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MULTOS Developer's Reference Manual

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Document References

All references to other available documentation is followed by the document acronym in square [ ] brackets. The latest versions are always available from the MULTOS web site http://www.multos.com.

[MDG]	mao-doc-ref-005 MULTOS Developer’s Guide Available under the “MULTOS Application Developer Licence”. To download visit http://www.multos.com
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Introduction

The MULTOS Developer's Reference Manual is intended to be a concise presentation of the MULTOS low-level API and associated information. All of the instructions and primitives are defined without reference to any implementation. The MULTOS Implementation Report should be consulted for any specific implementation requirements.

MULTOS step/one

This product is intended to provide issuers a low cost, high security, MULTOS compatible platform that can be used to deploy EMV applications using Static Data Authentication only. MULTOS step/one platforms support all instructions described in this document. However, for MULTOS step/one all primitives are considered to be optional. If implemented they will support the API described in this document. For further information regarding primitive support for MULTOS step/one, see www.multos.com.

Conventions and Assumptions

When reading this document there are some conventions and assumptions in place. They are:

- Hexadecimal numbers are indicated using a prefix of '0x'. For example, 0x16 is an hexadecimal value equal to 22 decimal.
- MULTOS is big-endian; i.e., the most significant byte is found at the lowest segment address and the least significant byte at the highest.
- Byte-blocks are always treated as unsigned.
- The stack operates on the principle of "last in, first out".

This document attempts to avoid development tool specific syntax. If you wish to try the examples given, you may need to modify the code to work within your particular development environment.

Instructions

The following sub-sections define the instructions available to an application. In addition to the conventions and assumptions given in the introduction there are some additional points to take into account. They are:

- If a label can be used, but is not specified, then the instruction will execute using a value of the appropriate size found on the stack. For example, "ADDB , 5" adds five to the byte on top of the stack.
- A label can be a named memory location that the assembler will translate into an address or it can be an address. For example, "ADDB myVar, 5" adds five to the variable held at the named location myVar, while "ADDB PB[0], 5" adds five to the byte value found at the base of public memory.

ADDB

This instruction adds the literal byte to either the byte at the top of the stack or the byte held at the location specified by the label.

Syntax

```
ADDB [label], byte
```

Remarks

The result of the addition is written to either the byte at the top of the stack or, if specified, the label. If the result of the addition is greater than 255 the condition code register is updated as below and the value returned is truncated to one byte.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if result of the addition is greater than 255, cleared otherwise
V Unchanged
N Unchanged
Z Set if the result of the addition is zero, cleared otherwise

Example

The following line adds 32 to the tenth byte of static memory:

```
ADDB SB[9], 0x20
```

The following example adds 16 to the value held at a named location:

```
// declare session variable
myNumber DYNAMIC BYTE
ADDB myNumber, 0x10
```

The next example adds 27 to the value placed on the top of the stack:

```
ADDB , 0x1B
```

The following examples show how the CCR is updated upon completion of the addition:

0xFF + 0x01 = 0x00; Carry is set and Zero is set
0xFF + 0x02 = 0x01; Carry is set and Zero is cleared
0x10 + 0x20 = 0x30; Carry and Zero are cleared
0x00 + 0x00 = 0x00; Carry is cleared and Zero is set

ADDN

This instruction adds the byte-block at the top of the stack to a byte-block specified by the label. If the label is omitted then the top two byte-blocks on the stack are used.

Syntax

```
ADDN   [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the operands of size block_length will be taken from the stack.

The result of the addition will be written to the address corresponding to the label or, if no label is given, to the byte block immediately below the topmost block. In no case is the top byte block changed by the operation.

The operation will work if the two blocks overlap.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if a carry occurs, cleared otherwise
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise.

Example

The following example adds the four bytes at the top of the stack to the four bytes at the base of the static area:

```
ADDN SB[0],4
```

The following example is the same as the previous example, but uses a label to identify the variable instead of using a register/offset pair directly.

```
myVar STATIC BYTE 4
ADDN myVar,4
```

The following example adds the four bytes at the top of the stack to the four bytes immediately below them on the stack.

```
//Stack = (bottom) 10,00,00,00,12,34,56,78 (top)
ADDN ,4
//Stack = (bottom) 22,34,56,78,12,34,56,78 (top)
```

The following example performs the addition of 0x00FF and 0x1001 on the stack and then adds the result, 0x1100, to a variable held in the static segment.

```
sResult STATIC Word = 0x1111

    PUSHW    0x00FF       //Stack = 00,FF
    PUSHW    0x1001       //Stack = 00,FF,10,01
    ADDN    ,2            //Stack = 11,00,10,01
    POPW                  //Stack = 11,00
    ADDN    sResult,2     //sResult now equals 0x2211
    POPW                  //Leave stack as found.
```

The following examples show how the CCR flags are set:

0xFFFFFFFF + 0x00000001 = 0x00000000; Carry is set and Zero is set
0xFFFFFFFF + 0x00000002 = 0x00000001; Carry is set and Zero is cleared
0x10000000 + 0x200000000 = 0x30000000; Carry and Zero are cleared
0x00000000 + 0x00000000 = 0x00000000; Carry is cleared and Zero is set

ADDW

This instruction adds the literal word to either the word at the top of the stack or the word held at the location specified by the label.

Syntax

```
ADDW    [label], word
```

Remarks

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the operands will be taken from the stack.

The result of the addition will be written to the address corresponding to the label or, if no label is given, to the topmost word.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if result is greater than 65535, cleared otherwise
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following line adds 0x2020 to the word at the bottom of the static segment:

```
ADDW    SB[0000],0x2020
```

The following line adds 0x1010 to the variable declared as myNum:

```
ADDW    myNum ,0x1010
```

The following line adds 0x1010 to the current stack word.

```
ADDW    ,0x1010
```

The following examples show how the CCR is set:

0xFF00 + 0x0100 = 0x0000; Carry is set and Zero is set
0xFF00 + 0x0200 = 0x0100; Carry is set and Zero is cleared
0x1000 + 0x2000 = 0x3000; Carry and Zero are cleared
0x0000 + 0x0000 = 0x0000; Carry is reset and Zero is set

ANDN

This instruction performs a bit-wise AND on a byte-block at the top of the stack with another byte-block specified by a label. If the label is omitted then the top two byte-blocks on the stack are used.

Syntax

```
ANDN  [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the operands of size block_length will be taken from the stack.

The result of the AND will be written to the address corresponding to the label or, if no label is given, to the byte block immediately below the topmost block. In no case is the top byte block changed by the operation.

The operation will work if the two blocks overlap.

The Carry Flag is not affected by this instruction.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following example performs a bit-wise AND operation between the four bytes at the top of the stack to the four bytes at the base of the static area. The result is written to SB[0].

```
ANDN SB[0],4
```

The following example is the same as the previous example, but uses a label to identify the variable instead of using a register/offset pair directly:

```
myVar   STATIC BYTE 4
ANDN    myVar,4
```

The following example performs a bit-wise AND operation between the four bytes at the top of the stack to the four bytes immediately below it on the stack.

```
//Stack = F0,F0,F0,F0,12,34,56,78
ANDN    ,4
//Stack = 10,30,50,70,12,34,56,78
```

The following example pushes two blocks of four bytes onto the stack and uses them as operands in a bit-wise AND operation. To further illustrate the use of the instruction a two byte bit-wise AND is then performed with a static variable.

```
sResultSTATIC    WORD = 0xF0F0

    PUSHW   0xFF00    //Stack = FF,00
    PUSHW   0xFF00    //Stack = FF,00,FF,00
    PUSHW   0x1234    //Stack = FF,00,FF,00,12,34
    PUSHW   0x5678    //Stack = FF,00,FF,00,12,34,56,78
    ANDN    ,4        //Stack = 12,00,56,00,12,34,56,78
    // the operation is: F0F0 AND 5678
    ANDN    sResult,2 //sResult = 0x5070
```

The following examples show how the CCR is set:

0xFF00 & 0x00FF = 0x0000; Zero is set
0xF0F0 & 0x00FF = 0x00F0; Zero is cleared

BRANCH

The branch instruction is used to move the code pointer to a location in the application relative to the current location. The branch may be made conditional on the current values of the condition register.

Syntax

```
BRA offset  //Branch always
BEQ offset  //Branch if Equal
BLE offset  //Branch if Less Than or Equal
BLT offset  //Branch if Less Than
BGT offset  //Branch if Greater Than
BGE offset  //Branch if Greater Than or Equal
BNE offset  //Branch if Not Equal
```

Remarks

The offset value refers to a location relative to the current instruction within the application's code space. It can be expressed as a fixed numeric value or as a named label within the application's source code. The latter case relies on the assembler to calculate the appropriate relative offset.

The BRANCH instruction has a range of -128 to 127 bytes inclusive; i.e., the branch can refer to a location 128 bytes prior to the current location of the code pointer or 127 bytes ahead of that location. If the branch destination lies outside of this range then a JUMP instruction should be used. Note that if the destination is within the given range, a branch is preferred because of the reduced code size produced.

The Code Pointer will point to the next instruction to execute and therefore a branch to relative address zero will have no effect, whilst a branch of -2 will branch back to the branch instruction. However, in most applications the value of the relative jump will be calculated automatically by the assembler.

The following table shows the condition code flags which are checked for each of the conditional branch instructions.

Mnemonic	Condition - description
BEQ	Z – CCR Z flag set
BLT	C – CCR C flag set
BLE	C or Z – either CCR C or CCR Z flag set
BGT	!(C or Z) – neither CCR C nor CCR Z flag set
BGE	!C– CCR C flag not set
BNE	!Z – CCR Z flag not set
BRA	always

The conditions based on the state of the carry flag (LT, LE, GT, and GE) are determined using unsigned comparisons. MULTOS does not interrogate the V or N flags and, therefore, does not directly support conditional program flow based on signed comparisons. If required, the application developer could implement such a flow by interrogating the N and V flags in the application source code. These values are made available using the primitive 'Load CCR'. Note that the underlying platform may not set the N or V flags.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example is a fragment of code that uses a conditional branch instructions to implement a loop.

```
loopCounter DYNAMIC BYTE

  // put zero value on stack
  PUSHZ   1
  // store it to counter
  STORE   loopCounter, 1
labelStartofLoop

  // carry out processing
  // increment loop counter
  INCN   loopCounter, 1
  // compare counter to literal maximum loop value
  CMPB   loopCounter, 5
  // if loop counter < 5 go around again
  BLT  labelStartofLoop
```

The next example illustrates the use of BRANCH when handling the instruction byte of an APDU command.

```
pINS   EQU   PT[-12]
    CMPB  pINS, 0xA4
    BEQ   cmdSelectFile
    CMPB  pINS, 0x10
    BEQ   cmdINS10
    CMPB  pINS, 0x20
    BEQ   cmdINS20

errNoINS
    EXITSW 0x6D,0x00
```

CALL

This instruction is used to call a function.

Syntax

```
CALL [function]   //Call always
CEQ  function     //Call if Equal
CLE  function     //Call if Less Than/Equal
CLT  function     //Call if Less Than
CGT  function     //Call if Greater Than
CGE  function     //Call if Greater Than/Equal
CNE  function     //Call if Not Equal
```

Remarks

The following table shows the condition code flags which are checked for each of the conditional call instructions.

Mnemonic	Condition - description
CEQ	Z – CCR Z flag set
CLT	C – CCR C flag set
CLE	C or Z – either CCR C or CCR Z flag set
CGT	!(C or Z) – neither CCR C nor CCR Z flag set
CGE	!C– CCR C flag not set
CNE	!Z – CCR Z flag not set
CALL	always

The conditions based on the state of the carry flag (LT, LE, GT, and GE) are determined using unsigned comparisons. MULTOS does not interrogate the V or N flags and, therefore, does not directly support conditional program flow based on signed comparisons. If required, the application developer could implement such a flow by interrogating the N and V flags in the application source code. These values are made available using the primitive ‘Load CCR’. Note that the underlying platform may not set the N or V flags

The CALL instruction is used to call a function. This would be written in assembler as a label and in MEL as a code address. It is also possible to omit the function to call from the instruction. In this case the code address to call is taken as the top two bytes of the stack, which the instruction will pop from the stack. Furthermore, the top two bytes of the stack must be a valid code address and the call must not be conditional.

Prior to the execution of the called function this instruction pushes four bytes of data on to the stack, the current local base register followed by the current code pointer register. The current code pointer register will point to the next instruction after the call, i.e., the location where execution will resume once the function returns. The value of the Local Base register is set to match the new Dynamic Top.

Provided that the called function has not changed the default value of the previous code pointer address execution continues from the instruction directly after the CALL instruction. Otherwise, execution resumes at the code address given.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example shows a simple function call. A function called fnBiggest accepts two words as input parameters and returns the largest of the two words. After the CALL instruction the value of 0x1000 will be left on the stack.

```
start
    PUSHW  0x0100
    PUSHW  0x1000
    CALL  fnBiggest
    EXIT

//================================================
fnBiggest
//================================================
// Input Param = wValue1, wValue2
// Ouptut Param = wBiggest
//
// WBiggest is the larger of the two input words
//================================================
//lWord1  IN  WORD
//lWord2  IN  WORD
// The negative address relative to this function's
// Lower Base include the 4 bytes of data that the
// call instruction places on the stack
lWord1  EQU  LB[-8]
lWord2  EQU  LB[-6]
    LOAD lWord1,2
    LOAD lWord2,2
    CMPN ,2
    BLT  fnBiggest_leave
    POPW
fnBiggest_leave
    RET 4,2
```

CLEARN

This instruction sets a byte-block to zero.

Syntax

```
CLEARN [label],block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the data of size block_length on the stack will be cleared.

The Condition Code Register is not affected by this instruction.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example clears the first 255 bytes of the public area and the top ten bytes of the stack.

```
pBase  EQU   PB[0000]

    CLEARN  pBase,0xFF
    CLEARN  ,0x0A
```

CMPB

This instruction compares a literal byte with either the byte at the top of the stack or the byte held at the location specified by the label.

Syntax

```
CMPB [label], byte
```

Remarks

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the instruction will compare the literal byte with the byte value at the top of the stack.

The comparison is performed by subtracting the literal byte from the value given. The result is discarded but the condition code register is updated. Note that the byte values are treated as unsigned values.

The result of the comparison is held in the Condition Code Register based on the criteria given in the table below.

Carry	Zero	Description
0	0	Target Byte > Literal Byte
0	1	Target Byte = Literal Byte
1	0	Target Byte < Literal Byte
1	1	Not possible

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C See table above
V Unchanged
N Unchanged
Z See table above

Example

The following example compares the byte held at PT[-12], to the literal value 0x90.

```
CMPB   PT[-12], 0x90
```

The following example is the same as the above example but uses a label to define the byte's location.

```
pINS EQU PT[-12]
    CMPB  pINS, 0x90
```

The following example compares the byte held at the top of the stack to the literal byte 0x90.

```
CMPB   ,0x90
```

The following example compares the class byte of the current APDU and jumps if it does not match what is expected.

```
pCLA  EQU  PT[-13]
    CMPB    pCLA, 0x90
    JNE     errWrongClass
//continue processing
errWrongClass
    //insert error code
    EXITSW  0x6E,0x00
```

CMPN

This instruction compares a byte-block of size n with another of the same size.

Syntax

```
CMPN [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the two blocks of data of size block_length on the stack will be compared.

The result of the comparison is held in the Condition Code Register based on the criteria given in the table below.

Carry	Zero	Description
0	0	Labelled Byte-block > Stack Top Byte-block
0	1	Labelled Byte-block = Stack Top Byte-block
1	0	Labelled Byte-block < Stack Top Byte-block
1	1	Not possible

The byte-block occupying the top of the stack is used as the basis of the comparison. The labelled byte-block is the block of size block_length found at the location given. If no label is given, then labelled byte-block is the data of size block_length below the block occupying the top of the stack.

