is 4) and last PostPANID (up to 4, default is 4) characters can be in the clear (unencrypted).

Track encrypted data

This field is the encrypted Track data, using either TDES-CBC or AES-CBC with initial vector of 0. If the original data is not a multiple of 8 bytes for TDES or a multiple of 16 bytes for AES, the reader right pads the data with 0.

The key management scheme is DUKPT or Fixed key. For DUKPT, the key used for encrypting data is called the Data Key. Data Key is generated by first taking the DUKPT Derived Key exclusive or'ed with 0000000000FF0000 to get the resulting intermediate variant key. The left side of the intermediate variant key is then TDES encrypted with the entire 16-byte variant as the key.

After the same steps are performed for the right side of the key, combine the two key parts to create the Data Key.

Track hashed data

The MSR reader uses SHA-1 to generate hashed data for both Track1, Track2 and Track3 unencrypted data. It is 20 bytes long for each track. This is provided with two purposes in mind: One is for the host to ensure data integrity by comparing this field with a SHA-1 hash of the decrypted Track data, prevent unexpected noise in data transmission. The other purpose is to enable the host to store a token of card data for future use without keeping the sensitive card holder data. This token may be used for comparison with the stored hash data to determine if they are from the same card.

Encryption output format setting

Command: `53 85 01 <Encryption Format>`

The encryption format options are as follows:

0: No longer supported

1: Enhanced encryption format

Encryption option setting (for enhanced encryption format only)

Command: `53 84 01 <Encryption Option>`

The encryption options are as follows (default 08h):

bit 0: 1: Track1 force encrypt
bit 1 1: Track2 force encrypt
bit 2 1: Track3 force encrypt
bit 3 1: Track3 force encrypt when card type is 0

Note:

- When force encrypt is set, this track is always be encrypted, regardless of card type. No clear/mask text will be sent.
- If and only if in enhanced encryption format, each track is encrypted separately. Encrypted data length will round up to 8 or 16 bytes.
- When force encrypt is not set, the data is encrypted in original encryption format, that is, only Track1 and Track2 of type 0 cards (ABA bank cards) will be encrypted.

Hash option setting:

Command: `53 5C 01 <Hash Option>`

The has options are as follows (default 7):

bit0 1: track1 hash is sent if data is encrypted

bit1	1: track2 hash is sent if data is encrypted
bit2	1: track3 hash is sent if data is encrypted

Mask option setting (for enhanced encryption format only)

Command: `53 86 01 <Mask Option> Mask Option:`

The default is **0x07**.

bit0: 1: Track1 mask data allowed to send when encrypted

bit1: 1: Track2 mask data allowed to send when encrypted

bit2: 1: Track3 mask data allowed to send when encrypted

When mask option bit is set, if data is encrypted (but not forced encrypted), the mask data is sent.

If mask option is not set, the mask data is not sent under the same condition.

Card encode type

The card type is 8x for enhanced encryption format and 0x for original encryption format.

Value	Encode Type
00h / 80h	ISO/ABA format
01h / 81h	AAMVA format
03h / 83h	Other
04h / 84h	Raw; un-decoded format

For Type 04 or 84 Raw data format, all tracks are encrypted and no mask data is sent. No track indicator ‘01’, ‘02’ or ‘03’ in front of each track. Track indicator ‘01’,’02’ and ‘03’ will still exist for non-encrypted mode.

Track1 through 3 status byte

Field 4:

Bit 0	1: Track1 decoded data present
Bit 1	1: Track2 decoded data present
Bit 2	1: Track3 decoded data present
Bit 3	1: Track1 sampling data present
Bit 4	1: Track2 sampling data present
Bit 5	1: Track3 sampling data present
Bit 6	1: Field 10 “optional bytes length” exists (0: No Field 10)

Clear/mask data sent status

Field 8 (Clear/mask data sent status) and field 9 (Encrypted/Hash data sent status) is only sent out in enhanced encryption format.

Field 8: Clear/masked data sent status byte:

Bit 0	1: Track1 clear/mask data present
Bit 1	1: Track2 clear/mask data present
Bit 2	1: Track3 clear/mask data present
Bit 3	1 if fixed key
Bit 4	0: TDES
Bit 5	0: No requirement to use IC (1st digit in Service Code is different from 2 or 6)
Bit 6	1: Pin Encryption Key
Bit 7	1: Serial # present

Encrypted/Hash data sent status

Field 9: Encrypted data sent status

Bit 0	1: Track1 encrypted data present
Bit 1	1: Track2 encrypted data present
Bit 2	1: Track3 encrypted data present
Bit 3	1: Track1 hash data present
Bit 4	1: Track2 hash data present
Bit 5	1: Track3 hash data present
Bit 6	1: session ID present
Bit 7	1: KSN present

Fixed key management data output enhanced format

Same as 4.14.10 DUKPT Level 3 Data Output Enhanced Format, only change <KSN> to <device serial number> plus two NULL bytes.

8. Appendix A: Default setting table

MSR Reading	Enabled
Decoding Method	Both Swiping Direction Decode mode
Track Separator Settings	CR
Terminator Settings	CR
Preamble Settings	None
Postamble Settings	None
Track Selected Settings	Any Track
Sentinel and T2 Account No	Send Sentinels and all T2 data
Data Edit Setting	Disabled
Track Prefix	None
Track Suffix	None

9. Appendix B: Magnetic stripe standard formats

ISO credit card format

ISO stands for International Standards Organization.

