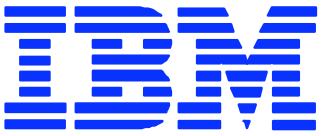

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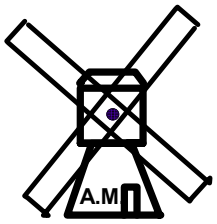
PIN Processing

PIN Verification

- A bank client withdraws Cash out of ATM
- Easy to understand transaction
- Secrecy of PIN is obvious



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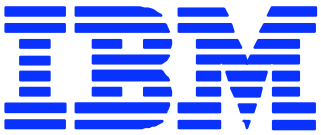

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An Example of PIN Processing

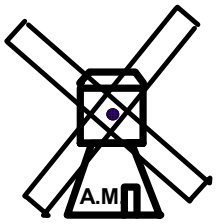
- A bank's customer complains about a PIN withdrawal

"I didn't do that cash withdrawal"

How can the bank prove that its not their fault ?

- By proving that no single employee can get a customer's PIN value
- By using certified cryptographic hardware
- By having strict procedures in place
  - To protect keys (that protect PIN's)
  - To protect PIN's

In a dispute in court, they should be able to win the case



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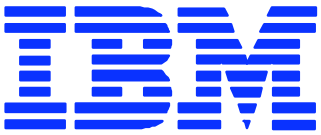

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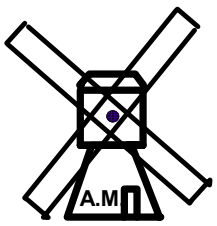
How is the PIN usually derived ?

PINs are calculated as follows.

- Take the last five significant digits of the account number, and prefix them by eleven digits of validation data.
- These are often the first eleven digits of the account number. They could also be a function of the card issue date.
- In any case, the resulting sixteen digit value is input to an encryption algorithm (TDES)
- The result is then Decimalised (mapping on 0,1,...9 digits)

  Result of decimalising is the "Natural PIN"



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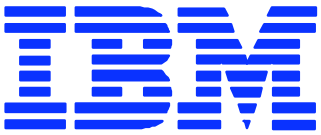

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How is the PIN usually derived ? Example

Data input to TDES algorithm: 0123456789012345
PIN key input to TDES algorithm: 23232323 89ABCDEF FEDCBA98 76543210
Output of DES algorithm: EC122671 C6B1AC05
Take first 4 digits (nibbles) and decimalise

First four digits decimalised --> 4212 E -> 4 C -> 2 1 -> 1 2 -> 2
Natural PIN = 4212 (question: Is this decimalisation OK ?)

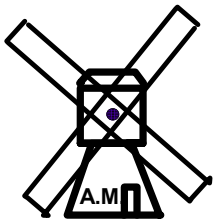
Selected Customer PIN: = 5446
Calculated Natural PIN = 4212
Offset: = 1234

Offset = Customer_PIN - Natural_PIN

Note: Offset is only used if the customer has a selectable PIN

Decimalisation table (example)

0 -> 0
1 -> 1
2 -> 2
3 -> 3
4 -> 4
5 -> 5
6 -> 6
7 -> 7
8 -> 8
9 -> 9
A -> 0
B -> 1
C -> 2
D -> 3
E -> 4
F -> 5



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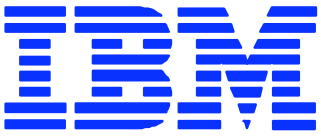

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Decimalization of the PIN

Example: The Natural PIN data is DC 88

Now we assume here in this example the following decimalisation table:

decimalisation table = 6028 0786 0808 3644

On offset 0 we have a 6	On offset 1 we have a 0
On offset 2 we have a 2	On offset 3 we have a 8
On offset 4 we have a 0	On offset 5 we have a 7
On offset 6 we have a 8	On offset 7 we have a 6
On offset 8 we have a 0	On offset 9 we have a 8
On offset 10 (A) we have a 0	On offset 11 (B) we have a 8
On offset 12 (C) we have a 3	On offset 13 (D) we have a 6
On offset 14 (E) we have a 4	On offset 15 (F) we have a 4