The operation will work if the two blocks overlap.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C See table above
V Unchanged
N Unchanged
Z See table above

Example

The following example compares the four bytes at the top of the stack to the four bytes at the base of public.

```
CMPN PB[0],4
```

The following example is the same as the previous example, but uses a label to identify the four bytes of public.

```
pPIN EQU PB[0]
CMPN pPIN,4
```

The following examples compare the four bytes at the top of the stack with the four bytes immediately below them on the stack.

```
PUSHW   0x1234
PUSHW   0x5678
PUSHW   0x1234
PUSHW   0x5678
CMPN      , 4
POPN    8            // clean up stack
BEQ       someLabel  // conditional branch will fire
PUSHW   0x1234
PUSHW   0x5678
PUSHW   0x1234
PUSHW   0x6789
CMPN      , 4
POPN     8            // clean up stack
BEQ       someLabel  // conditional branch will not fire
```

The following example compares a block of bytes held at the base of public to a byte-block held in static memory. This could typically be used to perform PIN verification.

```
sPIN STATIC BYTE 04 = 1,2,3,4
pPIN EQU PB[0]
   LOAD    pPIN,4
   CMPN    sPIN,4
   BNE     PinDoesNotMatch
   //Pin Matches
   //Insert code to flag a valid pin
   EXITSW   0x90,0x00
PinDoesNotMatch
   EXITSW   0x64,0x00
```

CMPW

This instruction compares a word value against a word literal.

Syntax

```
CMPW [label], word
```

Remarks

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the word on top of the stack will be compared to the literal word.

The result of the comparison is held in the Condition Code Register based on the criteria given in the table below.

Carry	Zero	Description
0	0	Target Word > Literal Word
0	1	Target Word = Literal Word
1	0	Target Word < Literal Word
1	1	Not possible

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C See table above
V Unchanged
N Unchanged
Z See table above

Example

The following example compares the literal word 0x0000 with the word whose starting address is eleven bytes from the top of the public area, PT[-11].

```
CMPW  PT[-11],0x0000
```

The following example is the same as the previous example except that a label is used to identify the start address,. which corresponds to the P1 and P2 parameter bytes.

```
pP1P2 EQU PT[-11]
CMPW  pP1P2, 0x0000
```

The following example compares the word at the top of the stack with the literal word 0x000.

```
CMPW ,0x0000
```

The following example compares the parameter bytes of the current APDU and jumps if they do not match what is expected.

```
 pP1P2 EQU PT[-11]

   CMPW    pP1P2, 0x01FF
   JNE     errWrongParameters
   // if equal processing continues

errWrongParameters
    //insert error code
    EXIT
```

DECN

This instruction performs a block decrement; i.e., it subtracts one from the value of a byte-block.

Syntax

```
DECN [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the data of size block_length on the stack will be decremented.

The CCR zero flag is updated by this instruction. For example,

DECN (0x000001) = 0x00000000; Zero is set
DECN (0x000011) = 0x00000010; Zero is reset

However, DECN does not modify the carry flag of the condition register. Decrementing a zero value by one results in 0xFFFF...FF. This does not set zero flag.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following example decrements the four byte-block at the base of the static area by one.

```
DECN  SB[0],4
```

The following example is the same as the previous example except that it uses a label to identify the variable to be decremented

```
sVar  STATIC BYTE 4
    DECN sVar,4
```

INCN

This instruction performs a block increment; i.e., it adds one to the value of a byte-block.

Syntax

```
INCN [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the data of size block_length on the stack will be incremented.

The CCR zero flag is updated by this instruction. For example,

INCN (0x000001) = 0x00000000; Zero is set
INCN (0x000011) = 0x00000010; Zero is reset

However, INCN does not modify the carry flag of the condition register.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following example increments the four byte-block at the base of the static area by one.

```
INCN  SB[0],4
```

The following example is the same as the previous example except that it uses a label to identify the variable to be incremented

```
sVar  STATIC BYTE 4
    INCN sVar,4
```

The following example decrements the word stored at the top of the stack by one.

```
INCN  ,2
```

INDEX

This instruction calculates the address of a record within an array of fixed length records.

Syntax

```
INDEX label, record_length
```

Remarks

This instruction also uses the top byte of the stack to indicate which record index is required. As this value is held in a single byte the maximum number of records is 256. Note also that the array index value uses zero based counting; e.g., the first record is at offset 0.

The record_length value is specified using a single byte. Therefore, the maximum length of a record is 255 bytes

The label, which must be present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair.

The result of the index instruction is a two byte value, which indicates the starting address of the record requested. Note, however, there is no requirement for the resulting address be valid. This instruction will calculate a two byte value based solely on the values passed to it.

The Index instruction performs the following calculation:

```
result = address(label) + (record_length * record_indicator)
```

where, address(label) is the segment address of the label or register/offset pair, record_length is a literal byte representing the record length, and record_indicator is the top byte of the stack.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if a carry occurs, cleared otherwise
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following extended example

```
// sByteArray assumed to start at Static Bottom;
// i.e., start address is SB[0]
sByteArray STATIC BYTE = 0xFF, 0xEF, 0xDF, 0xCF

// sWord Array assumed to follw previous array;
// i.e., start address is SB[4]
sWordArray STATIC WORD = 0x1010, 0x0101, 0xA5A5, 0x5A5A

// Get address of 3rd byte of sByteArray
PUSHB   2
INDEX    sByteArray, 1

// calculation would be result = 0 + (1 * 2) = 2.
// Therefore address of third byte is SB[2]

POPN    3 // clean stack of record_index and result

// Get 4th word of sWordArray
PUSHB    3
INDEX    sWordArray, 2

// calculation would be result = 4 + (2 * 3) = 10
// Therefore starting address of third word is SB[10]
```

The following example calculates the address of the twelfth record of an array of records, then copies this onto the stack. Unlike the previous example no assumption regarding the starting address of the array is made.

```
recNumber EQU 16
recLength EQU 32
sArray    STATIC BYTE recNumber*recLength

    PUSHB   11 //the twelfth record
    INDEX   sArray, recLength
    LOADI   ,recLength
```

JUMP

This instruction causes execution to continue from a different location in the application's code space. The jump may be made conditional on the current values of the condition register.

Syntax

```
JMP [label] //Jump always
JEQ  label  //Jump if Equal
JLE  label  //Jump if Less Than/Equal
JLT  label  //Jump if Less Than
JGT  label  //Jump if Greater Than
JGE  label  //Jump if Greater Than/Equal
JNE  label  //Jump if Not Equal
```

Remarks

This instruction differs from BRANCH in that the specified instruction is absolute from the start of the code rather than relative to the current instruction. The resulting machine code for JUMP is also one byte larger than that for BRANCH.

The label can be expressed as a fixed numeric value or as a named label within the application's source code. The latter case relies on the assembler to calculate the appropriate offset.

Similar to CALL, it is possible to omit the label from the instruction. In this case the code address to which to jump is taken to be the top two bytes of the stack, which the instruction will pop from the stack. Furthermore, the top two bytes of the stack must be a valid code address and the jump must not be conditional.

The following table shows the condition code flags which are checked for each of the conditional branch instructions.

Mnemonic	Condition - description
JEQ	Z – CCR Z flag set
JLT	C – CCR C flag set
JLE	C or Z – either CCR C or CCR Z flag set
JGT	!(C or Z) – neither CCR C nor CCR Z flag set
JGE	!C– CCR C flag not set
JNE	!Z – CCR Z flag not set
JRA	always

The conditions based on the state of the carry flag (LT, LE, GT, and GE) are determined using unsigned comparisons. MULTOS does not interrogate the V or N flags and, therefore, does not directly support conditional program flow based on signed comparisons. If required, the application developer could implement such a flow by interrogating the N and V flags in the application source code. These values are made available using the primitive 'Load CCR'. Note that the underlying platform may not set the N or V flags.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

In this example the labels 'SetID' and 'QueryID' are the designations of two functions. To execute a function, the proper APDU command instruction byte must be sent.

```
pINS EQU PT[-12]

    LOAD  pINS,1

    // if pINS = 0x10 then goto SetID
    CMPB  ,0x10
    JEQ  SetID

    // if pINS = 0x20 then goto QueryID
    CMPB  ,0x20
    JEQ  QueryID

    // if neither if statement applies
    // then exit and return 6D00
UnrecognisedInstruction
    EXITSW  0x6D,0x00

SetID
    //SetID command processing
    EXIT

QueryID
    //QueryID command processing
    EXIT
```

LOAD

This instruction pushes a byte-block onto the stack from either the current top of the stack or a location specified by the label.

Syntax

```
LOAD [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes.

If the label is omitted then the byte-block at the top of the stack is pushed; i.e., the top of the stack is duplicated.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example pushes the eight bytes held at the base of public onto the stack.

```
LOAD  PB[0],8
```

The following example is the same as the previous example except that it uses a label to identify the location of the eight bytes at the base of public

```
pKey  EQU PB[0]
LOAD  pKey,8
```

The following example pushes the top four bytes of the stack back onto the stack; that is it duplicates the top four bytes of the stack.

```
LOAD  ,4
```

The following example loads a four byte number from the bottom of the public segment onto the stack, doubles it by adding the value to itself, and leaves the result on the stack.

```
LOAD PB[0000],4
LOAD ,4
ADDN ,4
POPN 4
```

LOADA

This instruction pushes the address of a variable or register/offset onto the stack.

Syntax

```
LOADA   label
```

Remarks

The label may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair.

There is no requirement that the address is a valid address.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example pushes the address of the top byte of static onto the stack.

```
LOADA ST[-1]
```

The following example pushes the address of a variable onto the sack.

```
sMyVar STATIC WORD
LOADA  sMyVar
```

LOADI

This instruction pushes a block of bytes to the stack using indirect addressing.

Syntax

```
LOADI   [label],length
```

Remarks

If the label is given then the two byte address held at the label are used as the address of the byte-block to push onto the stack. If the label is omitted then the two bytes on the top of the stack are used as the address of the byte-block to push onto the stack.

The bytes stored at the label are not loaded. They are interpreted as the address of the byte-block to push onto the stack.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example pushes a variable onto the stack using indirect addressing. The variable sAddrVar is used to hold the address of the variable to push onto the stack. In this case the variable is assumed to be eight bytes long.

```
sAddrVar STATIC WORD
LOADI sAddrVar,8
```

The following example pushes a block of bytes onto the stack using the top two bytes of the stack as an address.

```
LOADI ,2
```

The following example calculates the address of the twelfth record of an array of records and then copies this record onto the stack. The Index instruction is used to calculate the address of the record and leave this on the stack; the LOADI instruction is used to push the record indirectly using the address on the top of the stack.

```
recNumber EQU 16
recLength EQU 32
sArray    STATIC BYTE recNumber*recLength
    PUSHB   11  //the twelfth record
    INDEX   sArray, recLength
    LOADI   ,recLength
```

The following example uses a variable, recAddr, to hold the address of the current record which is then moved to the base of public.

```
recAddr  DYNAMIC BYTE 2
// Put address of sArray on stack
    LOADA   sArray
// Move value to recAddr
    STORE   recAddr, 2
// Copy current record to public
    LOADI   recAddr,recLength
    STORE   PB[0],recLength
```

NOTN

This instruction performs a bit-wise NOT on a byte-block.

Syntax

```
NOTN [label],block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes.

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair that gives the address of the block to be inverted bit-wise. If a label is not specified, then the data of size block_length on the stack will be inverted.

The result is written to the label or the byte-block on the stack.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following example performs a bit-wise NOT operation on the first two bytes of the static area.

```
NOTN SB[0],2
```

The following example is the same as the previous example except that it uses a label to identify the bytes to perform the bit-wise NOT operation on.

```
myVar STATIC WORD
NOTN myVar,2
```

The following example performs a bit-wise NOT on the top eight bytes of the stack.

```
NOTN ,8
```

ORN

This instruction performs a bit-wise OR on a byte-block at the top of the stack with another byte-block specified by a label. If the label is omitted then the top two byte-blocks on the stack are used.

Syntax

```
ORN [label],block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the data of size block_length on the top of the stack and the byte block of size block_length below it on the stack will be the OR operands.

The result of the OR operation is written to the lower byte-block on the stack, or if specified, the byte-block held at the label. The byte-block at the top of the stack is not changed by this instruction.

The result of the operation updates the zero flag in the Condition Code Register. For example,

0x0000 OR 0x0000 = 0x0000; Zero is set
0xF0F0 OR 0xF0FF = 0xF0FF; Zero is reset

The Carry Flag is not affected by this instruction.

The operation will work if the two blocks overlap.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following example performs a bit-wise OR operation on the first two bytes of the static area.

```
ORN SB[0],2
```

The following example is similar to the previous example except that it uses a label to identify the bytes to perform the bit-wise OR operation on.

```
myVar STATIC WORD
ORN myVar,2
```

The following example uses two 8-byte blocks on the stack as operands.

```
ORN ,8
```

The following example the top stack byte and the byte below it on the stack are the OR operands. Note that the result is written to the lower stack byte.

```
PUSHB   0x10     // Stack = 10
PUSHB   0x02     // Stack = 10,02
ORN     , 1      // Stack = 12,02
```

PRIMRET

This instruction is used to call a primitive or return from a function call.

Syntax

```
PRIM primitive [,byte1 [,byte2 [,byte3]]]
RET [ [inBytes] [,outBytes]]
```

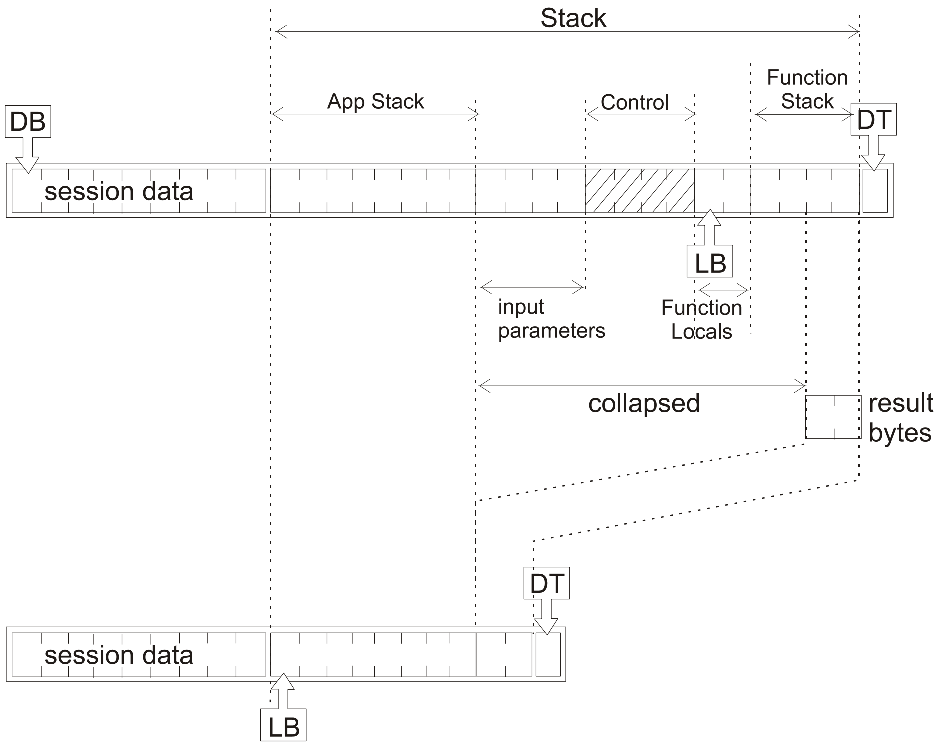
Remarks

This instruction performs two different operations depending upon the syntax used:

- The PRIM mnemonic is used to call a primitive with up to three bytes of arguments.
- The RET mnemonic is used to return from a function. The inBytes and outBytes are used to specify the number of bytes used by input parameters and the number of bytes which are to be returned as result bytes respectively. These are used by MULTOS to clean up the stack following the function's return.

Both the inBytes and outBytes values are specified using a single byte. Therefore, the maximum number of parameter bytes or returned bytes is 255 bytes

After returning from a function the stack will be cleaned up. The upper part of the following diagram shows the state of the stack while a function is executing. The lower portion illustrates the stack after the RET instruction executes.



The size of the input parameters is given in inBytes while the size of the result bytes is given in outBytes. For details on the control bytes see the CALL instruction. Any stack used by the function, shown as Function Stack in the above diagram, is removed along with any local variables declared by the function.

Local variables are shown as Function Locals in the above diagram. The overall effect of this is to remove the input parameters, return the output bytes and restore the LB and CP registers.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Although this instruction does not change any of the condition code flags the primitive called may itself have an effect on the flags.

Example

The following examples illustrate the use of the mnemonic PRIM. See the primitives section of this document for explanations of the primitives used.