Track1

Field ID	Contents	Length
a	Start Sentinel	1
b	Format Code "B"	1
c	Account Number	12 or 19
d	Separator "^"	1
e	Cardholder Name	Variable
f	Separator "^"	1
g	Expiration date 4	
h	Optional Discretionary data	Variable
i	End Sentinel	1
j	Linear Redundancy Check (LRC) Character	1

Track2

Field ID Character	Contents	Length
a	Start Sentinel	1
b	Account Number	12 or 19
c	Separator "="	1
d	Expiration date "YYMM"	4
e	Optional discretionary data	Variable
f	End Sentinel	1
g	Linear Redundancy Check (LRC) Character	1

AAMVA driver's license format

Track1

Field ID Character	Contents	Length
a	Start Sentinel	1
b	State or Province	2
c	City	13
d	Name	35
e	Address	29
f	End Sentinel	1
g	Linear Redundancy Check (LRC) Character	1

Track2

Field ID Character	Contents	Length
a	Start Sentinel	1
b	ANSI User Code	1
c	ANSI User ID	5
d	Jurisdiction ID/DL	14
e	Expiration date	4
f	Birth Date	8
g	Remainder of Jurisdiction	
i	ID/DL	5
h	End Sentinel	1
i	Linear Redundancy Check (LRC) Character	1

Track3

Field ID Character	Contents	Length
a	Start Sentinel	1
b	Template Version #	1
c	Security Version #	1
d	Postal Code	11
e	Class	2
f	Restrictions	10
g	Endorsements	4
h	Sex	1
i	Height	3
j	Weight	3
k	Hair Color	3
l	Eye Color	3
m	ID #	10
n	Reserved Space	16
o	Error Correction	6
p	Security	5
q	End Sentinel	1
r	Linear Redundancy Check (LRC) Character	1

10. Appendix C: Other mode card data output

There is an optional data output format supported by the MSR, allowing it to be compatible with specific software requirements.

```
<01h> <01h> <1Ah> <02h> <00h> <Left 8 bytes Device Serial Number>
<6 Byte Random data>

<30h> <31h> <264 bytes of Sampling data>.
```

11. Appendix D: Guide to encrypting and decrypting data

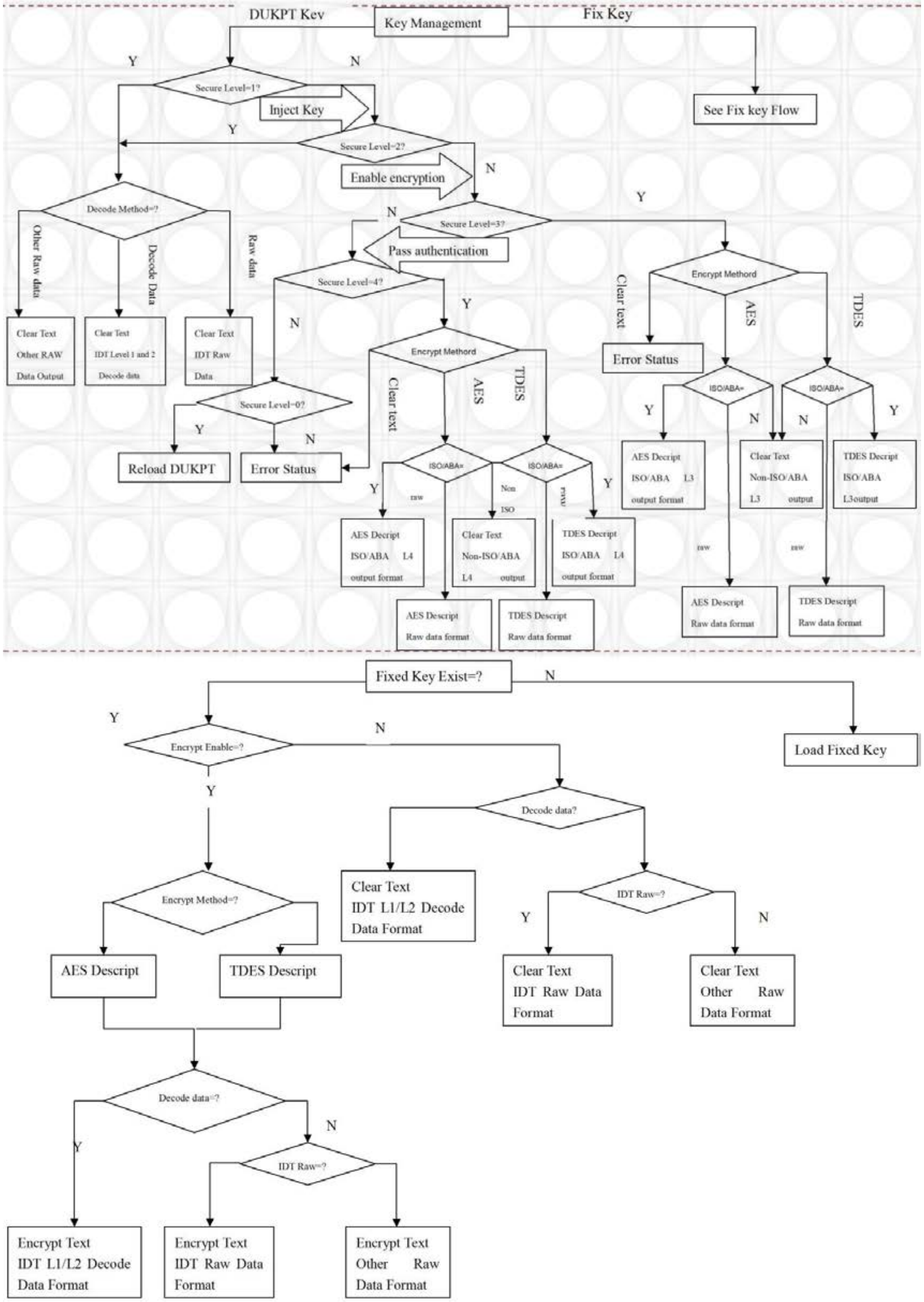
The encryption mode used by the MSR is called Cipher-block Chaining (CBC). With this method, each block of data is XOR'ed with the previous data block before being encrypted. The encryption of each block depends on all the previous blocks. As a result, each encrypted data block would need to be decrypted sequentially.