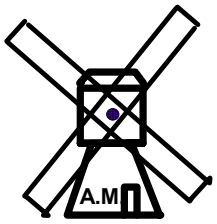
DC 88 now translates as follows to a natural PIN

D ---> 6
C ---> 3
8 ---> 0
8 ---> 0

So the PIN becomes 6300

Decimalisation table used here

0 -> 6
1 -> 0
2 -> 2
3 -> 8
4 -> 0
5 -> 7
6 -> 8
7 -> 6
8 -> 0
9 -> 8
A -> 0
B -> 8
C -> 3
D -> 6
E -> 4
F -> 4



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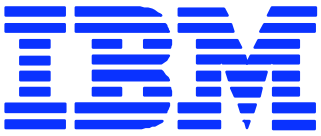

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PIN Blocks

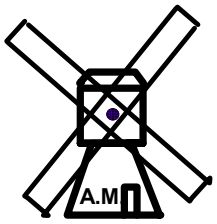
example of an **ISO0** PIN block:

```
PAN = 12 34 56 78 90 12  (6 bytes)
PIN = 42 12  ---> PIN length = 4

Interm. PIN Bl. = 04 42 12 FF FF FF FF FF
PAN Block       = 00 00 12 34 56 78 90 12
Clear PIN block = 04 42 00 CB A9 87 6F ED
```

The PIN block is always encrypted

$$E_K(PB)$$



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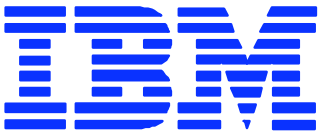

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Verification of the PIN

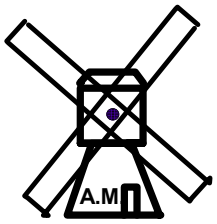
In concept there are 2 methods:

- PIN calculation method

  After receiving the encrypted trial PIN block the system calculates the correct PIN, based on PAN and other info (dec. table etc.) , decrypts the trial PIN block and compares the two clear PIN values. (inside hardware) The **CSNBPVR** call is used.

- PIN Database method (use reference PIN)

  After receiving the encrypted trial PIN block the system retrieves the encrypted reference PIN block from a database and compares the two values. This requires to use the **CSNBPTR** verb with keyword TRANSLAT.



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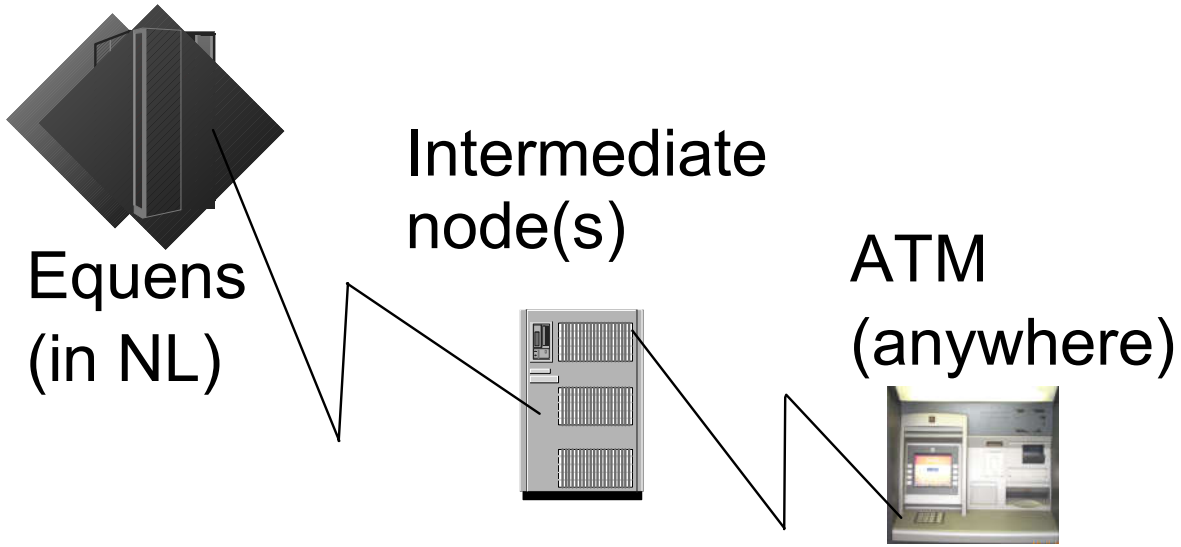
Verification of the PIN (simplified)