```
// Call CheckCase for ISO APDU Command Case3
PUSHB   3
PRIM    0x01

// Call MultiplyN to multiply two 2-byte values
PUSHW    6
PUSHW    1289
PRIM     0x10, 2

// Call Shift Right – shift value placed on stack 2 bits to the
left
BLOCKSIZE        EQU   8
MULTIPLYBYFOUR   EQU   2

   LOAD   PB[0], BLOCKSIZE
   PRIM   0x03, BLOCKSIZE, MULTIPLYBYFOUR
```

The following examples illustrate the uses of the RET mnemonic.

```
// Return from function with no Input or Output
RET
// Return from function with two Input and no Output bytes
RET 2
// Return from function with no Input and three Output bytes
RET , 3
// Return from function with two Input and three Output bytes
RET 2, 3
```

SETB

This instruction copies the literal byte to either the byte at the top of the stack or the byte held at the location specified by the label.

Syntax

```
SETB [label], byte
```

Remarks

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the byte set will be that on top of the stack.

The SETB instruction overwrites the top stack byte, it does not push a value onto the stack. So if there is no byte on the stack, the AAM will abend if the SETB instruction is executed.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example sets the byte at the top of the stack to 10

```
SETB    ,10
```

The following example sets the byte held at pSW2 to 0

```
pSW2    EQU PT[-1]
SETB    pSW2,0
```

SETW

This instruction copies the literal word to either the word at the top of the stack or the word held at the location specified by the label.

Syntax

```
SETW [label], word
```

Remarks

If a label is given then the word stored at the label is set to the literal word. The assembler will translate this into the corresponding register/offset pair during assembly, or alternatively the register/offset pair may be given explicitly.
If the label is omitted then the literal word is copied to the byte at the top of the stack.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example sets the word held at PT[-4] to 16.

```
SETW   PT[-4], 16
```

The following example is the same as the previous example, but as PT[-4] is the location of the La value it uses a label to identify the variable pLa instead of using a register/offset pair directly.

```
pLa    EQU PT[-4]
SETW   pLa, 16
```

The following example sets the word at the top of the stack.

```
SETW   , 0xFFFF
```

STACK

This instruction allows bytes or words to be pushed onto and popped from the stack.

Syntax

```
PUSHZ block_length   // Pushs block of zeros onto the stack
PUSHB byte           // Pushes a byte onto the stack
PUSHW word           // Pushes a word onto the stack
POPN  block_length   // Pops block of bytes from the stack
POPB                 // Pops a byte from the stack
POPW                 // Pops a word from the stack
```

Remarks

The action performed by this instruction depends upon the mnemonic used. There are six operations:

- Push Zero (PUSHZ): A block of zeros is pushed onto the stack. The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes.
- Push Byte (PUSHB): A literal byte is pushed onto the stack
- Push Word (PUSHW): A literal word is pushed onto the stack
- Pop Byte-block (POPN): A block of bytes is popped from the stack. The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes.
- Pop Byte (POPB): A single byte is popped from the stack.
- Pop Word (POPW): A single word, two bytes, is popped from the stack.

If an attempt is made to pop more bytes off the stack than are present on the stack then the MULTOS device will abend. Likewise, if there is insufficient space in dynamic memory to hold any bytes pushed onto the stack then the MULTOS device will also abend.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example uses the different mnemonics to manipulate the stack. The stack is empty at the start.

```
PUSHZ   3           //Stack = 00,00,00
PUSHB   10          //Stack = 00,00,00,0A
PUSHW   0x1234      //Stack = 00,00,00,0A,12,34
POPN    3           //Stack = 00,00,00
POPB                //Stack = 00,00
POPW                //Stack = EMPTY
```

STORE

This instruction moves a block of bytes from the stack to a given location.

Syntax

```
STORE [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes.

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the data of size block_length on the stack will be moved to the byte block below that on the top of the stack..

This instruction will pop the byte-block from the stack; i.e., the operation is a move and not a copy.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example copies the first eight bytes of the public area to the first eight bytes of the static area.

```
LOAD    PB[0], 8
STORE   SB[0], 8
```

The next example illustrates how the instruction functions when the label is not specified.

```
PUSHW   0x0000       // Stack = 00,00
PUSHW   0x1234       // Stack = 00,00,12,34
STORE   , 2          // Stack = 12,34
```

STOREI

This instruction moves a block of bytes from the stack to a given location using indirect addressing.

Syntax

```
STOREI [label], length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes.

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the destination address will be taken to be the two bytes below the block of size block_length on the top of the stack. In other words, the destination address must be placed onto the stack followed by the bytes to move.

This instruction will pop the byte-block from the stack; i.e., the operation is a move and not a copy.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example copies the bytes 0x12 and 0x34 to the base of static, which has an address of 0.

```
LOADA    SB[0]   // Stack = 00,00
PUSHW    0x1234  // Stack = 00,00,12,34
STOREI   , 2     // Stack = 00,00
```

The following example copies the word 0x1234 to the memory location in sValue as calculated using the INDEX instruction.

```
dAddr  DYNAMIC WORD
sValue STATIC WORD = 0xABCD, 0x4567, 0x0000, 0xEF89

   // use INDEX to get address of 3rd word in sValue array
   PUSHB   2
   INDEX   sValue, 2
   // move address to session variable
   STORE   dAddr, 2
   // remove pushed byte
   POPB
   // now push literal word and store at calculated address
   PUSHW    0x1234      // Stack = 12,34
   STOREI   sAddr,2     // Stack = {empty}
```

SUBB

This instruction subtracts the literal byte from either the byte at the top of the stack or the byte held at the location specified by the label.

Syntax

```
SUBB [label], byte
```

Remarks

The result of the operation is written to either the byte at the top of the stack or, if specified, the label.

If a label is specified then the literal byte is subtracted from the byte held at the label. The assembler will translate the label into the corresponding register/offset pair during assembly, or alternatively the register/offset pair may be given explicitly. If the label is omitted then the literal byte is subtracted from the byte at the top of the stack.

The result of the subtraction updates the Condition Code Register. the carry flag is set if the result of the operation would be less than zero, while the zero flag is set if the result of the operation is equal to zero. For example,

0x10 - 0x20 = 0xF0; Carry is set and Zero is reset
0x10 - 0x10 = 0x00; Carry is reset and Zero is set
0x20 - 0x10 = 0x10; Carry and Zero are reset

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if a borrow occurs, cleared otherwise
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following line subtracts 32 from the tenth byte of the Static Area.

```
SUBB  SB[9] ,32
```

The following example is similar to the previous example, but uses a label to identify the variable instead of using a register/offset pair directly.

```
myNum1 STATIC BYTE
SUBB  myNum1, 32
```

SUBN

This instruction subtracts the byte-block at the top of the stack from a byte-block specified by the label. If the label is omitted then the top two byte-blocks on the stack are used.

Syntax

```
SUBN [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then both operands of size block_length will be taken from the stack..

The result of the subtraction is written to the lower byte-block on the stack, or if specified, the byte-block held at the label. The byte-block at the top of the stack is not changed by this instruction.

The subtraction of the byte-blocks is performed as though the entire byte-block represents a single unsigned number and bits may be carried over from the least significant bytes to the most significant bytes.

The result of the addition updates the Condition Code Register. The carry flag is set if the result of the operation would be less than zero, while the zero flag is set if the result of the operation is equal to zero. For example,

0x20000000 - 0x20000000 = 0x00000000; Carry is reset and Zero is set
0x20000000 - 0x40000000 = 0xE0000000; Carry is set and Zero is reset
0x20000000 - 0x100000000 = 0x10000000; Carry and Zero are reset

The operation will work if the two blocks overlap.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if a borrow occurs, cleared otherwise
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following example subtracts the four bytes at the top of the stack from the four bytes at the base of the static area.

```
SUBN SB[0],4
```

The following example is similar to as the previous example, but uses a label to identify the variable instead of using a register/offset pair directly.

```
myVar STATIC BYTE 4
SUBN myVar,4
```

The following example subtracts the four bytes at the top of the stack from the four bytes immediately below them on the stack.

```
//Stack = BB,BB,BB,BB,11,11,11,11
 SUBN ,4
//Stack = AA,AA,AA,AA,11,11,11,11
```

The following example performs a subtraction on the stack and then subtracts the result from a variable held in the static segment.

```
sResult STATIC Word = 0x3000
    PUSHW   0x00FF         //Stack = 21,00
    PUSHW   0x1001         //Stack = 21,00,10,01
    SUBN   , 2             //Stack = 10,FF,10,01
    POPW                   //Stack = 10,FF
    SUBN    sResult,2      //sResult now equals 0x1F01
    POPW                   //Leave stack as found.
```

SUBW

This instruction subtracts the literal word from either the word at the top of the stack or the word held at the location specified by the label.

Syntax

```
SUBW    [label], word
```

Remarks

The result of the operation is written to either the word at the top of the stack or, if specified, the label.

If a label is specified then the literal word is subtracted from the word held at the label. The assembler will translate the label into the corresponding register/offset pair during assembly, or alternatively the register/offset pair may be given explicitly. If the label is omitted then the literal word is subtracted from the word at the top of the stack.

The result of the subtraction updates the Condition Code Register. The carry flag is set if the result of the operation is less than zero and the zero flag is set if the result of the operation is equal to zero. For example,

0x1000 - 0x2000 = 0xF000; Carry is set and Zero is reset
0x1000 - 0x1000 = 0x0000; Carry is reset and Zero is set
0x2000 - 0x1000 = 0x1000; Carry and Zero are reset

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if a borrow occurs, cleared otherwise
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following line subtracts 0x2020 from the word at the bottom of the Static Segment.

```
SUBB    SB[0], 0x2020
```

The following example is similar to the previous example, but uses a label to identify the variable instead of using a register/offset pair directly.

```
myNum1  STATIC WORD
SUBW    myNum1, 0x2020
```

SYSTEM

With the exception of NOP, system instructions perform an operation relating to setting the response that the application will return to the IFD and exiting an application.

Syntax

```
NOP
SETSW      SW1,SW2
SETLA      La
SETSWLA    SW1,SW2,La
EXIT
EXITSW     SW1,SW2
EXITLA     La
EXITSWLA   SW1,SW2,La
```

Remarks

The notation SW1 refers to the most significant byte and SW2 refers to the least significant byte of the status word. The notation La corresponds to the actual length of response data value.

When a MEL application exits the response returned to the terminal consists of two bytes, the Status Word. The default value is '0x9000', which indicates successful execution of an application function.

An application may also return response data back to the IFD. If data is to be sent, then the La, Length of Actual Response, should be set to the number of bytes that are to be returned. The default value is 0x00.

The operation of this instruction depends upon the mnemonic used.

Operation	Description
NOP	No operation
SETSW	Set the status word
SETLA	Set the length of response data returned
SETSWLA	Set the status word and length of response data returned
EXIT	Exit from the application
EXITSW	Set the status word and exit from the application
EXITLA	Set the length of response data returned and exits from the application
EXITSWLA	Set the status word, length of response data and exit from the application.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following extended example shows how an application could handle an APDU command INS. Note the use of EXITSW to exit the application and return the relevant status word.

```
pINS    EQU PT[-12]   // pINS is a label for Public Top - 12

chkCLA90              // Code block chkCLA90
    LOAD   pINS,1// Load the 1 byte instruction to stack
    CMPB   ,0x10 // Compare with the hex value 0x10
    BEQ    cmd10 // If equal jump to code block cmd10
    CMPB   ,0x20 // Compare with the hex value 0x20
    BEQ    cmd20 // If equal branch to code block cmd20

UnrecINS         // Instruction not recognised by the class
    EXITSW   0x6D,0x00 // Set SW1 to 0x6D and Sw2 to 0x00
```

Continuing from the previous example, the code snippet below illustrates a memory copy. Note that instruction EXITLA uses the default status word and set the actual length of response data.

```
cmd10            // Code block cmd10
    // Pop pCLA & pINS bytes off stack (1 WORD)
    POPW
    // assume sData of size 8 exists
    // copy to public using memory copy fixed length
    LOADA   PB[0]
    LOADA   sData
    PRIM      0x0E, 8
    // default 9000 SW used and LA set
    EXITLA   8

cmd20            // Code block cmd20
    POPW              // Pop pCLA & pINS bytes off stack

    // Command processing for Instruction 20

    EXIT              // Exit the application
```

TESTN

This instruction compares a byte-block with zero and sets the zero flag in CCR accordingly.

Syntax

```
TESTN  [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the data of size block_length on the stack will be tested.

The result of the operation updates the Condition Code Register. The zero flag is set if the operation is performed a byte-block with a value of zero. For example,

TESTN 0x000000; Zero is set
TESTN 0x000010; Zero is cleared

The TESTN instruction does not modify the carry flag of the condition register.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the byte-block equals zero, cleared otherwise

Example

The following example tests the four bytes at the top of the stack to determine if they are equal to zero.

```
TESTN SB[0], 4
```

The following example is the same as the previous example, but uses a label to identify the variable instead of using a register/offset pair directly.

```
myVar STATIC BYTE 4
TESTN myVar, 4
```

The following example tests the four bytes at the top of the stack then the top five bytes of the stack to determine if they are all equal to zero.

```
// Stack = FF,00,00,00,00
TESTN , 4    //CCR Z = Set
TESTN , 5    //CCR Z = Cleared
```

XORN

This instruction performs a bit-wise XOR on two bye blocks of the same size.

Syntax

```
XORN    [label], block_length
```

Remarks

The block_length value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The label, if present, may be either a named memory location, which the assembler will translate into a register / offset pair, or an explicit register / offset pair. If a label is not specified, then the both operands of size block_length are taken from the stack.

The result of the XOR operation is written to the lower byte-block on the stack, or if specified, the byte-block held at the label. The byte-block at the top of the stack is not changed by this instruction.

The result of the operation updates the zero flag condition code register. The flag is set if the result of the operation is equal to zero. For example,

0xF0F0 XOR 0xF0F0 = 0x0000; Zero is set
0xF0F0 XOR 0x00FF = 0xF00F; Zero is reset

The operation will work if the two blocks overlap

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Example

The following example performs a bit-wise XOR operation on the four bytes at the top of the stack with the four bytes at the base of the static area.

```
XORN SB[0], 4
```

The following example is similar to the previous example, but uses a label to identify the variable instead of using a register/offset pair directly.

```
myVar STATIC BYTE 4
XORN myVar,4
```

The following example pushes two words onto the stack and performs a bit-wise XOR on them before performing a two byte bit-wise XOR with a static variable. Note the way in which the stack and static variable change during the XORN operations.