To encrypt the data, first generate 8 bytes of 0x00 to use as an initialization vector which is XOR'ed with the first data block before it is encrypted. Then the data is encrypted with the device key using TDES algorithm. The result is again XOR'ed with the next 8-byte data block before it is encrypted. The process repeats until all the data blocks have been encrypted.

The host can decrypt the cipher text from the beginning of the block when the data is received. However, it must keep track of both the encrypted and clear text data. Or alternatively, the data can be decrypted backward form that last data block to the first, so that the decrypted data can replace the original data as the decryption is in process.

To decrypt the data using reverse method, first decrypt the last 8-byte of data using TDES decryption. Then perform an XOR operation with result and the preceding data block to get the last data block in clear text. Continue to decrypt the next previous block with the same method till it reaches the first block. For the first data block, the XOR operation can be skipped because it is XOR'ing with 00h bytes.

12. Appendix E: **Key management flow chart**



13. Appendix F: Example of decoded data decryption

The key for all examples is 0123456789ABCDEFFEDCBA9876543210.

Security Level 3 Decryption: Enhanced encryption format

Example of decryption of a three track ABA card with the enhanced encryption format. The MSR is set with default settings except enhanced encryption structure format.

Enhanced encryption Format (this can be recognized because the high bit of the fourth byte underlined (80) is 1.

```
029801803F48236B03BF252A343236362A2A2A2A2A2A2A393939395E42555348
204A

522F47454F52474520572E4D525E2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A
2A2A

2A2A2A2A2A2A2A2A2A2A3F2A3B343236362A2A2A2A2A2A2A393939393D2A2A2A
2A2A

2A2A2A2A2A2A2A2A2A2A3F2ADA7F2A52BD3F6DD8B96C50FC39C7E6AF22F06ED1F0
33BE0
FB23D6BD33DC5A1F808512F7AE18D47A60CC3F4559B1B093563BE7E07459072ABF
8FAAB
5338C6CC8815FF87797AE3A7BEAB3B10A3FBC230FBFB941FAC9E82649981AE79F2
63215

6E775A06AEDAFAF6F0A184318C5209E55AD44A9CCF6A78AC240F791B63284E15B4
0191

02BA6C505814B585816CA3C2D2F42A99B1B9773EF1B116E005B7CD8681860D174E
6AD3

16A0ECDBC687115FC89360AEE7E430140A7B791589CCAADB6D6872B78433C3A25D
A9DD
AE83F12FEFAB530CE405B701131D2FBAAD970248A456000933418AC88F65E1DB7E
D4D10
973F99DFC8463FF6DF113B6226C4898A9D355057ECAF11A5598F02CA31688861C1
57C1C E2E0F72CE0F3BB598A614EAABB162994901190000000000206E203
```

```
STX, Length(LSB, MSB), card type, track status, length Track1,
length Track2, length Track3 02 9801 80 3F 48-23-6B 03BF
```

The above broken down and interpreted 02:

STX character

98: low byte of total length 01: high byte of total length

80: card type byte (interpretation new format ABA card) 3F: 3 tracks of data all good

48: length of Track1 23: length of Track2 6B: length of Track3

03: tracks 1 and 2 have masked/clear data BF: bit 7=1: KSN included

Bit 6=0: no Session ID included so not level 4 encryption Bit 5=1: Track3 hash data present

Bit 4=1: Track2 hash data present Bit 3-1: Track1 hash data present

Bit 2=1: Track3 encrypted data present

Bit 1=1: Track2 encrypted data present Bit 0=1: Track1 encrypted data present

Track1 data masked (length 0x48)

```
252A343236362A2A2A2A2A2A2A2A393939395E42555348204A522F47454F524745
2057
```

```
2E4D525E2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A
2A2A
```

```
3F2A
```

Track1 masked data in ASCII

```
%*4266********9999^BUSH JR/GEORGE
W.MR^********************************?*
```

Track2 data in hex masked (length 0x23)

```
3B343236362A2A2A2A2A2A2A2A393939393D2A2A2A2A2A2A2A2A2A2A2A2A2A2A2A
3F2A
```

Track2 masked data in ASCII

```
;4266********9999=***************?*
```

In this example, there is no Track3 data either clear or masked (encrypted and hashed data is as follows). Track1 encrypted length 0x48 rounded up to 8 bytes = 0x48 (72 decimal).

```
DA7F2A52BD3F6DD8B96C50FC39C7E6AF22F06ED1F033BE0FB23D6BD33DC5A1F8
```

`08512F7AE18D47A60CC3F4559B1B093563BE7E07459072ABF8FAAB5338C6CC88`

`15FF87797AE3A7BE`

Track2 encrypted length 0x32 rounded up to 8 bytes =0x38 (56 decimal).

```
AB3B10A3FBC230FBFB941FAC9E82649981AE79F2632156E775A06AEDAFAF6F0A
184318C5209E55AD
```

Track3 encrypted length 0x6B rounded up to 8 bytes =0x70 (64 decimal).

```
44A9CCF6A78AC240F791B63284E15B4019102BA6C505814B585816CA3C2D2F42
A99B1B9773EF1B116E005B7CD8681860D174E6AD316A0ECDBC687115FC89360A
EE7E430140A7B791589CCAADB6D6872B78433C3A25DA9DDAE83F12FEFAB530CE
405B701131D2FBAAD970248A45600093
```

Track1 data hashed length 20 bytes: 3418AC88F65E1DB7ED4D10973F99DFC8463FF6DF

Track2 data hashed length 20 bytes: 113B6226C4898A9D355057ECAF11A5598F02CA31

Track3 data hashed length 20 bytes: 688861C157C1CE2E0F72CE0F3BB598A614EAABB1

KSN length 10 bytes: 62994901190000000002

LCR, check sum and ETX 06E203 Clear/Masked Data in ASCII:

Track1: %*4266********9999^BUSH JR/GEORGE

W.MR^******************************?* Track2:

;4266********9999=***************?*

Key Value: 1A 99 4C 3E 09 D9 AC EF 3E A9 BD 43 81 EF A3 34 KSN: 62 99 49

01 19 00 00 00 00 02

Decrypted Data: Track1 decrypted

```
%B4266841088889999^BUSH JR/GEORGE
W.MR^0809101100001100000000046000000?!
```

Track2 decrypted

```
;4266841088889999=080910110000046?0
```

Track3 decrypted

;3333333333767676070707767676333333333376767607070776767633333333
3767

67607070776767633333333337676760707?2

Track1 decrypted data in hex including padding zeros (but there are no pad bytes here):

25423432363638343130383838393939395E42555348204A522F47454F524745
2057

2E4D525E30383039313031313030303031313030303030303030303436303030
3030

3F21

Track2 decrypted data in hex including padding zeros

3B34323636383431303838383939393D30383039313031313030303030303436
3F30

0000000000

Track3 decrypted data in hex including padding zeros

3B33333333333333333333333736373637363037303730373736373637363333333
3333

33333333373637363736303730373037373637363736333333333333333333333337
3637

36373630373037303737363736373633333333333333333333373637363736303
3037

3F320000000000

14. Appendix G: Example of HP raw data decryption

Original raw data forward direction

01D67C81020408102D4481020408102042890A350854A2FB3EE4BA3D4065B67A9C391F

582A42B9

9A858A90AF60852B14AA628A0D

028FC210842C18421084030092040B51581F24B56074404811160D

Original raw data backward direction

01A28CAA51A9420DEA12A342B33A84A835F13872BCDB4C0578BA4EF9BE8A542158A122

840810204081024568102040810 27CD60D02D11024045C0D5A49F03515A04092018042

10843068421087E20D

Note:

- There is track number before each track. Track1 is 01, Track2 is 02, Track3 is 03.
- There is a track separator after each track: 0D.

Example of decryption of a two-track ABA card with the original encryption format

This decryption is for both Fix & DUKPT key management.

The MSR has default settings.

Key for all examples is 0123456789ABCDEFFEDCBA9876543210

Original encryption format

Original encryption format (this can be recognized because the high bit of the fourth byte underlined):

(1) is 0.

028700041B331A0027D2E435CEE303F007E977B598B7E3C57C76F4445E309F6916C032

1A0F915B6E490813498839049FE5204762327C3C758C5BF82542DEEDD8D6AF88019149

```
A702FF2D43BD4AD60031FA450720B00D7808E15F3D5B29AE712C64A1212E9AF6F4
83BD
40798A9FF2DDE77D046620B55BCE94A4D5534CF57E7E07629949011A0000000001
871D
```

```
03
```

STX, Length (LSB, MSB), card type, track status, length Track1, length Track2, length Track3 02 8700 04 1B 33 1A 00

Track1 & 2 encrypted length 0x33+0x1A rounded up to 8 bytes =0x4D -> 0x50 (80 decimal)

```
27D2E435CEE303F007E977B598B7E3C57C76F4445E309F6916C0321A0F915B6E49
0813
```

```
498839049
```

```
FE5204762327C3C758C5BF82542DEEDD8D6AF88019149A702FF2D43BD4AD60031F
A450 720B00 D7808
```

Track1 hashed: E15F3D5B29AE712C64A1212E9AF6F483BD40798A

Track2 hashed: 9FF2DDE77D046620B55BCE94A4D5534CF57E7E07

KSN 629949011A0000000001

LRC, checksum and ETX `87 1D 03`

Key Value: 8A 60 A3 EB 80 87 63 52 B8 F5 05 CD A8 3C 33 70

KSN: 62 99 49 01 1A 00 00 00 00 01

Decrypted raw data:

```
01D67C81020408102D4481020408102042890A350854A2FB3EE4BA3D4065B67A9C
391F
```

```
582A42B99A858A90AF60852B14AA628A028FC210842C18421084030092040B5158
1F24 B5607440481116
```

```
-=-=-=--=-=-=--=-=-=--=-=-=--=-=-=--=-=-=--=-=-=--=-=-=--=-=-=--=-
=-=--=-=-=--=-=-=--
```

```
=-=-=--=-
```