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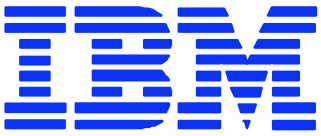

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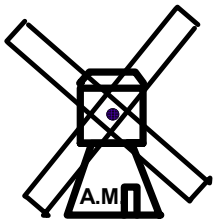
Verification of the PIN (simplified)

INSIDE HSM at bank-side:

- Decrypt trial PIN block $E_{K_{atm}}(PB)$
- Derive / Calculate reference PIN
- Compare decrypted trial PIN and reference PIN
- Return YES or NO to caller

No clear PIN ever shows up



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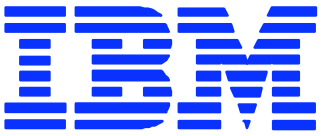

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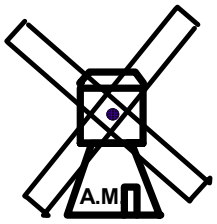
Example of HSM PINVER function (simplified)

Encrypted_PIN_Verify (
PIN_encr_key,
PIN_ver_key,
PIN_info,
PAN_info,
Encrypted_trial_PIN_block,
Result)

To decrypt trial PIN → PIN_encr_key

To derive reference PIN → PIN_ver_key

The function checks the correct key type



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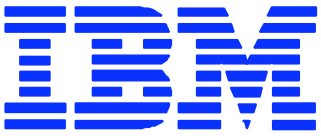

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Key Separation (1)

What would happen if PIN_DECIPHER_key could be used in Decipher function ?

BIG TROUBLE CAN OCCUR

BECAUSE $E_{K_{atm}}(PB) \rightarrow PB$

Therefore we MUST use key separation, so that a PIN-key never can exist as a decipher-key

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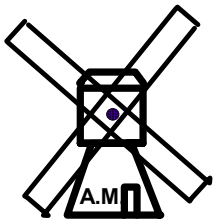

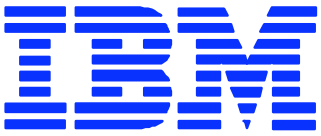

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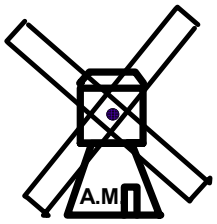
Key Separation (2)

- We limit a key to just the function it is designed to run.
- The key-type is determined before the key exists (or is generated)
- The key-type can't be changed afterwards

In a well designed key management system
no tricks are applicable on the key



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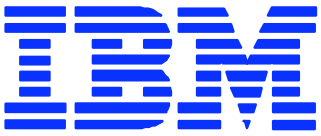

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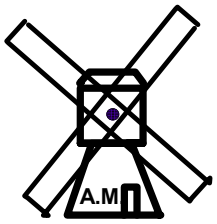
Key Separation (3)

Many hardware vendors use key-tokens that contain extended key-information

- value of key (encrypted)
- type of key
- how should the key be treated
- activation / expiration date



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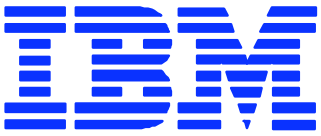

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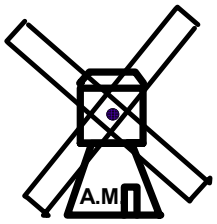
Key Separation (4)