```
sResult STATIC WORD = 0x1111
    PUSHW   0xFF00      // Stack = FF,00
    PUSHW   0x1234      // Stack = FF,00,12,34
    XORN    , 2         // Stack = ED,34,12,34
    XORN    sResult,2   // sResult = FC, 25
```

Primitives

MULTOS defines built-in functions, known as primitives, are available for use by any application. The MULTOS specification states whether a primitive is mandatory or optional for implementation and a type approved MULTOS implementation must comply with a stated specification. Each sub-section lists the availability and mandatory / optional status of the primitive. Unavailable primitives are identified thus, ☒, optional are identified thus, ☑ , and available are identified thus, ☑.

Deprecated primitives, marked☑, should no longer be used in new applications because either a) they have been superseded by a higher level primitive or b) are little used; they are earmarked for removal in future releases.

As mentioned in the introduction, for MULTOS step/one products, all primitives available in MULTOS are considered optional and a developer should check the specific implementation.

The conventions and assumptions given in the introductory section apply here. There are also further points of note:

- Primitives are divided into sets: Set Zero, Set One, Set Two and Set Three. The classification is based on the number of arguments included in line with the primitive call. For example, "PRIM 0x01" is part of Set Zero as no arguments are present. However, "PRIM 0x01, 1" is part of Set One as there is a single in line argument.
- All arguments are 1 byte in size and must be compile time constants. Stack based parameters are used for variable values used by the primitives.
- The stack operates on the principle "last in, first out". In the subsections that follow stack usage is illustrated using diagrams such as:

Stack In	OperandA	OperandB
Stack Out	Output	

  The Stack In values are referred to as input parameters and those in Stack Out are referred to as output parameters. The leftmost value is considered to be the first in. In the example above, OperandA is placed on the stack first followed by OperandB. In terms of addressing the rightmost value is below dynamic top (DT) and each value can be located using negative offsets. If the size of the operands is 2 bytes, then OperandA starts at DT[-4] and OperandB at DT[-2].
- The illustrations use relative sizes to show which operand is larger. So, a 1-byte value should be shown as smaller than a 2-byte value. The actual size of the operands is given in the description that follows the illustration.

Add BCDN

This primitive adds two stack resident unsigned byte blocks of the same size, where the blocks hold binary coded decimal (BCD) values. The result is placed on the stack.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
//Stack  holds  Operand1,  Operand2  bytes
PRIM  0x11,  length
```

Arguments

The argument *length* gives the size of the byte blocks to be added.

Stack Usage

Stack In	Operand1	Operand2
Stack Out	Output	

The parameters *Operand1* and *Operand2* are both of size *length* and these are the values that will be added. The parameter *Output* is of size *length* and holds the result of the addition.

Remarks

The value designated by an operand should be in BCD format. If not in BCD format, the processing in MULTOS device will abnormally end the application.

The CCR C flag is set if the result of the operation is greater than that which can be held in *length* bytes. The Z flag is set if the result is zero.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if a carry occurs, cleared otherwise.
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise.

Primitive set and number

Set one, number 0x11

Examples

The following examples are meant to demonstrate how the primitive may be used as well as indicate how the CCR C and Z bit flags are set.

```
// 99  + 1  = 100
PUSHB 0x99        // stack = 0x99
PUSHB 0x01        // stack = 0x99, 0x01
PRIM 0x11, 1      // stack = 0x00 and CCR C and Z are set
       // NOTE: as length = 1, the normal addition
       // result of 100 is truncated to 00

// 99  + 2  = 101
PUSHB 0x99        // stack = 0x99
PUSHB 0x02        // stack = 0x99, 0x02
PRIM 0x11, 1      // stack = 0x01 and CCR C set and Z cleared
       // NOTE: as length = 1, the normal addition
       // result of 101 is truncated to 01

// 101 + 150 = 251
PUSHW 0x0101      // stack = 0x01, 0x01
PUSHW 0x0150// stack = 0x01, 0x01, 0x01, 0x50
PRIM 0x11, 2// stack = 0x02, 0x51 both CCR C and Z are cleared
       // NOTE: as length = 2, the normal addition
       // result of 251 is expressed as 0251

// 0 + 0 = 0
PUSHW 0x0000      // stack = 0x00, 0x00
PUSHW 0x0000// stack = 0x00, 0x00, 0x00, 0x00
PRIM 0x11, 2// stack = 0x00, 0x00 and CCR C cleared, Z set
       // NOTE: as length = 2, the normal addition
       // result of 0 is expressed as 0000
```

AES ECB Decipher

This primitive performs AES ECB Decipher on a sixteen byte block of memory in accordance with [FIPS197].

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM   0xD6
```

Arguments

None.

Stack Usage

Stack In	KeyAddr	KeyLen	OutputAddr	InputAddr
Stack Out	{empty}			

The 2 byte parameter KeyAddr is the starting address of the AES key to be used.
The 1 byte parameter KeyLen is the length in bytes of the AES key at address KeyAddr.
The 2 byte parameter OutputAddr is the starting address of the resultant 16-bytes of plaintext.
The 2 byte parameter InputAddr is the starting address of the 16-bytes of ciphertext.

Remarks

This primitive performs the AES ECB decipher operation on a 16-byte block of memory. The AES key is held in a block of length KeyLen.

Valid key lengths are 16, 24 and 32 bytes.

The output is written at the specified segment address and this may be the same as the address of the input; i.e., the output overwrites the input.

This primitive is only available to an application if “Strong Cryptography” is set on in the application’s access_list when loaded.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged

N	Unchanged
Z	Unchanged

Primitive set and number

Set one, number 0xD6

Example

The following example declares 16 bytes of static memory to hold the 16 byte (128-bit) length AES Key, the ciphertext is held as session data, while the resulting plaintext will be written to public. The address for each of these is loaded onto the stack and the AES Decipher primitive is called.

```
prmAESDecipher  EQU  0xD6
KEYLEN  EQU  16

sKey  STATIC BYTE 16 =
0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08,0x09,0x0A,0x0B,0x0C,0x0D
,0x0E,0x0F,0x10
dCiphertext  DYNAMIC BYTE 16
pPlaintext PUBLIC BYTE 16

    LOADA   sKey
    PUSHB   KEYLEN
    LOADA   pPlaintext
    LOADA   dCiphertext
    PRIM    prmAESDecipher
```

AES ECB Encipher

This primitive performs AES ECB Encipher on a sixteen byte block of memory in accordance with [FIPS197].

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD7
```

Arguments

None.

Stack Usage

Stack In	KeyAddr	KeyLen	OutputAddr	InputAddr
Stack Out	{empty}			

The 2 byte parameter KeyAddr is the starting address of the AES key to be used.
The 1 byte parameter KeyLen is the length in bytes of the AES key at address KeyAddr.
The 2 byte parameter OutputAddr is the starting address of the resultant 16-bytes of ciphertext.
The 2 byte parameter InputAddr is the starting address of the 16-bytes of plaintext.

Remarks

This primitive performs the AES ECB encipher operation on a 16-byte block of memory. The AES key is held in a block of length KeyLen.

Valid key lengths are 16, 24 and 32 bytes.

The output is written at the specified segment address and this may be the same as the address of the input; i.e., the output overwrites the input.

This primitive is only available to an application if “Strong Cryptography” is set on in the application’s access_list when loaded.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged

Z Unchanged

Primitive Set and Number

Set zero, number 0xD7

Example

The following example declares 24 bytes of static memory to hold the 24-byte (192-bit) AES Key, the plaintext is held as session data, while the resulting ciphertext will be written to public. The address for each of these is loaded onto the stack and the AES Encipher primitive is called.

```
prmAESEncipher  EQU  0xD7
KEYLEN          EQU  24

sKey  STATIC BYTE 24 =
0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08,0x09,0x0A,0x0B,0x0C,0x0D
,0x0E,0x0F,0x10, 0x11, 0x12, 0x13, 0x14, 0x15, x016, 0x17, 0x18
dPlaintext  DYNAMIC BYTE 16
pCiphertext PUBLIC BYTE 16

    LOADA   sKey
    PUSHB   KEYLEN
    LOADA   pPlaintext
    LOADA   dCiphertext
    PRIM    prmAESEncipher
```

Bit Manipulate Byte

This primitive performs bit-wise operations on the top byte of the stack.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
//Stack holds ByteIn parameter bytes
PRIM 0x01, Option, MaskByte
```

Arguments

The argument *Option* is a bitmap controlling what logical operation is performed and *MaskByte* is a literal byte holding the mask to use for operation.

Stack Usage

Stack In	ByteIn
Stack Out	ByteOut

The 1-byte parameter *ByteIn* is the byte value that will be manipulated according to the binary operation specified by *Option* using the literal *MaskByte* as the second operand. The
1-byte value *ByteOut* depends on the *Options* argument. It may be the original byte or the result of the logical operation.

Remarks

Depending on the *Option* argument this primitive performs one of four binary logical operations. They are:

- AND: which returns a true bit only if both corresponding bits in the input and mask are true
- OR: which returns a true bit if either of the corresponding bits in the input or mask are true
- XOR: This is a logical Exclusive OR operation, which returns a true bit only if either of the corresponding bits in the input or mask are true, but false if both are true
- EQU: This logical operation is also known as a Exclusive NOR (XNOR), which returns a true bit only if both corresponding bits in the input and mask are of the same value

The following table shows how the *Option* argument is coded. The numbers in the top row correspond to the bit offset, where the most significant bit occupies offset 7.

7	6	5	4	3	2	1	0	Comments
0	-	-	-	-	-	-	-	Do not modify *ByteIn*
1	-	-	-	-	-	-	-	Overwrite *ByteIn* with result of operation
-	0	0	0	0	0	-	-	Any other values are undefined
-	-	-	-	-	-	0	0	Calculate *ByteIn* XOR *MaskByte*
-	-	-	-	-	-	0	1	Calculate *ByteIn* EQU *MaskByte*
-	-	-	-	-	-	1	0	Calculate *ByteIn* OR *MaskByte*
-	-	-	-	-	-	1	1	Calculate *ByteIn* AND *MaskByte*

Regardless of whether the *ByteIn* value is modified, the Condition Code Register reflects the result of the operation.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Primitive Set and Number

Set two, number 0x01

Example

The following table lists acceptable values for the *Option* argument.

Option Value	Interpretation
0x00	*ByteIn* remains unchanged after XOR; i.e. *ByteOut = ByteIn*
0x01	*ByteIn* remains unchanged after EQU; i.e. *ByteOut = ByteIn*
0x02	*ByteIn* remains unchanged after OR; i.e. *ByteOut = ByteIn*
0x03	*ByteIn* remains unchanged after AND; i.e. *ByteOut = ByteIn*
0x80	*ByteOut* holds result of *ByteIn* XOR *MaskByte*
0x81	*ByteOut* holds result of *ByteIn* EQU *MaskByte*
0x82	*ByteOut* holds result of *ByteIn* OR *MaskByte*
0x83	*ByteOut* holds result of *ByteIn* AND *MaskByte*

The following code snippet uses the primitive to ascertain the value of a bit flag held at bit offset six. The primitive number and option value have been defined using the assembler directive EQU, which is similar in function to the C expression #define and should not be confused with the exclusive NOR operation.

```
prmBitManipByte   EQU  0x01
optANDwithResult EQU  0x83

flagValueSet      EQU  0x40 // bit 6 set

dynFlags     DYNAMIC BYTE 1

  LOAD dynFlags, 1
  PRIM prmBitManipByte, optANDwithResult, flagValueSet
  CMPB , flagValueSet
  POPB
  BEQ  label_flag_set
```

The next example tests the value of the flag variable and will set bit 0 if it is equal to an expected value.

```
optEQUnoResult         EQU  0x01
optXORwithResult       EQU  0x80

flagExpectedValue      EQU  0x5A
flagEVCheckOK          EQU  0x01


  LOAD dynFlags, 1
  PRIM prmBitManipByte, optEQUnoResult, flagExpectedValue
  BNE  label_expected_value_check_failed
  // use primitive again to update flag value on stack
  PRIM      prmBitManipByte, optXORwithResult, flagEVCheckOK
  // move new value back to session variable
  STORE     dynFlags, 1
```

Bit Manipulate Word

This primitive performs bit-wise operations on the top word of the stack.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
//Stack holds WordIn parameter bytes
PRIM 0x01, Option, MaskWord
```

Arguments

The argument *Option* is a bitmap controlling what logical operation is performed and *MaskWord* is a literal word holding the mask to use for operation.

Stack Usage

Stack In	WordIn
Stack Out	WordOut

The 2-byte parameter *WordIn* is the value that will be manipulated according to the binary operation specified by *Option* using the literal *MaskWord* as the second operand. The 2-byte value *WordOut* depends on the *Options* argument. It may be the original word or the result of the logical operation.

Remarks

Depending on the *Option* argument this primitive performs one of four binary logical operations. They are:

- AND: which returns a true bit only if both corresponding bits in the input and mask are true
- OR: which returns a true bit if either of the corresponding bits in the input or mask are true
- XOR: This is a logical Exclusive OR operation, which returns a true bit only if either of the corresponding bits in the input or mask are true, but false if both are true
- EQU: This logical operation is also known as a Exclusive NOR (XNOR), which returns a true bit only if both corresponding bits in the input and mask are of the same value

The following table shows how the *Option* argument is coded. The numbers in the top row correspond to the bit offset, where the most significant bit occupies offset 7.

7	6	5	4	3	2	1	0	Comments
0	-	-	-	-	-	-	-	Do not modify *WordIn*
1	-	-	-	-	-	-	-	Overwrite *WordIn* with result of operation
-	0	0	0	0	0	-	-	Any other values are undefined
-	-	-	-	-	-	0	0	Calculate *WordIn* XOR *MaskWord*
-	-	-	-	-	-	0	1	Calculate *WordIn* EQU *MaskWord*
-	-	-	-	-	-	1	0	Calculate *WordIn* OR *MaskWord*
-	-	-	-	-	-	1	1	Calculate *WordIn* AND *MaskWord*

Regardless of whether the *WordIn* value is modified, the Condition Code Register reflects the result of the operation.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if result is zero, cleared otherwise

Primitive Set and Number

Set three, number 0x01

Example

The following table lists acceptable values for the *Option* argument.