15. Appendix H: Example of SPI sender chip controlling

```
/*H***************************************************************************
  * NAME:      spi_drv.h
  * Copyright (c) 2003 ID TECH.
  * RELEASE:   cc03-demo-spi-0_0_1
* REVISION:    1.1.1.1
  * PURPOSE:
  * spi lib header file
****************************************************************************/


#ifndef
_spi_DRV
_H_
#define
_spi_DRV
_H_

/*_____I N C L U D E S_______*/


/*_____D E F I N I T I O N___*/
// Pin define
 #define _DAV_IN              P3_4                                    // SPI
 chip has data ready
 #define _SPI_SS              P1_1                                    // SPI
 chip select pin


//In Sender mode, the baud rate can be selected from a baud rate generator which is controlled
//by three bits in the SPCON register: SPR2, SPR1 and SPR0. The Sender clock is
//chosen from one of seven clock rates resulting from the division of the internal clock by
//2, 4, 8, 16, 32, 64 or 128.


#define SPI_RATIO_2   0x00 // FCLK PERIPH/2
#define SPI_RATIO_4   0x01 // FCLK PERIPH/4
#define SPI_RATIO_8           0x02 // FCLK
PERIPH/8 #define SPI_RATIO_16 0x03 // FCLK
PERIPH/16
#define SPI_RATIO_32   0x80 // FCLK PERIPH/32
#define SPI_RATIO_64   0x81 // FCLK
PERIPH/64 #define SPI_RATIO_128      0x82
// FCLK PERIPH/128 #define
SPI_RATIO_INVALID     0x83 // No
BRG


/*     M A C R O S    */
// SPIF: Serial Peripheral data transfer flag
// Cleared by hardware to indicate data transfer is in progress or has been
// approved by a clearing sequence.
// Set by hardware to indicate that the data transfer has been completed.
#define Spif_set()     ((SPSCR & MSK_SPSCR_SPIF) == MSK_SPSCR_SPIF) // If equal, the
data transfer has been completed.
/*_____D E C L A R A T I O N */ Uchar spi_set_speed(Uchar data
ratio);
void spi_sender_init(Uchar data cpol, Uchar data cpha, Uchar data ssdis, Uchar
data speed); void spi_Sendout(Uchar data inchar);


#endif /* _SPI_DRV_H_ */
/*C**************************************************************************
  * Module:    main.c
/****************************************************************************
  * Copyright (c) 2004 ID TECH inc.,
/****************************************************************************
  * CREATION_DATE:     2004.1.10
/****************************************************************************
  * PURPOSE:
```

```
  * spi library low level functions (init, receive and send functions)
  * and global variables declarations to use with user software application
*****************************************************************************/
/*_____I N C L U D E S_______*/ #include "spi_drv.h"
/*_____M A C R O S___________*/ #define MAX_LEN    512
/*_____D E F I N I T I O N___*/

Uchar data SPI_IPNT; // Temp buffer to store SPI data.
Uchar data Command_OUTbuf[MAX_LEN]; // Command
output buffer Uchar data Command_INbuf[MAX_LEN];
// Command input buffer Uint16 data spilength; //
received command length
Uint16 data Command_Length; // output command length
/*_____D E C L A R A T I O N */

void main(void){
Uint16 data i, j; // Internal counter.


        spi_sender_init(0, 0, 1, 32); //SPI sender mode, initialize to CPOL=0,
CPHA=0, SSDIS=1, bitrate=Fper/32
Enable_spi_interrupt(); // Turn on SPI interrupt in system.
_SPI_SS = 0; // Disable SPI receiver during power on, to prevent indeterminate state.


do{ // keep polling...
{
// .............      Other subroutine to handle other tasks
}


if(_DAV_IN){ // If DAV pin is high level, SPI receiver has data ready.
                      _SPI_SS = 1; // To Generate a falling edge. Not useful for clock phase
0, but clock phase 1 needs this falling edge.
delay10us(); // Wait for high level get steady.
_SPI_SS = 0; // Pull chip select pin low, ready to start SPI communication. spilength
= 0; // Initialize Command_buf pointer.


                      while(_DAV_IN){ // Keep polling DAV pin till it turns low level.
Polling interval is 40us in this demo code.


in this subroutine too.




buffer.
spi_Sendout(0xff); // Send out any data to get SPI receiver input, delay 40us
Command_INbuf[spilength++] = SPI_IPNT; // Save data into Command_buf. if(spilength >= MAX_LEN){
// Quit while loop if read the end of input
break;
}


high.
```

```
}
_SPI_SS = 1; // Read out all the data from SPI receiver, set chip select pin to idle

for(i = 0; i < spilength; i++){ // Send out data from UART port.
put_byte(Command_INbuf[i]);
}
}

{
// .............       Other subroutine to handle other tasks
}

if(SPISenderCommandReady){ // If SPI sender wants to send a command to SPI receiver
                      _SPI_SS = 1; // To Generate a falling edge. Not useful for clock
phase 0, but clock phase 1 needs this falling edge.
delay10us(); // Wait for high level get steady.
_SPI_SS = 0; // Pull chip select pin low, ready to start SPI communication.

for(j = 0; j < Command_Length; j++){ // Send out whole command string.
spi_Sendout(Command_OUTbuf[j]);


chip select pin to idle high.

}

{

tasks
}
```