Many properties of the keys are coded in "Variants" or "Control Vectors" (IBM)

- A property of the key is a bit in the CV
- The CV is part of the encryption of the key



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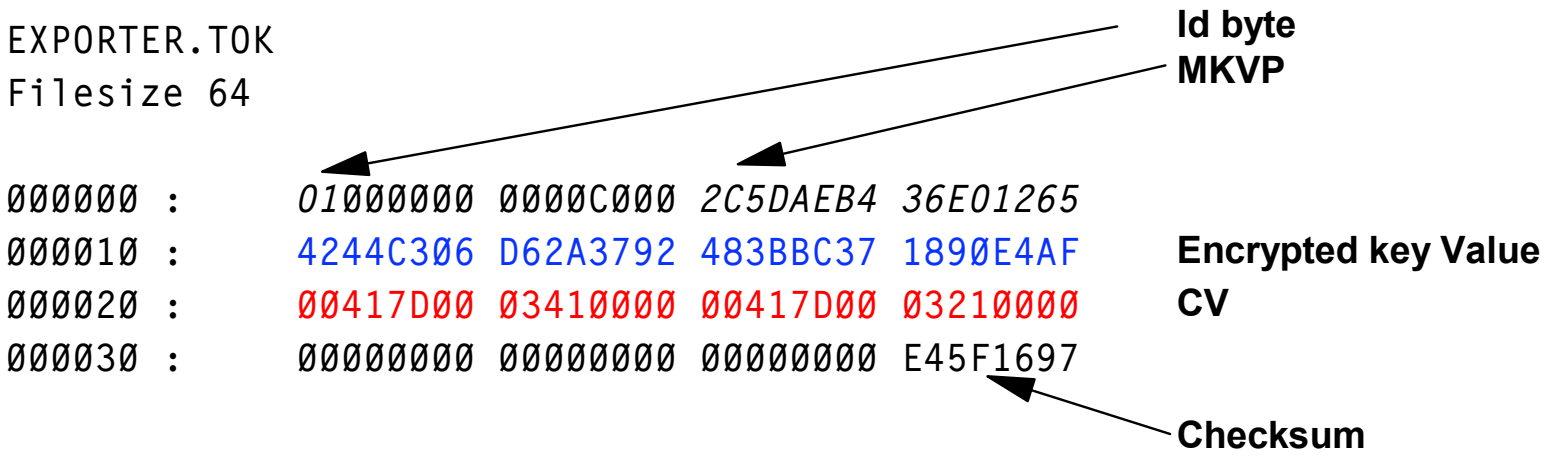
Key Separation (5)

An example of an IBM key-token



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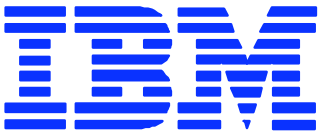

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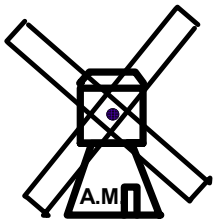
Most commonly used PIN Verbs

CSNBCPE	Clear PIN Encrypt
CSNBPGN	Clear PIN Generate
CSNBEPG	Encrypted PIN Generate
CSNBPVR	Encrypted PIN Verify
CSNBPTR	PIN Block Translate



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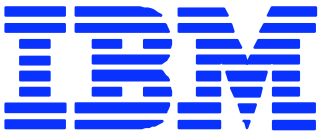

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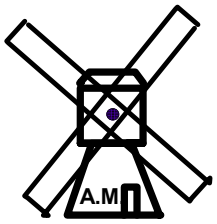
CSNBCPE Clear PIN Encrypt

Builds a Clear PIN Block and Encrypts it

```
CSNBCPE(      &rc,
              &rs,
              &exit_data_length,
              exit_data,
              opinenc_key_token,   ──►  to encrypt PIN block
              &rule_array_count,
              rule_array,
              clear_PIN,
              input_PINprofile,    ──►  to build the PAN block
              PAN_data,
              &sequence_nr,
              enc_PIN_block_ISO0);
```