Option Value	Interpretation
0x00	*WordIn* remains unchanged after XOR; i.e. *WordOut = WordIn*
0x01	*WordIn* remains unchanged after EQU; i.e. *WordOut = WordIn*
0x02	*WordIn* remains unchanged after OR; i.e. *WordOut = WordIn*
0x03	*WordIn* remains unchanged after AND; i.e. *WordOut = WordIn*
0x80	*WordOut* holds result of *WordIn* XOR *MaskWord*
0x81	*WordOut* holds result of *WordIn* EQU *MaskWord*
0x82	*WordOut* holds result of *WordIn* OR *MaskWord*
0x83	*WordOut* holds result of *WordIn* AND *MaskWord*

The following code snippet uses the primitive to set the four least significant bytes of the word on top of the stack. The primitive number and option value have been defined using the assembler directive EQU, which is similar in function to the C expression #define and should not be confused with the exclusive NOR operation.

```
prmBitManipByte   EQU  0x01
optORwithResult   EQU  0x82

dynFlags     DYNAMIC WORD

  LOAD dynFlags, 2
  PRIM prmBitManipByte, optORwithResult, 0x000F
```

Block Decipher

This primitive performs a Block Decipher on a block of memory. The algorithms that may be used are DES, Triple DES, SEED and AES in ECB and CBC modes of operation.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xDA, AlgorithmID, ChainingMode
```

Arguments

The 1-byte argument AlgorithmID indicates the type of decipher algorithm to be used.

AlgorithmID	Algorithm	4.2	4.3	4.4
0x03	DES [FIPS46-3]	Optional	Mandatory	Mandatory
0x04	Triple DES [FIPS46-3]	Optional	Mandatory	Mandatory
0x05	SEED [KISA]	Optional	Optional*	Mandatory
0x06	AES [FIPS197]	Optional	Optional*	Mandatory

*mandatory if the algorithm is supported by an implementation

The 1-byte argument Chaining Mode indicates the block cipher mode of operation to be used.

ChainingMode	
0x01	ECB
0x02	CBC
0x03	CTR
0x04	CFB

Stack Usage

ECB mode

Stack In	InputLen	KeyAddr	KeyLen	OutputAddr	InputAddr
Stack Out	{empty}				

- The 2-byte parameter InputLen specifies the number of bytes to decipher.
- The 2-byte parameter KeyAddr is the address of the key(s) to be used. The size and format of the key(s) at this address depends upon the specified algorithm, as follows.

- DES: one 8-byte DES key.
- Two key triple DES: two 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8.
- Three key triple DES: three 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8 and the third key is located at address KeyAddr+16.

- SEED: one 16-byte key.
- AES : one 16, 24 or 32 byte AES key.

- The 1-byte parameter KeyLen is the length of the key(s) to be used.
- The 2-byte parameter OutputAddr is the start address of the resultant plaintext.
- The 2-byte parameter InputAddr is the start address of the ciphertext to be deciphered.

CBC mode

CBC mode requires the addition of an Initialisation Vector of length equal to the block size for the selected algorithm. The stack for this mode is:

Stack In	IVLen	IVAddr	InputLen	KeyAddr	KeyLen	OutputAddr	InputAddr
Stack Out	{empty}						

- The 1-byte parameter IVLen specifies the size of the Initialisation Vector.
- The 2-byte parameter IVAddr is the address of the Initialisation Vector. The size of the Initialisation Vector depends upon the specified algorithm, as follows.
  - DES: 8 bytes.
  - Two key triple DES: 8 bytes.
  - Three key triple DES: 8 bytes.
  - SEED: 16 bytes.
  - AES: 16 bytes.

- The 2-byte parameter InputLen specifies the number of bytes to decipher.
- The 2-byte parameter KeyAddr is the address of the key(s) to be used. The size and format of the key at this address depends upon the specified algorithm, as follows.
  - DES: one 8-byte DES key.
  - Two key triple DES: two 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8.
  - Three key triple DES: three 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8 and the third key is located at address KeyAddr+16.
  - SEED: one 16-byte key.
  - AES : one 16, 24 or 32 byte AES key.

- The 1 byte parameter KeyLen is the length in bytes of the key at address KeyAddr.
- The 2-byte parameter OutputAddr is the starting address of the resultant plaintext.
- The 2-byte parameter InputAddr is the start address of the ciphertext to be deciphered.

CTR chaining mode

Stack In	IVLen	IVAddr	InputLen	KeyAddr	KeyLen	Output Addr	InputA ddr	Counter Width
Stack Out	{empty}							

CTR mode is specified in ISO/IEC-10116.
- The 1-byte parameter IVLen specifies the size of the Initialisation Vector.
- The 2-byte parameter IVAddr is the address of the Initialisation Vector. The size of the Initialisation Vector depends upon the specified algorithm, as follows.
  - DES: 8 bytes.

- Two key triple DES: 8 bytes.
- Three key triple DES: 8 bytes.
- SEED: 16 bytes.
- AES: 16 bytes.

- The 2-byte parameter InputLen specifies the number of bytes to decipher.
- The 2-byte parameter KeyAddr is the address of the key(s) to be used. The size and format of the key at this address depends upon the specified algorithm, as follows.
    - DES: one 8-byte DES key.
    - Two key triple DES: two 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8.
    - Three key triple DES: three 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8 and the third key is located at address KeyAddr+16.
    - SEED: one 16-byte key.
    - AES: one 16, 24 or 32 byte AES key.

- The 1 byte parameter KeyLen is the length in bytes of the key at address KeyAddr.
- The 2-byte parameter OutputAddr is the starting address of the resultant plaintext.
- The 2-byte parameter InputAddr is the start address of the ciphertext to be deciphered.
- The 1-byte parameter CounterWidth refers to the width of the counter to be used. This can be upto the IVLen.

Examples of different counter widths:
AES CTR mode, CounterWidth = 4, IVLen = 16.
IV = FFEEDDCCBBAA99887766554433221100

Round 1 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	33	22	11	00
Round 2 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	33	22	11	01
Round 3 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	33	22	11	02

AES CTR mode, CounterWidth = 4, IVLen = 16.
IV = FFEEDDCCBBAA998877665544FFFFFF

Round 1 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	FF	FF	FF	FF
Round 2 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	00	00	00	00
Round 3 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	00	00	00	01

AES CTR mode, CounterWidth = 16, IVLen = 16.
IV = FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF

Round 1 IV	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
Round 2 IV	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
Round 3 IV	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	01

CFB mode

CFB mode requires the addition of an Initialisation Vector of length equal to the block size for the selected algorithm. The stack for this mode is:

Stack In	IVLen	IVAddr	InputLen	KeyAddr	KeyLen	Output Addr	Input Addr	FeedbackSize
Stack Out	{empty}							

- The 1-byte parameter IVLen specifies the size of the Initialisation Vector.
- The 2-byte parameter IVAddr is the address of the Initialisation Vector. The size of the Initialisation Vector depends upon the block length of the specified algorithm, as follows.

- DES: 8 bytes.
- Two key triple DES: 8 bytes.
- Three key triple DES: 8 bytes.
- SEED: 16 bytes.
- AES: 16 bytes.

- The 2-byte parameter InputLen specifies the number of bytes to decipher.
- The 2-byte parameter KeyAddr is the address of the key(s) to be used. The size and format of the key at this address depends upon the specified algorithm, as follows.

- DES: one 8-byte DES key.
- Two key triple DES: two 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8.
- Three key triple DES: three 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8 and the third key is located at address KeyAddr+16.
- SEED: one 16-byte key.
- AES: one 16, 24 or 32 byte AES key.

- The 1 byte parameter KeyLen is the length in bytes of the key at address KeyAddr.
- The 2-byte parameter OutputAddr is the starting address of the resultant plaintext.
- The 2-byte parameter InputAddr is the start address of the ciphertext to be deciphered.
- The 1-byte parameter FeedbackSize refers to the number of bits to be used as feedback. This can be upto the block length of the algorithm.

Remarks

This primitive performs the block decipher operation on a block of memory of InputLen bytes. The algorithm used may be DES, Two Key Triple DES, Three Key Triple DES, SEED and 128/192/256-bit Key AES. The key is held in a block of the appropriate length for the algorithm.

In ECB and CBC chaining mode, DES algorithms require that the ciphertext length is a multiple of 8 bytes and the SEED and AES-128/192/256 algorithms require that the ciphertext is a multiple of 16 bytes. If the ciphertext length does not meet these restrictions then the primitive will abend. Padding is not removed during the block decipher operation.

In CTR and CFB mode there is no restriction that the plaintext be a multiple of the algorithms block length.

The output is written at the specified segment address and this may be the same as the address of the input; i.e., the output overwrites the input. However, the output plaintext cannot partially overlap the input ciphertext. If the primitive is called with partially overlapping input and output memory areas then it abends. If an Initialisation Vector is used then this can be at any segment address, including in the input ciphertext or output plaintext memory areas.

Refer to the relevant MULTOS Implementation Report for the platform you are developing on as not all combinations of algorithm and chaining modes may be supported by the platform.

CTR mode may not be available for all algorithms and the implementation may restrict the maximum CounterSize supported. Refer to the MULTOS Implementation Report for the platform.

This primitive is only available to an application if “Strong Cryptography” are set on in the application’s access_list when loaded.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged.

Primitive Set and Number

Set two, number 0xDA

Block Encipher

This primitive performs a Block Encipher on a block of memory. The algorithms that may be used are DES, Triple DES, SEED and AES in ECB and CBC modes of operation.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xDB, AlgorithmID, ChainingMode
```

Arguments

The 1-byte argument AlgorithmID indicates the type of encipher algorithm to be used.

AlgorithmID	Algorithm	4.2	4.3	4.4 / 4.5
0x03	DES [FIPS46-3]	Optional	Mandatory	Mandatory
0x04	Triple DES [FIPS46-3]	Optional	Mandatory	Mandatory
0x05	SEED [KISA]	Optional	Optional*	Optional*
0x06	AES [FIPS197]	Optional	Optional*	Optional*

*mandatory if the algorithm is supported by an implementation

The 1-byte argument Chaining Mode indicates the block cipher mode of operation to be used (**NOTE:** please refer to the Implementation Report for the device you are using to find out which modes are supported).

ChainingMode	
0x01	ECB
0x02	CBC
0x03	CTR
0x04	CFB

Stack Usage

ECB mode

Stack In	InputLen	KeyAddr	KeyLen	OutputAddr	InputAddr
Stack Out	{empty}				

- The 2-byte parameter InputLen specifies the number of bytes to encipher.
- The 2-byte parameter KeyAddr is the address of the key(s) to be used. The size and format of the key(s) at this address depends upon the specified algorithm, as follows.

- DES: one 8-byte DES key.
- Two key triple DES: two 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8.

- Three key triple DES: three 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8 and the third key is located at address KeyAddr+16.
- SEED: one 16-byte key.
- AES: one 16, 24 or 32 byte AES key.

- The 1-byte parameter KeyLen is the length of the key(s) to be used.
- The 2-byte parameter OutputAddr is the start address of the resultant ciphertext.
- The 2-byte parameter InputAddr is the start address of the plaintext to be enciphered.

CBC chaining mode

Stack In	IVLen	IVAddr	InputLen	KeyAddr	KeyLen	OutputAddr	InputAddr
Stack Out	{empty}						

- The 1-byte parameter IVLen specifies the size of the Initialisation Vector.
- The 2-byte parameter IVAddr is the address of the Initialisation Vector. The size of the Initialisation Vector depends upon the specified algorithm, as follows.
  - DES: 8 bytes.
  - Two key triple DES: 8 bytes.
  - Three key triple DES: 8 bytes.
  - SEED: 16 bytes.
  - AES: 16 bytes.

- The 2-byte parameter InputLen specifies the number of bytes to encipher.
- The 2-byte parameter KeyAddr is the address of the key(s) to be used. The size and format of the key at this address depends upon the specified algorithm, as follows.
  - DES: one 8-byte DES key.
  - Two key triple DES: two 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8.
  - Three key triple DES: three 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8 and the third key is located at address KeyAddr+16.
  - SEED: one 16-byte key.
  - AES : one 16, 24 or 32 byte AES key.

- The 1 byte parameter KeyLen is the length in bytes of the key at address KeyAddr.
- The 2-byte parameter OutputAddr is the starting address of the resultant ciphertext.
- The 2-byte parameter InputAddr is the start address of the plaintext to be enciphered.

CTR chaining mode

Stack In	IVLen	IVAddr	InputLen	KeyAddr	KeyLen	Output Addr	Input Addr	Counter Width
Stack Out	{empty}							

CTR mode is specified in ISO/IEC-10116.
- The 1-byte parameter IVLen specifies the size of the Initialisation Vector.
- The 2-byte parameter IVAddr is the address of the Initialisation Vector. The size of the Initialisation Vector depends upon the specified algorithm, as follows.
  - DES: 8 bytes.

- Two key triple DES: 8 bytes.
- Three key triple DES: 8 bytes.
- SEED: 16 bytes.
- AES: 16 bytes.

- The 2-byte parameter InputLen specifies the number of bytes to encipher.
- The 2-byte parameter KeyAddr is the address of the key(s) to be used. The size and format of the key at this address depends upon the specified algorithm, as follows.

- DES: one 8-byte DES key.
- Two key triple DES: two 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8.
- Three key triple DES: three 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8 and the third key is located at address KeyAddr+16.
- SEED: one 16-byte key.
- AES: one 16, 24 or 32 byte AES key.

- The 1 byte parameter KeyLen is the length in bytes of the key at address KeyAddr.
- The 2-byte parameter OutputAddr is the starting address of the resultant ciphertext.
- The 2-byte parameter InputAddr is the start address of the plaintext to be enciphered.
- The 1-byte parameter CounterWidth refers to the width of the counter to be used. This can be upto the IVLen.

Examples of different counter widths:
AES CTR mode, CounterWidth = 4, IVLen = 16.
IV = FFEEDDCCBBAA99887766554433221100

Round 1 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	33	22	11	00
Round 2 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	33	22	11	01
Round 3 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	33	22	11	02

AES CTR mode, CounterWidth = 4, IVLen = 16.
IV = FFEEDDCCBBAA998877665544FFFFFF

Round 1 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	FF	FF	FF	FF
Round 2 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	00	00	00	00
Round 3 IV	FF	EE	DD	CC	BB	AA	99	88	77	66	55	44	00	00	00	01

AES CTR mode, CounterWidth = 16, IVLen = 16.
IV = FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF

Round 1 IV	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
Round 2 IV	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
Round 3 IV	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	01

CFB chaining mode

Stack In	IVLen	IVAddr	InputLen	KeyAddr	KeyLen	Output Addr	Input Addr	FeedbackSize
Stack Out	{empty}							

- The 1-byte parameter IVLen specifies the size of the Initialisation Vector.

- The 2-byte parameter IVAddr is the address of the Initialisation Vector. The size of the Initialisation Vector depends upon the block length of the specified algorithm, as follows.
    - DES: 8 bytes.
    - Two key triple DES: 8 bytes.
    - Three key triple DES: 8 bytes.
    - SEED: 16 bytes.
    - AES: 16 bytes.

- The 2-byte parameter InputLen specifies the number of bytes to encipher.
- The 2-byte parameter KeyAddr is the address of the key(s) to be used. The size and format of the key at this address depends upon the specified algorithm, as follows.
    - DES: one 8-byte DES key.
    - Two key triple DES: two 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8.
    - Three key triple DES: three 8-byte DES keys. The first key is located at address KeyAddr and the second key is located at address KeyAddr+8 and the third key is located at address KeyAddr+16.
    - SEED: one 16-byte key.
    - AES: one 16, 24 or 32 byte AES key.

- The 1 byte parameter KeyLen is the length in bytes of the key at address KeyAddr.
- The 2-byte parameter OutputAddr is the starting address of the resultant ciphertext.
- The 2-byte parameter InputAddr is the start address of the plaintext to be enciphered.
- The 1-byte parameter FeedbackSize refers to the number of bits to be used as feedback. This can be upto the block length of the algorithm.

Remarks

This primitive performs the block encipher operation on a block of memory of InputLen bytes. The algorithm used may be DES, Two Key Triple DES, Three Key Triple DES, SEED and 128/192/256-bit Key AES. The key is held in a block of the appropriate length for the algorithm.

In ECB and CBC chaining mode, DES algorithms require that the plaintext length is a multiple of 8 bytes and the SEED and AES-128/192/256 algorithms require that the plaintext is a multiple of 16 bytes. If the plaintext length does not meet these restrictions then the primitive will abend.

In CTR and CFB mode there is no restriction that the plaintext be a multiple of the algorithms block length.

The output is written at the specified segment address and this may be the same as the address of the input; i.e., the output overwrites the input. If an implementation has any restrictions around this then it will be documented in the [MIR]. If an Initialisation Vector is used then this can be at any segment address, including in the input plaintext or output ciphertext memory areas.

Refer to the relevant MULTOS Implementation Report for the platform you are developing on as not all combinations of algorithm and chaining modes may be supported by the platform.

CTR mode may not be available for all algorithms and the implementation may restrict the maximum CounterSize supported. Refer to the MULTOS Implementation Report for the platform.

This primitive is only available to an application if "Strong Cryptography" are set on in the application's access_list when loaded.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged.