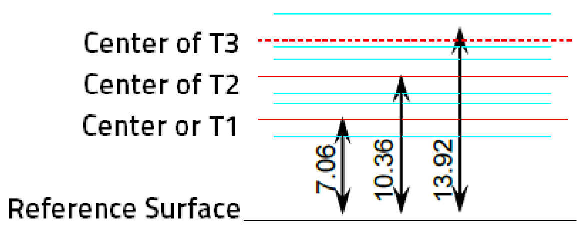
```
}

        _SPI_SS = 1; // Read out all the data from SPI receiver, set BeepOn_Long(); // Send
out one beep to indicate command finished.


// .............       Other subroutine to handle other
}
while( TRUE );
}
/*C**************************************************************************
  * Module:     spi_drv.c
/***************************************************************************
  * Copyright (c) 2004 ID TECH inc.,
/***************************************************************************
  * CREATION_DATE:     2004.1.10
/***************************************************************************
  * PURPOSE:
  * spi library low level functions (init, receive and send functions)
  * and global variables declarations to use with user software application
****************************************************************************/
/*_____I N C L U D E S_______*/ #include "spi_drv.h"
/*_____M A C R O S____*/
/*_____D E F I N I T I O N___*/ Uchar transmit_completed = 0; //
0 by default
extern Uchar data SPI_IPNT;
/*_____D E C L A R A T I O N */

// Here are some global flags to use with spi library
// These global flags are used to communicate with higher level functions ( user application )
// Here the global variables to communicate with spi interrupt routine

/*F**************************************************************************
  * NAME: spi_isp
*
  * PARAMS: none
  * return: none
  * PURPOSE:
  * spi - interruption program for serial transmission ( Sender and Receiver mode )
*
  * NOTE:
*****************************************************************
**********/ Interrupt(void spi_isp(void), IRQ_SPI){
if(Spif_set()){ // Quit if data transfer has not been
completed. transmit_completed = 1;   // Set software complete
flag
SPI_IPNT = SPDAT;      // Store SPI input data in SPI_IPNT. SPDAT - Serial Peripheral
Data R
e
g
i
s
t
e
r
return
   ;
    }
}
/*F**************************************************************************
  * NAME: spi_set_speed
  * PARAMS: ratio: spi clock ratio/XTAL
  * return: Uchar: status
  * PURPOSE:
  * Configure the baud rate of the spi, set CR2, CR1, CR0
  * NOTE:
  * This function is only used in spi sender mode, called by spi_sender_init
*****************************************************************
**********/ Uchar spi_set_speed(Uchar data ratio){
switch(ratio){ // Set SPCON register
case 2: SPCON |= SPI_RATIO_2; break; // FCLK PERIPH/2 case 4: SPCON
```

```
|=  SPI_RATIO_4;  break;  //  FCLK  PERIPH/4  case  8:  SPCON  |=
SPI_RATIO_8; break; // FCLK PERIPH/8
case 16:SPCON |= SPI_RATIO_16;break; // FCLK PERIPH/16
case 32:SPCON |= SPI_RATIO_32;break; // FCLK PERIPH/32
case 64:SPCON |= SPI_RATIO_64;              break; // FCLK
PERIPH/64 case 128:SPCON |= SPI_RATIO_128;  break; // FCLK
PERIPH/128
default :      return FALSE;
}
return TRUE;
}

/*F*************************************************************************
  * NAME: spi_sender_init
  * PARAMS:
  * cpol: Uchar CPOL value
  * cpha: Uchar CPHA value
  * ssdis: Uchar SSDIS value
  * speed: Uchar spi speed ratio transmission Vs Fper
  * return:    none
*
  * PURPOSE:
  * Initialize the spi module in sender mode
*
  * EXAMPLE:
  * spi_sender_init(0,0,1,32); // init spi in mater mode with CPOL=0, CPHA=0,
  * // SSDIS=1 and bitrate=Fper/32
  * NOTE:
***************************************************************************/
void spi_sender_init(Uchar data cpol, Uchar data cpha, Uchar data ssdis, Uchar
data speed){ SPCON = 0; // Initialize SPCON: Serial Peripheral Control Register
SPCON |= MSK_SPCON_MSTR; // Serial Peripheral Sender: Set to configure the SPI as a Sender.
_SPI_SS = 1; // Initialize chip select pin to idle - high
level. spi_set_speed(speed); // Set SPI sender speed to
Fper/32.
if(cpol) SPCON |= MSK_SPCON_CPOL; // Cleared to have the SCK set to "0" in idle state.
if(cpha) SPCON |= MSK_SPCON_CPHA; // Cleared to have the data sampled when the SCK leaves
the idle
state
if(ssdis)      SPCON |= MSK_SPCON_SSDIS; // Set to disable chip select in both Sender and
Receiver modes. Select manually control CS pin.
SPCON |= MSK_SPCON_SPEN; // Set to enable the SPI interface.
}

/*F*************************************************************************
  * NAME: spi_Sendout
  * PARAMS: inchar: the desired character to send out
  * return: none
*
  * PURPOSE:
  * Send out one character
  * NOTE:
  * This function is use only in spi sender mode
******************************************************************
**********/ void spi_Sendout(Uchar data inchar){
Uchar data m;
SPDAT = inchar;// send a data, put the data into SPDAT register
while(!transmit_completed);// wait for transmission complete (interrupt
complete), flag
transmit_completed will be set in SPI interrupt
subroutine. transmit_completed = 0;   // clear software
transmit end flag
m = 4; // Delay 40us then poll for DAV pin status or send out next
byte. do{
delay10us();
}while(m--)
```

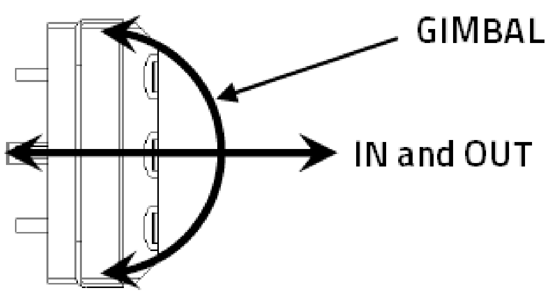
16. APPENDIX I: Magnetic heads mechanical design guidelines

This installation guide is specifically to be used when installing HP magnetic heads with spring mounts.

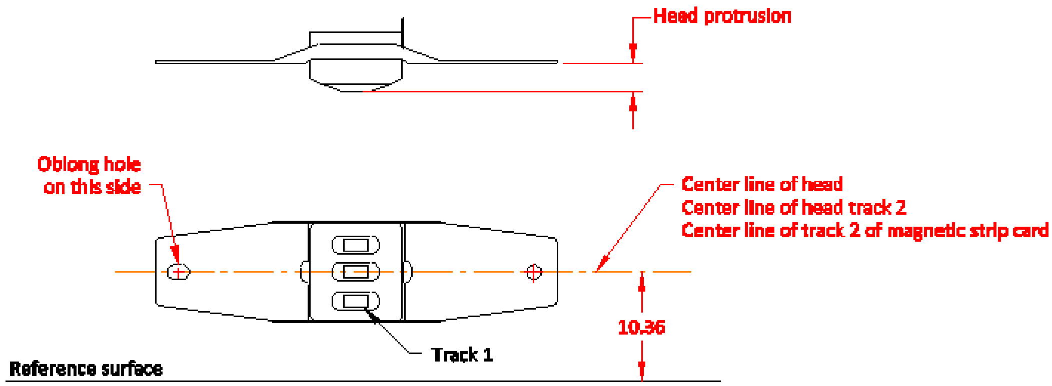
1. ISO 7810 and ISO 7811 standards define the specification for all "standard" magnetic stripe cards. The proper location of each magnetic track's centerline is shown in the figure below (**Note:** The reference surface for the card is the edge of the card; and it is the surface the card rides on when referring to the magnetic head).