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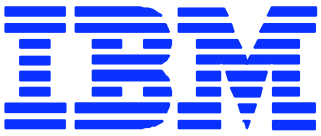

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CSNBPGN Clear PIN Generate

Generates a Clear PIN from Validation data

```
strncpy((char * ) decimalization_table, "0123456789012345"      , 16);
memcpy((char * ) data_array     , decimalization_table                  , 16);
memcpy((char * ) data_array + 16, validation_data                       , 16);
memcpy((char * ) data_array + 32, "                "                    , 16);

CSNBPGN(      &rc,
              &rs,
              &exit_data_length,
              exit_data,
              pingen_key_token,  ------>  to generate the PIN
              &rule_array_count,
              rule_array,
              &PIN_length,
              &PIN_check_length,
              data_array,        ------>  Dec table and
              clear_PIN_from_CCA);        Validation data
```

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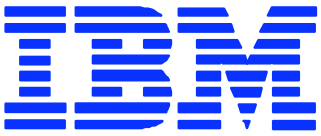

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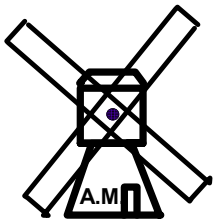
CSNBEPG Encrypted PIN Generate

Generates a PIN
Makes a PIN Block based on PIN and PAN
Encrypts the PIN block

```
CSNBEPG(      &rc,
              &rs,
              &exit_data_length,
              exit_data,
              pingen_key_token,    // to generate the clear PIN
              opinenc_key_token,   // to encipher the clear PIN
              &rule_array_count,
              rule_array,
              &PIN_length,
              data_array,              // dec. table and val. data
              input_PINprofile,
              PAN_data,          // to build PAN block
              &sequence_nr,
              enc_PIN_block_bin);
```



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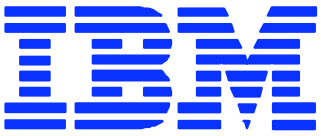

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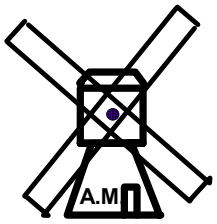
CSNBPVR Encrypted PIN Verify

Verifies a PIN from an Encrypted PIN block

```
CSNBPVR(      &rc,
              &rs,
              &exit_data_length,
              exit_data,
              ipinenc_key_token,    // IPINENC key to decipher the trial PIN block
              pinver_key_token,     // PINVER key, to generate the A-PIN
              PIN_profile,
              PAN_data,                          // To build the PAN Block
              Trial_Enc_ISO0_PIN_block,    // Coming from ATM or POS
              &rule_array_count,
              rule_array,
              &PIN_check_length,
              data_array);              // Dec. table, Validata data
                                           and offset ( if IBM-PINO)
```



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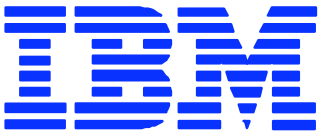

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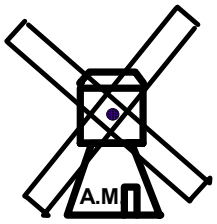
Tricks with Decimalization tables

- There exist tricks with Dec.Tables
- An example is a DEC.table of 1111111111111111
  This will always deliver a PIN of 1111
- Another example is 0100000000000000
  Here when you enter 0000 as a trial PIN it will tell
  you whether a '2' is in the Natural PIN
  You can repeat this from 0 to 9
- See also "**Decimalisation table attacks for PIN cracking**"
  Written in 2003 by Mike Bond and Piotr Zielinski
- So you might want to protect your DEC. tables



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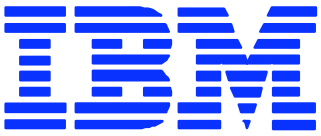

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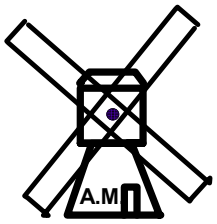
HSM Internal Decimalization tables

- To protect the INTEGRITY of DEC. tables you can store them inside the HSM
- You can load DEC. table inside the crypto hardware
  - For ICSF you store DEC. tables inside HW. using TKE
  - On a Workstation you store DEC. tables inside HW. using CSUACFC
- There is Dual control on the load of DEC tables
- "Load" and "Activate" use different ACP's

- At CSNBPVR call, you must supply the DEC.table that is to be used. The call will check then, that the same table is Loaded and set ACTIVE inside the card.