Primitive Set and Number

Set two, number 0xDB

Call Codelet

This primitive is used to access a code held in a codelet.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x83
```

Arguments

None.

Stack Usage

Stack In	CodeletID	codeAddr
Stack Out	LinkageData	

The 2-byte *CodeletID* identifies which codelet to execute, while the 2-byte *codeAddr* is the start address within the codelet's code area at which to start execution. The 6-byte *LinkageData* field is automatically handled by the operating system. These values are present so that when the codelet uses the primitive 'Return from Codelet' MULTOS can continue the normal execution of the application.

Remarks

This primitive is used to call a codelet that is stored on the MULTOS device. When the codelet is called it is considered to be part of the executing application's memory space. Therefore, the codelet is able to read from and write to any data area of the application's memory.

The 2-byte codelet ID is a unique MULTOS KMA registered value, which identifies a particular codelet. If a codelet with ID of 0 is called, the AAM will execute the currently selected application from the code segment offset specified by the second parameter placed on the stack. Use of this primitive with a codelet ID which is not stored on the device will result in the abnormal end of application execution.

The value *CodeAddr* is the code address of the entry point within the Codelet where execution will begin. Valid Codelet Entry Addresses for the codelet must be obtained from the provider of the codelet.

This primitive is used in conjunction with the 'Return from Codelet' primitive. That primitive will return control to the application code.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

set zero, number 0x83

Example

The following example checks that a particular codelet exists and if so proceeds to call the codelet. Note that the codelet ID used below is fictitious.

```
prmCallCodelet          EQU  0x83
prmQueryCodelet         EQU  0x84
CODELETID               EQU  0xF1F2

      PUSHW CODELETID
      PRIM  prmQueryCodelet
      // CCR Z flag cleared if does not exist
      BEQ   warning_CodeletUnsupported
      // otherwise call the codelet from start
      // codelet ID remained on stack
      PUSHZ 2
      PRIM  prmCallCodelet
```

Call Extension 0,1,2,3,4,5,6

These primitives call an proprietary extension primitive.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x80, PrimType_LSB, PrimType_MSB, ParamByte
PRIM 0x81, PrimType_LSB, PrimType_MSB, ParamByte
PRIM 0x82, PrimType_LSB, PrimType_MSB, ParamByte
PRIM 0x83, PrimType_LSB, PrimType_MSB, ParamByte
PRIM 0x84, PrimType_LSB, PrimType_MSB, ParamByte
PRIM 0x85, PrimType_LSB, PrimType_MSB, ParamByte
PRIM 0x86, PrimType_LSB, PrimType_MSB, ParamByte
```

Arguments

The 1-byte arguments *PrimType_MSB* and *PrimType_LSB* represent the most significant byte and least significant byte of the primitive type. The 1-byte argument *ParamByte* is an optional parameter that may be passed to the primitive.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

Remarks

These primitives are intended to permit up to six implementors to introduce proprietary extension primitives; i.e., primitives that are not described in this document. As these are proprietary the exact usage of these primitives are dependent upon the implementation.

MAOSCO will assign each MULTOS implementor one of the Call Extension Primitive Numbers, from zero to six, and each is able to add up to 65535 new primitives to their MULTOS implementations.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Three, Numbers 0x80,0x81,0x82,0x83,0x84,0x85,0x86

Card Block

This primitive blocks the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x05, MSB_StartAddress_MAC, LSB_StartAddress_MAC
```

Arguments

The 1-byte arguments MSB_StartAddress_MAC and LSB_StartAddress_MAC represent the most significant and least significant byte of the offset in Public memory where the MAC value is held.

In MULTOS 4.3 and above, the 2 arguments are ignored and may contain any value.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

Remarks

For MULTOS 4.2 and below:
In order for an application to use this primitive to block a MULTOS device a Card Block MAC (CBMAC) must be supplied to the application to authenticate the card block operation.

For MULTOS 4.3 and above:
This primitive is successful if the “card_block” bit in the application’s access_list is set.

If successful the zero flag is set, and the device is blocked. A blocked device will not allow any applications to be selected either implicitly, as is the case with default and shell mode, or explicitly through the Select File command. However, during the session in which a device is blocked the application that called the primitive is still operational and may continue to process commands. Once the application session ends it and all applications can not be selected. Once a device is blocked MULTOS will return a response status of "6A81, Function Not Supported" if an attempt is made to select an application, unless that application has the “card_unblock” bit set in the application’s access_list.

If unsuccessful the zero flag is reset, and the device's blocked status is not changed. The application may continue processing as normal and the MULTOS device will continue to process as before.

The Card Block primitive is closely associated with the EMV command Card Block. Please note that the EMV MAC supplied is intended to permit an application to verify the authenticity of the APDU command data. On the other hand the CBMAC allows the MULTOS 4.2 and below device to authenticate that the request to block the device.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the device is successfully blocked, and cleared otherwise.

Primitive Set and Number

set two, number 0x05

Examples

The following example illustrates the use of this primitive when the CBMAC value is held at the base of public memory. The incoming data is structured as given in the example.

```
prmCardBlock     EQU  0x05

// assumes public data starts here
pCBMAC  PUBLIC BYTE 8
pEMVMAC PUBLIC BYTE 8

   // assumes a CheckEMVMAC function with 8-byte MAC as parameter
   LOAD pEMVMAC, 8
   CALL CheckEMVMAC
   // assumes function cleans stack and sets CCR.Z
   BNE  label_failed_EMVMAC_check
   // otherwise, do card block with CBMAC at PB[0] = PB[0000]
   PRIM prmCardBlock, 0, 0
   // check result
   BEQ  label_card_blocked
```

This second example assumes that the CBMAC is placed at different offsets within public and that the first two bytes of incoming command data correspond to the most significant and least significant bytes respectively. No EMV MAC handling is shown.

```
// assumes public starts here
pMSB          PUBLIC BYTE 1
pLSB          PUBLIC BYTE 1
pVariableData     PUBLIC BYTE 32

   // just do card block
   PRIM prmCardBlock, pMSB, pLSB
```

Card UnBlock

This primitive unblocks the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☑	☑	☑	☑

Syntax

```
PRIM 0x13
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

Remarks

This primitive is successful if the device is currently blocked and the “card_unblock” bit in the application’s access_list is set.

If successful the zero flag is set, and the device is unblocked.
If unsuccessful the zero flag is reset, and the device's blocked status is not changed.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the device is successfully unblocked, and cleared otherwise.

Primitive Set and Number

set zero, number 0x13

Examples

The following example illustrates the use of this primitive to unblock a device.

```
prmCardBlock      EQU  0x13

  PRIM prmCardUnBlock
  // check result
  BEQ  label_card_unblocked
```

Check BCD

This primitive returns whether the number provided is in binary decimal format.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1	MULTOS 4.5.x
✗	✗	✗	✗	✗	✓

Syntax

```
PRIM   0xDA
```

Arguments

None.

Stack Usage

Stack In	Length	Address
Stack Out	Result	

The Length parameter is one byte and the Address parameter is two bytes in size.
The Length is the length of the block and Address is the segment address of the block containing the number to be tested. Result is one byte and holds the result of the operation as follows:

- 0 = Not a BCD number
- 1 = BCD number

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set zero, number 0xDA

Check Case

This primitive performs three vital functions in that it:

- instructs the operating system how to interpret incoming command APDU
- validates the incoming command as far as is possible under the transport protocol
- permits MULTOS to handle low level communication between the device and the terminal

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
//Stack holds ISOCase parameter byte
PRIM 0x01
```

Stack Usage

Stack In	ISOCase
Stack Out	{empty}

The 1-byte parameter ISOCase indicates which ISO Command Case is expected.

Arguments

None.

Remarks

ISO/IEC 7816 – 4 describes the four possible command cases. In brief, they are:

Case	Command Data Sent	Response Data Expected
1	No	No
2	No	Yes
3	Yes	No
4	Yes	Yes

Once an incoming command has been identified by the application as being one that it can process, Check Case should be called using the expected ISO command case as the stack based parameter. If the data in public is consistent with the expected command case, the CCR Z flag will be set and cleared otherwise. If the *ISOCase* parameter is not a valid command case indicator the primitive will consider this to be an inconsistency and clear the CCR Z flag.

The operating system's handling of a Case 1 command is such that only a status word is returned. There are, however, some interface devices that expect an acknowledgement byte to be transmitted prior to the status word. In order to cater for these devices both MULTOS 4 and MULTOS 4.2 support an *ISOCase* parameter value of 5. The handling of this case value is exactly the same as that for Case 1 with the exception that an acknowledgement byte is transmitted.

The amount of APDU command checking that can be performed by the primitive is based on the transport protocol in use. In most cases an application does not need to be aware of the low level transport handling that occurs as MULTOS ensures that it is takes place. In those cases where more information is required, please see [MDG].

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the specified case is consistent with the data in Public, cleared if it is not

Primitive Set and Number

Set zero, number 0x01

Example

The following example checks that the ISO Case of the current APDU is ISO Case 2 and jumps to an error handler if the wrong case is detected.

```
prmCheckCase EQU 0x01

PUSHB  0x02
PRIM   prmCheckCase
JNE    errWrongCase
//continue processing ISO Case 2
```

Checksum

This primitive generates a four byte checksum over a block of memory of variable size.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
//Stack holds Length, BlockAddr parameter
PRIM 0x82
```

Arguments

None.

Stack Usage

Stack In	Length	BlockAddr
Stack Out	CheckSum	

The 2-byte parameter *Length* is the size in bytes of the area over which to calculate a checksum value. The *BlockAddr* parameter is 2 bytes in size and indicates the start address of the input block. Both of these are overwritten by 4-byte result of the checksum algorithm given as *CheckSum* above.

Remarks

The following C code illustrates an implementation of the checksum algorithm:

```
unsigned byte message[Length]
unsigned byte checksum[4];

checksum[0] = 0x5A;
checksum[1] = 0xA5;
checksum[2] = 0x5A;
checksum[3] = 0xA5;
for ( j = 0; j < Length; ++ j )
{
  // add data byte into most significant byte of checksum
  checksum[0] += message[j];
  // add each byte of checksum into the next byte
  checksum[1] += checksum[0];
  checksum[2] += checksum[1];
  checksum[3] += checksum[2];
}
```

The result of each byte addition is held in single byte, where any result greater than 255 is truncated in such a way that the least significant byte of the result is maintained. That is to say the carries are dropped from each addition. For example, 0xFF + 0x02 = 0x01.

If the block is in Static and transaction protection is on, the checksum calculation takes pending writes into account. This is an exception to the general rule that pending writes are not visible to the application until they are committed.

It is valid to calculate the checksum of a block of length zero; the result is 0x5AA55AA5.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0x82

Example

The first example code fragment calculates the checksum of the word 0x9988:

```
CheckSumMe DYNAMIC BYTE 2 = 0x99, 0x88

PUSHW 0x0002      // length of block to check sum
LOADA CheckSumMe  // 2 byte address of block to check sum
                  // stack now has 4 bytes
PRIM 0x82         // invoke CheckSum primitive
             // result on stack = 0x7B, 0x13, 0x05, 0x9C
             // overwrites 4 byte input
```

The result, where all the operands and results are hexadecimal values, is calculated as follows:

	Checksum[0]	Checksum[1]	Checksum[2]	Checksum[3]
Initial value	5A	A5	5A	A5
1st Byte (0x99)	5A + 99 = F3	A5 + F3 = 98	5A + 98 = F2	A5 + F2 = 97
2nd Byte (0x88)	F3 + 88 = 7B	98 + 7B = 13	F2 + 13 = 05	97 + 05 = 9C

The following example performs a check sum over a block of the static area. This may be used to verify that data has been loaded into the variables correctly. It is assumed that the correct value for the checksum is held in the bottom four bytes of public

```
prmCheckSum EQU  0x82
```

```
sName    STATIC BYTE 10

    PUSHW    10
    LOADA    sName
    PRIM     prmCheckSum
    CMPN     PB[0000],4
    JNE      InvalidCheckSum
```

Configure READ BINARY

This primitive configures/deactivates the accelerated MULTOS READ BINARY command to directly access a specified application Static memory space with optional secure messaging.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
✗	✓	✓	✓	✓	✓

Syntax

```
PRIM  0xDC, Options
```

Arguments

The 1 byte argument *Options* is used to configure or deactivate the accelerated READ BINARY command as follows.

b7-b4	b3-b0	Meaning
0	0	Deactivate the accelerated READ BINARY command
0	1-F	RFU
1	0	Activate accelerated ICAO READ BINARY command with no BAC
1	1	Activate accelerated ICAO READ BINARY command with optional BAC
1	2	Activate accelerated ICAO READ BINARY command with mandatory BAC
1	3	Activate accelerated ICAO READ BINARY command with optional BAC lite (no MAC)
1	4	Activate accelerated ICAO READ BINARY command with mandatory BAC lite (no MAC)
1	5-F	Reserved for future ICAO Read Binary secure messaging modes (e.g. BAC Lite)
2-F	x	RFU

Stack Usage (Options = 0x00)

If *Options* = 0x00 then the stack will contain the following:

Stack In	{empty}
Stack Out	{empty}

Stack Usage (Options = 0x10)

If *Options* = 0x10 then the stack will contain the following:

Stack In	*Channel*	*DataAddr*
Stack Out	{empty}	

The 1-byte *Channel* value identifies the channel containing the data to be directly accessed by the accelerated READ BINARY command. A value of 0 specifies the applications Static memory; all other values are RFU.

The 2-byte *DataAddr* value identifies the segment address of the parameter block for the specified channel. For channel 0 the parameter block contains the following parameters, from low address to high address:

- 4-byte offset from the start of Static of the data that is to be directly accessed by the accelerated READ BINARY command.
- 4-byte length of the Static data that is to be directly accessed by the accelerated READ BINARY command.

Stack Usage (Options = 0x11 or 0x12)

If *Options* = 0x11 or 0x12 then the stack will contain the following:

Stack In	*SSCAddr*	*KeyMacAddr*	*KeyEncAddr*	*Channel*	*DataAddr*
Stack Out	{empty}				

The 2-byte values *SSCAddr*, *KeyMacAddr* and *KeyEncAddr* identify the segment address of the 8-byte counter, 16-byte MAC key and 16-byte encryption key that are used by the secure messaging.

The 1-byte *Channel* value identifies the channel containing the data to be directly accessed by the accelerated READ BINARY command. A value of 0 specifies the applications Static memory; all other values are RFU.

The 2-byte *DataAddr* value identifies the segment address of the parameter block for the specified channel. For channel 0 the parameter block contains the following parameters, from low address to high address:

- 4-byte offset from the start of Static of the data that is to be directly accessed by the accelerated READ BINARY command.
- 4-byte length of the Static data that is to be directly accessed by the accelerated READ BINARY command.

Stack Usage (Options = 0x13 or 0x14)

If *Options* = 0x13 or 0x14 then the stack will contain the following:

Stack In	*KeyEncAddr*	*Channel*	*DataAddr*
Stack Out	{empty}		

The parameter descriptions are the same as above for options 0x11 and 0x12.

Remarks

The Z flag is set if the configuration/deactivation is successful. It is cleared if the Options argument contains an unsupported value. Invalid segment or Static addresses will cause an abend.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged.
V Unchanged
N Unchanged
Z Set if successful, cleared otherwise.

Primitive Set and Number

Set one, number 0xDC

Control Atomic Writes

This primitive controls whether all future writes to Static are atomic. If transaction protection is enabled then non-atomic writes do not form a part of the transaction. Atomic writes are automatically enabled when an application starts, when it delegates and when it exits.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

```
PRIM  0x18, Option
```

Arguments

The 1-byte argument Option defines whether atomic writes are to be disabled/enabled:

- 0x00 – atomic writes disabled
- 0x01 – atomic writes enabled

Stack Usage

Stack In	{empty}
Stack Out	{empty}

Remarks

Invalid Option will cause an abend.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged.