2. The head mounting should allow the head to follow the magnetic stripe on the card. In other words, the magnetic head needs to have the freedom to gimbal (rotate about Track2's centerline) and move in/out to remain in contact with the surface of the card, after head is assembled to the rail. The following figure shows the rotational and linear movements that the head mounting must allow.



3. The head has to be mounted in relation to the reference surface on which the card slides so that the magnetic tracks of the head are positioned at the same distance from the reference (bottom of slot) as the magnetic tracks on the card (refer to dimensions in #1 above). A typical HP magnetic head with spring is shown in the following illustration. The mounting holes (centered on Track2's centerline) in the spring are used for mounting the head and positioning the track locations. (**Note:** The oblong hole in the spring must be oriented as shown in the drawing to locate tracks 1 through 3 properly).



The center line of head should be parallel to the reference surface.

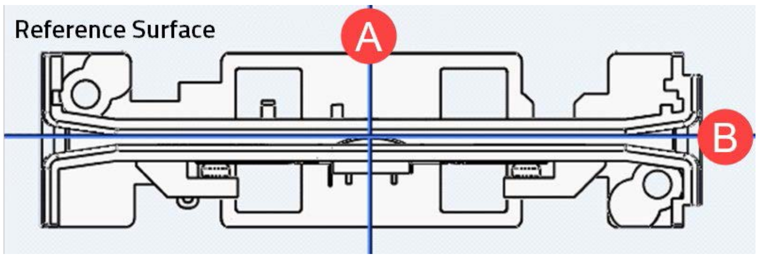
4. The card thickness must be considered when designing the rail and head mounting. The distance between the head (located on the crown of the head) and opposing wall of card slot must be positioned so that it has a minimum of 0.010 inches (0.25mm) movement when a minimum card thickness is swiped, any less movement could result in unreliable reading. Or put another way: the distance between the crown of the head and the opposing slot wall should be only a fraction of the minimum card thickness that will slide through the reader, so the magnetic head always exerts pressure on the card. The pressure allows for proper contact of the head to stripe especially at high speeds.

5. Standard card thickness is 0.76mm±10%, if only standard cards are to be used, the rule should be the Apex (crown of head) of the head should be a maximum of 0.25mm from opposing card slot wall. If a thinner or thicker than standard card is used, the distance the head is positioned from the opposing wall needs to be adjusted (this will require a unique rail design with either wider or narrower card slot width).

6. The minimum slot width should be maximum card thickness plus 0.15~0.30mm. The suggested minimum slot width is 1.03+0.08 -0 mm when a standard card is used.

7. The design should ensure there is no excessive force or deformation of head spring during the assembly of head to the rail or after head is assembled to prevent permanent deformation of the head spring. The head spring must be mounted so that it is free to gimbal about the spring holes.

8. The bottom of slot and the slot walls should not have any discontinuities and must be flat (no deformation is allowed). The portion of the slot wall, about 10mm on each side of the magnetic head's crown, should not have draft and must be perpendicular to the bottom of slot (reference surface). The slot width in lead-in and lead-out area shall be greater and must have gradual transition with no edges, or angles to interfere with the smooth swiping of a card.



A. Plane of Head Gap

B. Plane of Slot Wall

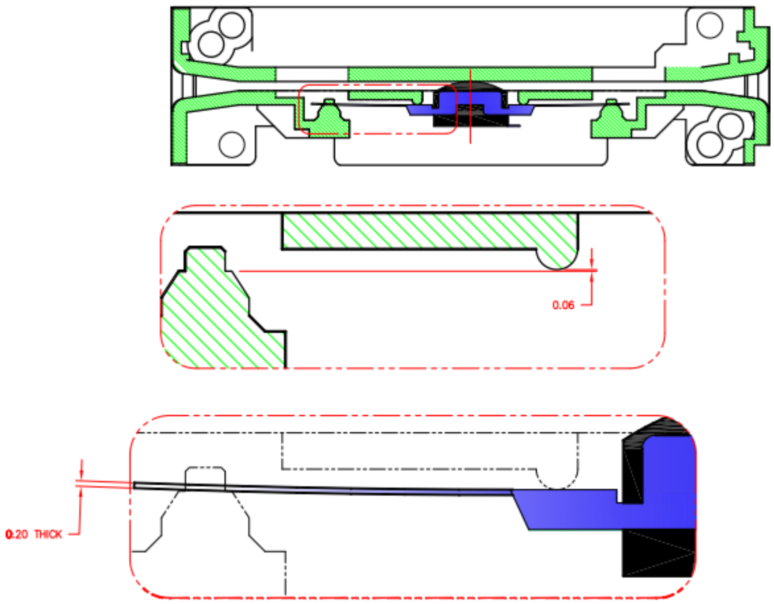
9. Depending on the requirement of swipe life cycles, a suitable material for the rail shall be decided. If the life of the reader is to be greater than 50,000 passes, the bottom of slot must embed a metal wear plate (stainless steel is the metal of preference to avoid corrosion), or the plastic material used for the slot needs to be significantly harder than the card material to ensure adequate rail life.

10. The back side (pin side) of magnetic head shall have enough reserved space to prevent interference with other parts during swiping of maximum thickness cards. The design must provide for a minimum of 1.25~1.52mm space behind the head to allow for proper gimbal and head movement during card swiping. The head opening in the rail must allow room for maximum gimbal action.

11. When the head is installed into the rail, the spring holding the head should be slightly preloaded. Preloading the spring will ensure that the head has some stability at the first impact with the card, which is important especially if the card is swiped at high speed. (If the spring is not preloaded it will tend to vibrate when the card impacts the head; vibration would cause head to lose contact with the card.)