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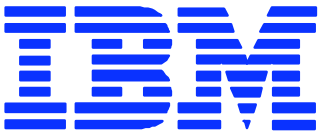

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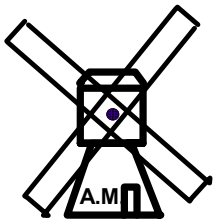
ACP's involved in PIN Processing

- 0X353 Load Decimalization tables
- 0X354 Delete Decimalization tables
- 0X355 Activate Decimalization tables
  Note: If this ACP is ON,
  a Load will also Activate
- 0X356 Use Only Valid Decimalization tables
  To enforce a DEC Table that was
  ACTIVE already in the card



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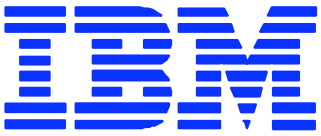

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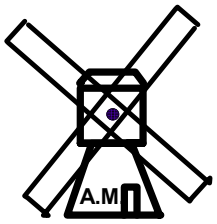
Customer Selectable PIN's (1)

- Some banks want to enable their customers to select their own PIN
- The Natural (calculated PIN) stays the same
- There is a value OFFSET involved
- Offset = Customer PIN - Natural PIN



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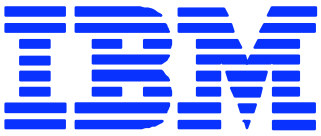

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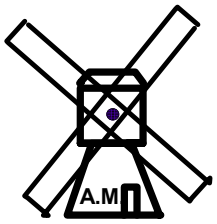
Customer Selectable PIN's Terminology

- C-PIN The Customer selected PIN
- A-PIN The Natural (calculated PIN)
- O-PIN The OFFSET value
- T-PIN The Trial PIN



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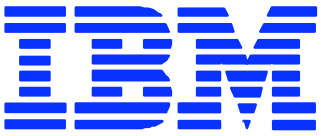

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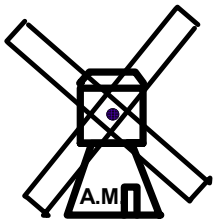
Customer Selectable PIN's (2)

The subtraction is done without carry

```
C-PIN        = 1453
Natural PIN  = 2506
             ----------
Offset       = 9957
```



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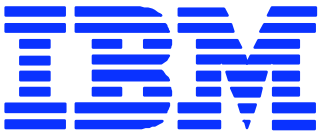

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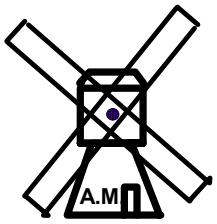
Customer Selectable PIN's (3)

- The Trial PIN block AND the Offset are Input to CSNBPVR call
- The Offset is in 3rd 16 bytes of Input parameter data_array
- Rule_array keyword is IBM-PINO and not IBM-PIN

  Then CSNBPVR will include the Offset



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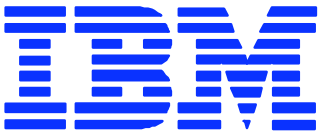

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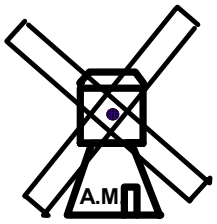
Customer Selectable PIN's (4)