Primitive set and number

Set one, number 0x18

Control Auto Reset WWT

This primitive controls the MULTOS automatic requesting of the Work Waiting Time extensions.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Flag which indicates whether the reset WWT
// functionality should be disabled or enabled
PRIM 0x10
```

Arguments

None.

Stack Usage

Stack In	Flag
Stack Out	{empty}

The 1-byte parameter Flag can take one of two values. If it has a value of 0x00, the function is enabled and if the value is 0x01 it is disabled.

Remarks

By default, MULTOS causes a message to be automatically sent to the terminal to inform it that more time is required for processing to complete during the execution of long commands. An application can, if it wishes, send these messages manually by calling the Control Auto Reset WWT primitive with Flag = 0x01 and then calling the Reset WWT primitive periodically during the execution of the command. The time during which MULTOS does not automatically reset the WWT is from when the primitive is called to when MULTOS sends the command response back to the IFD or to when the application calls the Control Auto Reset WWT primitive again with Flag = 0x00, whichever comes first.

The Control Auto Reset WWT primitive completely disables the MULTOS automatic generation of reset WWT messages, even during computationally intensive primitives. MULTOS only guarantees that no reset WWT messages are generated by MULTOS if the Control Auto Reset WWT primitive is called in the first two MEL instructions executed following the reception of an application command. The first pushes the byte value 0x01 the second calls the primitive.

The status of the auto reset functionality of MULTOS is maintained when one application delegates to another application or when a delegate application exits. For example, (1) if an application disables the MULTOS automatic generation of reset WWT messages and then delegates to a second application, the automatically generate reset WWT messages will remain disabled. (2) if an application delegates to a second application which then disables the MULTOS automatic generation of reset WWT messages, on exit back to the first application, automatic generation of reset WWT messages will remain disabled.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0x10

Example

The following code fragment shows the recommended declarations and usage for this primitive.

```
prmControlAutoResetWWT EQU 0x10
```

The following example makes a call to the Control Auto Reset WWT primitive to stop MULTOS automatically resetting the WWT.

```
PUSHB 0x01
PRIM prmControlAutoResetWWT
```

The following example makes a call to the Control Auto Reset WWT primitive to start MULTOS automatically resetting the WWT.

```
PUSHB 0x00
PRIM prmControlAutoResetWWT
```

Convert BCD

This primitive converts a BCD-encoded value to the equivalent binary value and a binary value to the equivalent BCD-encoded value.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM   0x14, Mode
```

Arguments

The argument *Mode* specifies the BCD conversion to be performed and must be equal to one of the following values.

- 0x00 to convert a BCD-encoded value to the equivalent binary value.
- 0x01 to convert a binary value to the equivalent BCD-encoded value.

The primitive abends if the argument *Mode* is not equal to one of these values.

Stack Usage

Stack In	DestLength	SourceLength	DestAddr	SourceAddr
Stack Out	{empty}			

The *DestLength* and *SourceLength* parameters are one byte in size and the *DestAddr* and *SourceAddr* parameters are two bytes in size. The values *SourceLength* and *DestLength* are the length of the source and destination data in bytes. The values *SourceAddr* and *DestAddr* are the segment addresses of the source and destination data.

Remarks

When converting from a BCD-encoded value the source data must have a valid BCD format for the conversion to succeed. If the format is invalid then the destination data is undefined and the Condition Code Register's Z flag becomes cleared.

When performing a conversion the number of bytes needed to hold the converted value may be larger than the destination length. If the converted value is too large to be held in the destination area then the destination data is undefined and the Condition Code Register's Z flag becomes cleared.

If the conversion succeeds then the Condition Code Register's Z flag becomes set.

This primitive works correctly even if the source and destination blocks overlap.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the conversion succeeds, cleared otherwise.

Primitive Set and Number

Set One, number 0x14

Example

The following converts a BCD-encoded value held in Public into the equivalent binary value held in Static.

```
prmConvertBCD EQU 0x14
PUSHB   0x06        //Length of destination area
PUSHB   0x06        //Length of source area
LOADA   SB[0000]    //Address of destination data
LOADA   PB[0000]    //Address of source data
PRIM prmConvertBCD, 0x00
```

Delegate

This primitive allows an application to invoke another application on the MULTOS device; that is the current application temporarily ceases to execute and the delegate application is executed.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x80
```

Arguments

None.

Stack Usage

Stack In	AIDAddr
Stack Out	{empty}

The 2-byte parameter *AIDAddr* is the starting address of the application ID to which the executing application wishes to delegate.

Remarks

The delegate application must be specified by an AID field, which is defined as a one-byte length followed by an Application Identifier of the length given. For example, to delegate to an application with an Application ID of F000000000AB the AID field, sAID below, would be:

```
sAID STATIC BYTE 6 = 0x05, 0xF0, 0x00, 0x00, 0x00, 0xAB
```

The Delegation primitive supports partial Application IDs; that is to say if the Application ID to delegate to is shorter than an applications AID then they are considered to match if the most significant bytes match. For example, if an attempt is made to delegate to an application with AID of 0xF000 then the application with AID given above will be considered as a match since the most significant bytes of the application's AID match the given AID.

Delegation fails, and 0x6A83 is placed in SW1-SW2, if:

- there is no application whose AID matches the AID specified by the delegator.
- the AID length is outside the permissible range of 1 to 16 bytes inclusive.
- the delegate is already active; i.e., an attempt is made to delegate recursively
- the implementation defined maximum number of delegations has been exceeded

If the delegate application abends then the MULTOS device goes mute and all execution of application ceases.

If transaction protection is on, Delegate rolls back any uncommitted writes and turns transaction protection off. Delegate always has this effect regardless of whether delegation succeeds.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0x80

Example

The following example writes an APDU into the Public area and delegates to an application with AID of 0xF0000000000001.

```
prmDelegate EQU  0x80
// pSW1 is the 2 byte SW1 SW2 of the Status Word

sAID  STATIC BYTE 8 = 7,0xF0,0,0,0,0,0,1

   // Delegation
   LOADA    sAID
   PRIMprmDelegate
   // Check if SW = 6A83
   LOADpSW1,2
   CMPWpSW1,0x6A,0x83
   // if so, jump to failed delegation handling
   JEQ DelegateFailed
```

DES ECB Decipher

This primitive performs DES ECB Decipher on an eight byte block of memory.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☐	☐	☐

Syntax

```
PRIM 0xC5
```

Arguments

None.

Stack Usage

Stack In	KeyAddr	OutputAddr	InputAddr
Stack Out	{empty}		

Each parameter is 2 bytes in size and represents the starting address of an 8-byte block of memory.

Remarks

This primitive performs the DES decipher operation on an 8-byte block of memory. The DES key is held in an 8-byte block. MULTOS ignores the parity bits.

The output is written at the specified segment address and this may be the same as the address of the input; i.e., the output overwrites the input.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0xC5

Example

The following example declares 8 bytes of static memory to hold the DES Key, the plaintext is held as session data, while the resulting ciphertext will be written to public. The address for each of these is loaded onto the stack and the DES ECB Decipher primitive is called.

```
prmDESECBDecipher  EQU  0xC5

sKey  STATIC BYTE 8 = 0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08
dPlaintext  DYNAMIC BYTE 8
pCiphertext PUBLIC BYTE 8

    LOADA   sKey
    LOADA   dPlaintext
    LOADA   pCiphertext
    PRIM    prmDESECBDecipher
```

DES ECB Encipher

This primitive performs DES ECB Encipher on an eight byte block of memory.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☐	☐	☐

Syntax

```
PRIM 0xC1
```

Stack Usage

Stack In	KeyAddr	OutputAddr	InputAddr
Stack Out	{empty}		

Each parameter is 2 bytes in size and represents the starting address of an 8-byte block of memory.

Arguments

None.

Remarks

This primitive performs the DES encipher operation on an 8-byte block of memory. The DES key is held in an 8-byte block. MULTOS ignores the parity bits.

The output is written at the specified segment address and this may be the same as the address of the input; i.e., the output overwrites the input.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0xC1

Example

The following example declares 8 bytes of static memory to hold the DES Key, the plaintext is held as session data, while the resulting ciphertext will be written to public. The address for each of these is loaded onto the stack and the DES ECB Decipher primitive is called.

```
prmDESECBEncipher  EQU  0xC1

sKey  STATIC BYTE 8 = 0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08
dPlaintext  DYNAMIC BYTE 8
pCiphertext PUBLIC BYTE 8

    LOADA   sKey
    LOADA   pCiphertext
    LOADA   dPlaintext
    PRIM    prmDESECBEncipher
```

DivideN

This primitive performs an unsigned division of two unsigned byte blocks.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
//Stack holds block length parameter
PRIM 0x08, Length
```

Arguments

The argument *Length* expresses the number of bytes in each byte block.

Stack Usage

Stack In	Numerator	Denominator
Stack Out	Quotient	Remainder

Each parameter is of size *Length*.

Remarks

The argument *Length* is specified using a single byte. Therefore, the maximum possible length of a block is 255 bytes.

This primitive performs unsigned division of the numerator by the denominator. These values are overwritten with the resulting quotient and remainder. All of these parameters are of size *Length*.

If the denominator is zero, then:

- The C flag is set.
- The Z flag is unchanged.
- The data in Dynamic is unchanged.

If the denominator is non-zero, then:

- The C flag is cleared.
- The Z flag is set if the numerator is less than the denominator, and cleared otherwise

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if the denominator is zero, cleared otherwise
V Unchanged
N Unchanged
Z Set if the quotient is zero, cleared if the quotient is non-zero, remains unchanged if the denominator is zero.

Primitive Set and Number

Set one, number 0x08

Example

The following example divides 4128 (hexadecimal 0x1020) by 256 (hexadecimal 0x0100).

```
PUSHW   0x1020
PUSHW   0x0100          //Stack = 10,20,01,00
PRIM    prmDivideN, 2   //Stack = 00,10,00,20
                     // CCR C and Z cleared
```

The example above indicates that (4128 / 256) = 16 (0x0010) with a remainder of 32 (0x0020) or, when expressed as a fraction, 16 32/256. The result is correct as (256 x 16) + 32 = 4128
The next example reverses the previous and divides 256 by 4128.

```
PUSHW   0x0100
PUSHW   0x1020          // Stack = 01, 00, 10, 20
PRIM    prmDivideN, 2   //Stack = 00,00,01,00
                     // CCR C cleared, Z set
```

This new example indicates that (256 / 4128) = 0 (0x0000) with a remainder of 256 (0x0100), or, as a fraction 0 256/4128. The result is correct as (4128 x 0) + 256 = 256. Here the CCR Z flag has been set to indicate that the quotient is 0.

Division by 0 results in the CCR C flag being set and the data on the stack is left unchanged.

ECC Addition

This primitive adds two points on the elliptic curve specified by the supplied domain parameters.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD0
```

Arguments

None.

Stack Usage

Stack In	domainAddr	point1Addr	point2Addr	outAddr
Stack Out	{empty}			

All parameters are 2 bytes in size. The value held at *domainAddr* represents the elliptic curve domain parameter. Both *point1Addr* and *point2Addr* are the location of the operands. The *outAddr* is the location to which to write the result of the addition.

Remarks

This primitive calculates the point that is the result of the addition of two points on the elliptic curve specified by the domain parameters. If the two points are equal the primitive calculates the double of the point.

Both input points must be in the same representation, affine or projective, and the result is produced in that same representation. If the input representation is different from that of the application, then calling the primitive results in an abend.

Possible point representation values are:

0x04: Affine: X and Y values included
0x84: Projective: X, Y and Z values provided
0x0F: Affine: Use Gx and Gy values from domain parameters
0x8F: Projective: Use Gx, Gy from domain parameters with Z = 1
0x00: Affine: Use infinity as the point
0x80: Projective: Use infinity as the point

Points are structured as follows:

BYTE representation | BYTE X[primeLen] | BYTE Y[primeLen] | BYTE Z[primeLen]

Domain parameters are structures as follows

BYTE format[1] | BYTE primeLen | BYTE P[primeLen] | BYTE A[primeLen] | BYTE B[primeLen] | BYTE Gx[primeLen] | BYTE Gy[primeLen] | BYTE N[primeLen] | 0x00[2] | BYTE H

Notes:
[1] Only supported value at present is 0x00
[2] This fixed zero byte is only required for MULTOS 4.2.1 and earlier.

If the result of the addition is infinity the Z flag is set and the representation of infinity is written to the output address specified.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is infinity, cleared otherwise

Primitive Set and Number

Set zero, number 0xD0

Example

The following example shows how to use the ECC Addition primitive to add two points stored in Dynamic placing the result back in Dynamic and then adding the base point of the elliptic curve.

```
prmEccAdd EQU 0xD0

sDomain STATIC BYTE 124 // The domain parameters for a 160 bit curve
eccBasePointAffine STATIC BYTE 0x0F// The base point in affine
//---------------------------------------------------
//Call ECC Add to add points together
//---------------------------------------------------
LOADA sDomain           // Load addr domain parameters
LOADA LB[0]             // Load addr of first input point
LOADA LB[0x29]          // Load addr of second input point
LOADA LB[0]             // Load addr of output point
PRIM prmEccAdd
//---------------------------------------------------
//Call ECC Add to add points together
//---------------------------------------------------
LOADA sDomain           // Load addr domain parameters
LOADA LB[0]             // Load addr of 1st input point
LOADA eccBasePointAffine// addr 2nd point (base point)
LOADA LB[0]             // Load addr of output point
PRIM prmEccAdd
BEQ Infinity
EXIT
Infinity
EXITSW 0x9E, 0x20
```

ECC Convert Representation

This primitive converts the representation of an elliptic curve point.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD1
```

Arguments

None.

Stack Usage

Stack In	domainAddr	pointAddr	outAddr
Stack Out	{empty}		

All parameters are 2 bytes in size. The value held at *domainAddr* represents the elliptic curve domain parameters. The value found at *pointAddr* is the location of the point to convert. The *outAddr* is the location to which to write the result of the addition.

Remarks

This primitive converts any elliptic curve point, including the point at infinity, from affine to projective representation, or from projective to affine representation. If the input point is in affine representation the output point will be written in projective representation with a randomised Z co-ordinate.

See ECC Addition for details of domain parameters, points and point representations.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0xD1

Example

The following example shows how to use the ECC Convert Representation primitive to convert a point stored in Dynamic from projective to affine representation and place the result in Public.

```
prmEccConvert EQU 0xD1

sDomain STATIC BYTE 124 // The domain parameters for a 160 bit
curve
//--------------------------------------------------
//Call ECC Convert to convert point to affine representation
// (word) Address of Domain Parameters
// (word) Address of Input Point
// (word) Address of Output Point
//--------------------------------------------------
LOADA sDomain              // Load addr domain parameters
LOADA LB[0]           // Load addr of input point
LOADA PB[0]           // Load addr of output point
PRIM prmEccConvert
EXITLA 0x29
```

ECC ECIES Decipher

This primitive performs an ECIES (Elliptic Curve Integrated Encryption Scheme) decryption of a given message.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
✗	✓	✓	✓	✓	✓

Syntax

```
PRIM 0xE9, Options
```

Arguments

The 1 byte argument *Options* is used to specify the algorithm to be used and whether the private key input will be maintained in a "protected" form.

Options	Algorithm	Protect Private Key
0x00	ECIES_KEM with DEM3 (see ISO 18033-2). Hash method is SHA-256.	No
0x01	ECIES_KEM with DEM3 (see ISO 18033-2). Hash method is SHA-512.	No
0x80	ECIES_KEM with DEM3 (see ISO 18033-2). Hash method is SHA-256.	Yes
0x81	ECIES_KEM with DEM3 (see ISO 18033-2). Hash method is SHA-512.	Yes

Stack Usage

Stack In	domainAddr	Length	privatekeyAddr	inputAddr	messageAddr
Stack Out	{empty}				

All parameters are 2 bytes in size. . *domainAddr* is the location of the elliptic curve domain parameter. Length is the length of the deciphered message written to location messageAddr. privatekeyAddr is the location of the private key to be used. inputAddr is the location of the enciphered message to be processed.