12. The HP solution to preload the head spring is to add 2 symmetrical bumps one on each side of the head (head window), molded into the rail (see drawing below). We recommend that the difference between the spring resting surfaces and the crown of the bumps is 0.06+/_0.03 mm, which for a head spring that is 0.20 mm thick results in a 0.14+/- 0.03 mm bow. The bumps should by cylindrical and their crown parallel with the slot wall

opposite to the head crown; this ensures that when the head is mounted into the rail, its crown is parallel to the slot surface and makes good contact with the magnetic stripe on the card. See the below drawing:



13. The length, width and height of rail's slot will affect the stability of reading performance.

    a. The length of the slot to be maximum permitted by dimensional constraints (if possible, it should be 2 times the length of the card).

    b. The slot width to be approx. 0.20 mm bigger than the maximum thickness card that will be swiped through the slot.

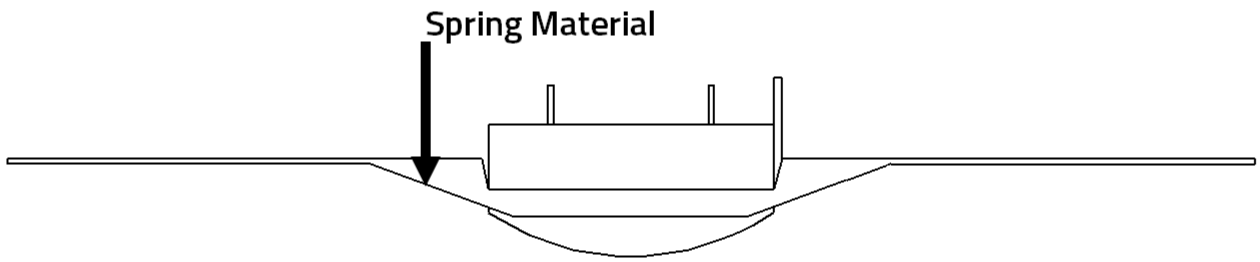
    c. The height of the slot should be as big as the dimensional constraints allow but shall not extend over the embossing area of the card unless there is a provision (recess) in the rail wall design to allow for such embossing.

14. The window in the rail wall through which the head protrudes into the slot should be big enough to allow free movement of the head.

15. The clearance between the head and the wall of the rail window depends on the amount of head travel and on the head protrusion. (The distance from the crown of the head to the surface of the spring)

16. For a standard rail with 1.03 $^{+0.08}_{-0}$ mm wide slot and a standard ID Tech head with 3.50 head protrusion minimum 1.25 mm clearance must be allowed on all sides of the head. (**Note**: This guideline does not apply when low profile heads are used. The window must allow clearance for the portion of the spring welded to the magnetic head as shown in the

following figure.)



HP can provide samples of a rail and magnetic head for design reference. Order these through your local sales representative using the following part numbers:

- 90 mm rail 80006248-001
- Standard wing spring head 80027236-001

17. Appendix J: Firmware upgrade

HP TM4 SPI The MSR firmware can be updated through the SPI communication port.

HP can provide Windows-based utility software, FWUpdate.exe, and an RS-232 to SPI converter board for reference. The customer can also develop their own software to upgrade the firmware. (Prerequisite: The host must already be in communication with The MSR. It must support regular commands like “read firmware version.”)

Procedure

TriMag IV firmware can be updated using the following commands.

Except where noted, commands should be wrapped in STX (0x02) and ETX (0x03), followed by a one- byte LRC (calculated as the XOR of all preceding bytes including STX and ETX).

Also, except where noted, a successful response will begin with ACK (0x06).

Basic steps

1. Read firmware version (52 22 88 command). This is to confirm current reader is working.

2. Erase firmware (53 7E 0D 31 01 02 03 04 05 06 07 08 04 03 02 01).

The firmware is erased in about 2 seconds, then rise DAV line to request the send of 0x5A. Host needs to read this response.

Note: The DAV line is high for 500 mS. If software does not read a response, the MSR shifts to RS232 communication. In such a case, you must cycle the MSR power and read response within the 500 mS DAV high period to get the 5A byte.

HP suggests waiting another 3 seconds after reading the response, then perform the following loading sequence.

Load new firmware

1. Send hex byte 0xBD to start loading.

2. Open firmware bin file and send the whole file to the MSR.

Note: The new firmware file is a binary file that contains 26K bytes encrypted firmware and 4 bytes CheckSum and LRC. The CheckSum and LRC is checked by the MSR. The MSR decides to reject or accept the firmware download. (The host does not need to check these bytes, only send the whole file.)

1. Wait for DAV line high and read one-byte response.

2. Wait for 3 seconds.

Example

The following is an example when loading firmware with HP FWupdate software.

Step 1: Review current firmware version:

OUT	02 52 22 88 03 f9		
IN	06 02 49 44 20 54 45	43	..ID TEC 250ms
	48 20 54 4d 34 20 53	65	H TM4 Se
	63 75 72 65 48 65 61	64	cureHead
	20 53 50 49 20 52 65	61	SPI Rea
	64 65 72 20 56 31 2e	32	der V1.2 4.049..

B. Erase current firmware:

OUT	02 53 7e 0d 31 01 02	03	.S..1... 18sc
	04 05 06 07 08 04 03	02	....
	01 03 1c	...	

Note: It takes about 2 seconds for The MSR to finish erasing firmware. The host should wait for DAV line rise and read the response 5A. The host might wait another 3 seconds to perform following loading step.

Step 2: Download firmware

1. Send one byte for getting into download mode: BD.
2. Send encrypted bin file (new firmware file).
3. Wait for DAV line rise, get one-byte response, ignore it.
4. Wait a few seconds (about 3 seconds).

Step 3: Check new firmware version

OUT	02 52 22 88	03 f9	.R"...	5.0sc
IN	06 02 49 44	20 54 45 43	..ID TEC	251ms
	48 20 54 4d	34 20 53 65	H TM4 Se	
	63 75 72 65	48 65 61 64	cureHead	
	20 53 50 49	20 52 65 61	SPI Rea	
	64 65 72 20	56 31 2e 32	der V1.2	
	34 2e 30 35	30 03 1f	4.050..	