These are the Customer Selectable PIN's that I use in my examples

C-PIN	= 1234	02489
Natural PIN	= 4212	91862
	---	---
Offset	= 7022	11627



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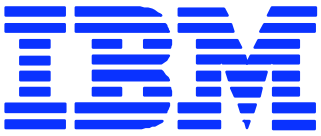

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AM. PIN Example programs

- pin_pgn (Generate Clear PIN)
- pin_pgn_bad_dec_table

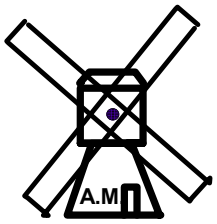
- pin_load_dec_table
- pin_activate_dec_table
- pin_list_dec_table

- pin_cpe (Build PIN Blk and Encrypt)

- pin_create_trial_block (emulate an ATM)
- pin_create_trial_block_offset

- pin_pvr
- pin_pvr_offset

- pin_epg (Encrypted PIN Generate)



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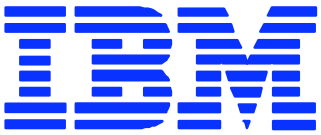

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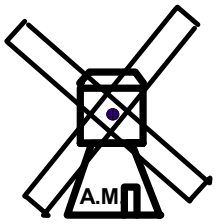
AM. PIN Example programs Input Data

Clear PINGEN key 23232323 89ABCDEF FEDCBA98 76543210
Clear OPINENC key 01234567 89ABCDEF FEDCBA98 76543210
Decimalization table 0123456789012345



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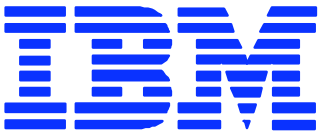

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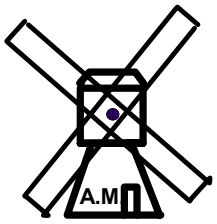
AM. PIN Example programs Data TC1

PIN_length	4
Validation data	"123456789012"
Validation data padded	"1234567890120000" right padded w. '0'
Validation data length	12
Validation data length f. enc	16
PAN_data	"123456789012"
Enciphered val. data bin (hex)	EC122671 C6B1AC05
A-PIN , C-PIN, O-PIN	4212 1234 7022
Intermediate PIN block (hex)	044212FF FFFFFFFF
PAN_block (hex)	00001234 56789012
Clear ISO-0 PIN block	044200CB A9876FED
Enciphered ISO-0 PIN block	AAE7EAA6 26FA17D4



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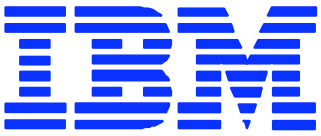

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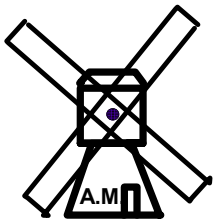
AM. PIN Example programs Data TC2

PIN_length	5
Validation data	"123456789"
Validation data padded	"123456789000000"
Validation data length	9
Validation data length f. enc	16
PAN_data	"123456789012"
Enciphered val. data bin (hex)	918621FB 8F5A853D
A-PIN , C-PIN, O-PIN	91862 02489 11627
Intermediate PIN block (hex)	0591862F FFFFFFFF
PAN_block (hex)	00001234 56789012
Clear ISO-0 PIN block	0591941B A9876FED
Enciphered ISO-0 PIN block	7F200768 16951CC8



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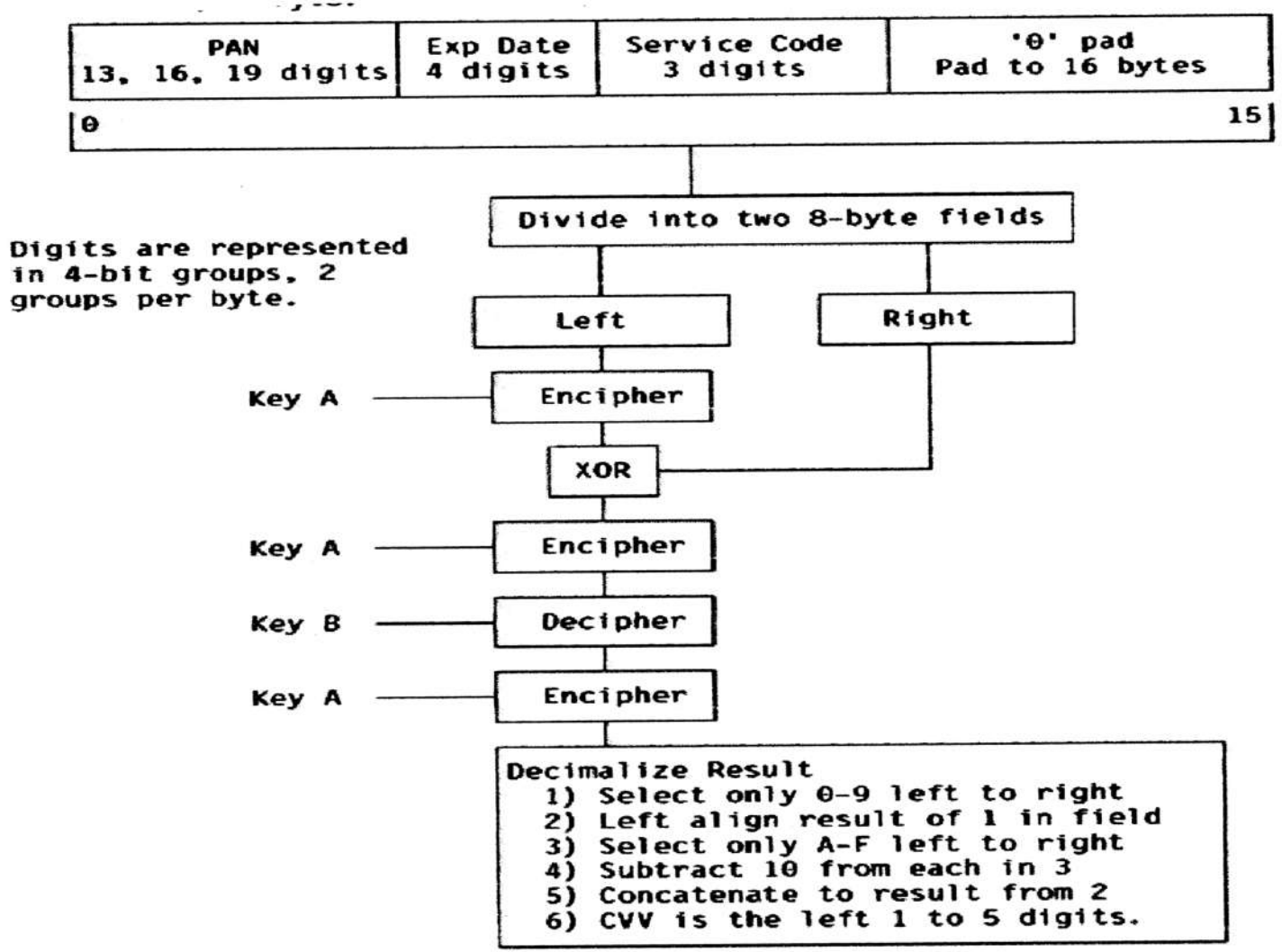
CVV = Card Verification Value



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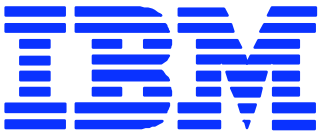

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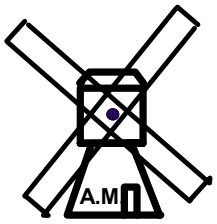
CVV Generate and Verify

- The CVV will be generated at Credit Card Issue and will be printed on the card.
- Therefore the issuer needs to run CVV Generate
- CVV generate is an ICSF API call CSNDCSG
- At transaction verification a CVV Verify might run
- CVV Verify is an ICSF API call CSNDCSV
- See demo program des_cvv_generate_verify



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