The private key is of length prime_len. The enciphered message is in the form (R, X, T) where R is prime_len x 2 bytes, X is Length bytes and T is half the hash size bytes.

Remarks

The Z flag is cleared on successful decipher.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Cleared if success, set if failure

Primitive Set and Number

Set one, number 0xE9

Example

ECC ECIES Encipher

This primitive performs an ECIES (Elliptic Curve Integrated Encryption Scheme) encryption of a given message.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xEA, Options
```

Arguments

The 1 byte argument *Options* is used to specify the algorithm to be used.

Options	Algorithm
0x00	ECIES_KEM with DEM3 (see ISO 18033-2). Hash method is SHA-256.
0x01	ECIES_KEM with DEM3 (see ISO 18033-2). Hash method is SHA-512.

Stack Usage

Stack In	domainAddr	Length	publickeyAddr	messageAddr	outputAddr
Stack Out	{empty}				

All parameters are 2 bytes in size. . *domainAddr* is the location of the elliptic curve domain parameter. Length is the length of the plaintext message to be processed at location messageAddr. publickeyAddr is the location of the public key to be used. outputAddr is the location where the enciphered message is written.

The public key consists of ecc_X followed by ecc_Y and is of length prime_len x 2. The enciphered message is in the form (R, X, T) where R is prime_len x 2 bytes, X is Length bytes and T is half the hash size bytes.

Remarks

The Z flag is cleared on successful encipher.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged

N	Unchanged
Z	Cleared if success, set if failure

Primitive Set and Number

Set one, number 0xEA

Example

ECC Elliptic Curve Diffie Hellman

This primitive performs an Elliptic Curve Diffie Hellman key agreement in accordance with ANSI X9.63.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xE8, Options
```

Arguments

The 1 byte argument *Options* is used to specify whether the private key input will be maintained in a "protected" form.

Options	Protect Private Key
0x00	No
0x80	Yes

Stack Usage

Stack In	domainAddr	privatekeyAddr	publickeyAddr	sharedAddr
Stack Out	{empty}			

All parameters are 2 bytes in size. *domainAddr* is the location of the elliptic curve domain parameter. privatekeyAddr is the location of the private key to be used. publickeyAddr is the location of the public key to be used. sharedAddr is the location where the shared secret key is written.

The private key is of length prime_len. The public key consists of ecc_X followed by ecc_Y and is of length prime_len x 2. The shared secret key is of length prime_len.

Remarks

The Z flag is cleared on successful processing.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Cleared if success, set if failure

Primitive Set and Number

Set one, number 0xE8

Example

ECC Equality Test

This primitive tests if two points on the specified elliptic curve are equal.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD2
```

Arguments

None.

Stack Usage

Stack In	domainAddr	point1Addr	point2Addr
Stack Out	{empty}		

All parameters are 2 bytes in size. The value held at *domainAddr* represents the elliptic curve domain parameters. The values found at *point1Addr* and *point2Addr* are the locations of the points to test for equality.

Remarks

This primitive tests if two points on the elliptic curve specified by the supplied domain parameters are equal. Both input points must be in the same representation, affine or projective, or the application calling the primitive will abend.

See ECC Addition for details of domain parameters, points and point representations.

The Z flag is set to indicate that the two points are equal.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the two points are equal, cleared otherwise

Primitive Set and Number

Set zero, number 0xD2

Example

The following example shows how to use the ECC Test for Equality primitive to determine if a point supplied in Public is equal to the base point of the elliptic curve.

```
prmEccEqual EQU 0xD2

sDomain STATIC BYTE 124 // The domain parameters for a 160 bit
curve
eccBasePointAffine STATIC BYTE 0x0F  // The base point in affine
//--------------------------------------------------
//Call ECC Equal to compare points
//  (word) Address of Domain Parameters
//  (word) Address of First Point
//  (word) Address of Second Point
//--------------------------------------------------
LOADA sDomain          // Load addr domain parameters
LOADA eccBasePointAffine// Load addr 1st pt (base point)
LOADA PB[0]            // Load addr second point
PRIM prmEccEqual
BEQ PointsEqual
EXIT
PointsEqual
EXITSW 0x9E,0x20
```

ECC Generate Key Pair

This primitive generates an Elliptic Curve Cryptography public and private key pair.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
✗	✓	✓	✓	✓	✓

Syntax

```
PRIM 0xE7, Options
```

Arguments

The 1 byte argument *Options* is used to specify whether the private key input will be maintained in a “protected” form.

Options	Protect Private Key
0x00	No
0x80	Yes

Stack Usage

Stack In	domainAddr	keyAddr
Stack Out	{empty}	

All parameters are 2 bytes in size. *domainAddr* is the location of the elliptic curve domain parameter. keyAddr is the location where the key pair generated will be written.

The key pair consists of the public key followed by the private key. The public key consists of ecc_X followed by ecc_Y and is of length prime_len x 2. The private key is of length prime_len.

Remarks

The Z flag is cleared on successful key pair generation.

The format of the domain parameters is shown in the example below. P, A, B, Gx, Gy and N are prime_len long. The format, prime length and H are a single byte.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C	Unchanged
V	Unchanged

N Unchanged
Z Cleared if success, set if failure

Primitive Set and Number

Set one, number 0xE7

Example

```
#define ECC_KEY_LEN          28              // 224 bit prime
#define PRIM_GEN_ECC_PAIR         0xE7
typedef struct
{
        BYTE x[ECC_KEY_LEN];
        BYTE y[ECC_KEY_LEN];
} ecc_public_s;
typedef struct
{
        ecc_public_s publicKey;
        BYTE privateKey[ECC_KEY_LEN];
} ecc_s;

#pragma melstatic
BYTE abDomainParams[] = {
 0x00,                                                  // Format of domain params
 0x1C,                                                  // Prime length in bytes
 0xAC,0x75,0xCF,0x35,0x99,0x88,0x5A,0x6A,0x26,0xB2,0x0F,0x52,0x71,0xAB,0x95,0xA3,
 0xF0,0xD2,0x4B,0x74,0x37,0x21,0x46,0xCC,0xDB,0xA0,0x5F,0xA9,                    // P
 0x93,0x62,0xE8,0xF2,0x7B,0xDC,0xA9,0x6F,0x81,0xE6,0xBF,0xA6,0x79,0x5E,0x10,0x60,
 0xA9,0x69,0xD2,0x0D,0x9F,0x88,0x2E,0xB4,0xD8,0xE8,0xD4,0x20,                    // A
 0x89,0xD8,0x66,0x9D,0x59,0x20,0x5C,0xB4,0xA3,0x6E,0xEC,0x01,0x22,0xC6,0x49,0x1C,
 0x92,0xB6,0x18,0xB8,0xFC,0x09,0xB6,0xD6,0xF3,0x24,0xAA,0xCA,                    // B
 0x2E,0xDA,0x6A,0x9C,0xE8,0x53,0x3B,0xBC,0xB8,0x1D,0x49,0xF4,0x69,0xB5,0x43,0x95,
 0xD3,0x1A,0x64,0xB8,0x14,0x8B,0x92,0xB3,0x6B,0xC0,0x23,0x00,                    // Gx
 0x84,0xDA,0x69,0x9D,0xF7,0x56,0xBF,0x58,0xC9,0x50,0x76,0x7A,0xD7,0xF8,0x84,0x62,
 0x1E,0x2F,0x5C,0xFC,0x28,0x25,0x97,0x99,0x14,0x05,0xB2,0x4D,                  // Gy
 0x0F,0xAD,0x9E,0x79,0x3C,0x80,0xC2,0x66,0xBD,0xB3,0x18,0xAA,0x67,0x6C,0x9E,0xDB,
 0x4F,0xB6,0x53,0xCF,0x4F,0x67,0x92,0x37,0x13,0x37,0x56,0xA1,                  // N
 0x0B                                                                          // H
};
ecc_s sEccKeyPair;

void main(void)
{
        __push (abDomainParams);
        __push (&sEccKeyPair);
        __code (PRIM, PRIM_GEN_ECC_PAIR, 0x00);

        // …etc
}
```

ECC Generate Signature

This primitive generates an Elliptic Curve Cryptography signature.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xE5, Options
```

Arguments

The 1 byte argument *Options* is used to specify the algorithm to be used and whether the private key input will be maintained in a "protected" form.

Options	Algorithm	Protect Private Key
0x00	ECDSA	No
0x80	ECDSA	Yes

Stack Usage

Stack In	domainAddr	privatekeyAddr	hashAddr	sigAddr
Stack Out	{empty}			

All parameters are 2 bytes in size. *domainAddr* is the location of the elliptic curve domain parameter. privatekeyAddr is the location of the private key to be used. hashAddr is the location of the hash code over which the signature is generated. sigAddr is the location where the signature is written.

The private key and hash code are of length prime_len. The signature produced is (R, S) and is of length 2 x prime_len.

Remarks

The Z flag is cleared on successful signature generation.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Cleared if success, set if failure

Primitive Set and Number

Set one, number 0xE5

Example

ECC Inverse

This primitive calculates the inverse (negation) of a point on an elliptic curve.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD3
```

Arguments

None.

Stack Usage

Stack In	DomainAddr	pointAddr	outAddr
Stack Out	{empty}		

All parameters are 2 bytes in size. The value held at *domainAddr* represents the elliptic curve domain parameters. The value found at *pointAddr* is the location of the point to convert. The *outAddr* is the location to which to write the result of the inversion calculation.

Remarks

This primitive calculates the inverse (negation) of a point on an elliptic curve.
The output point will be written in the same representation (affine or projective) as the input point.

The values 0x0F or 0x8F may be specified in the Point Representation byte of the point stored at *pointAddr* to indicate that the base point of the elliptic curve group is to be used as the input point. See ECC Addition for details of points and point representations.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0xD3

Example

The following example shows how to use the ECC Inverse primitive with the ECC Addition primitive to subtract two points stored in Dynamic placing the result back in Dynamic.

```
prmEccInv EQU 0xD3

sDomain STATIC BYTE 124 // The domain parameters for a 160 bit
curve
//---------------------------------------------------
//Call ECC Inverse to add points together
//---------------------------------------------------
LOADA sDomain          // Load addr domain parameters
LOADA LB[0x29]         // Load addr of input point
LOADA LB[0x29]         // Load addr of output point
PRIM prmEccInv
//---------------------------------------------------
//Call ECC Add to add points together
//---------------------------------------------------
LOADA sDomain          // Load addr domain parameters
LOADA LB[0]            // Load addr of first input point
LOADA LB[0x29]         // Load addr second point
LOADA LB[0]            // Load addr of output point
PRIM prmEccAdd
BEQ Infinity
EXIT
Infinity
EXITSW 0x9E, 0x20
```

ECC Scalar Multiplication

This primitive calculates a scalar multiplication of a point on the specified elliptic curve.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD4
```

Arguments

None.

Stack Usage

Stack In	domainAddr	pointAddr	mAddr	outAddr
Stack Out	{empty}			

All parameters are 2 bytes in size. The value held at *domainAddr* represents the elliptic curve domain parameters. The value found at *pointAddr* is the location of the input point and *mAddr* is the location of the multplier. The *outAddr* is the location to which to write the result of the multiplication.

Remarks

This primitive performs a scalar multiplication of a point on the elliptic curve specified by the supplied domain parameters by the specified unsigned integer multiplier which is one byte longer than the length specified in the domain parameters. The result, a point on the curve, is written at the specified segment address in the same representation as the input point.

The values 0x0F or 0x8F may be specified in the Point Representation byte of the point stored at pointAddr to indicate that the base point of the elliptic curve group is to be used as the input point. See ECC Addition for details of domain parameters, points and point representations.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is infinity, cleared otherwise

Primitive Set and Number

Set zero, number 0xD4

Example

The following example shows how to use the ECC Scalar Multiplication primitive to multiply a base point by a random number stored in Dynamic placing the result back in Dynamic.

```
prmEccMult EQU 0xD4

eccBasePointAffine STATIC BYTE 0x0F  // The base point in affine
prmGetRandomNumber EQU 0xC4
sDomain STATIC BYTE 124 // The domain parameters for a 160 bit
curve
//---------------------------------------------------
//Pad out stack
//---------------------------------------------------
PUSHZ 17
//---------------------------------------------------
//Generate Random Number
//---------------------------------------------------
PRIM prmGetRandomNumber
PRIM prmGetRandomNumber
PRIM prmGetRandomNumber
//---------------------------------------------------
//Call ECC Mult
//---------------------------------------------------
LOADA sDomain           // Load addr domain parameters
LOADA eccBasePointAffine// Load addr input point (base point)
LOADA DT[-25]           // Load addr of 21 byte multiplier
LOADA DT[-47]           // Load addr of output point
PRIM prmEccMult
POP
BEQ Infinity
EXIT
Infinity
EXITSW 0x9E, 0x20
```

ECC Verify Point

This primitive verifies that a point is a valid elliptic curve point.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD1, VerType
```

Arguments

The argument *VerType* can take one of three values depending on what type of verification is required. A value of 0x00 indicates the no group order check should be performed. A value of 0x01 means that the point should have the same order *N* as specified in the domain parameters. A value of 0x02 indicates that the point should not have order less than or equal to *H* as specified in the domain parameters.

Stack Usage

Stack In	domainAddr	pointAddr
Stack Out	{empty}	

All parameters are 2 bytes in size. The value held at *domainAddr* represents the elliptic curve domain parameters. The value found at *pointAddr* is the location of the point to verify. See ECC Addition for details of domain parameters, points and point representations.

Remarks

This primitive verifies that the specified point :

- is not infinity
- is a point on the elliptic curve defined by the specified domain parameters
- If *VerType* is set to 0x01: has the same order *N* as the group order specified in the domain parameters
- If *VerType* is set to 0x02: does not have order less than or equal to *H* the co-factor specified in the domain parameters

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged

N Unchanged
Z Set if the point is not valid, cleared otherwise

Primitive Set and Number

Set one, number 0xD1

Example

The following example shows how to use the ECC Verify primitive to verify that a point stored in Public is valid and has the same order as the base point of the elliptic curve.

```
prmEccVerify EQU 0xD1

sDomain STATIC BYTE 124 // The domain parameters for a 160 bit
curve
//---------------------------------------------------
//Call ECC Verify to check the point
//---------------------------------------------------
LOADA sDomain         // Load addr domain parameters
LOADA PB[0]           // Load addr input point
PRIM prmEccVerify, 0x01
BEQ Invalid
EXIT
Invalid
EXITSW 0x9E, 0x20
```

ECC Verify Signature

This primitive verifies an Elliptic Curve Cryptography signature.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xE6, Options
```

Arguments

The 1 byte argument *Options* is used to specify the algorithm to be used.

Options	Algorithm
0x00	ECDSA

Stack Usage

Stack In	domainAddr	publickeyAddr	sigAddr	hashAddr
Stack Out	{empty}			

All parameters are 2 bytes in size. *domainAddr* is the location of the elliptic curve domain parameter. publickeyAddr is the location of the private key to be used. sigAddr is the location of the signature to be verified. hashAddr is the location of the hash code to be compared in the verification.

The public key consists of ecc_X followed by ecc_Y and is of length prime_len x 2. The signature is (R, S) and is of length 2 x prime_len. The hash code is of length prime_len.

Remarks

The Z flag is cleared on successful signature verification.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Cleared if success, set if failure

Primitive Set and Number

Set one, number 0xE6

Example

Exchange Data

This primitive allows a MULTOS application to import data from or export data to a non-MULTOS application.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x85
```

Arguments

None.

Stack Usage

Stack In	Channel	DataAddr
Stack Out	{empty}	

The 1-byte *Channel* value identifies the non-MLTOS application with which the application wishes to exchange data. The 2-byte *DataAddr* is the location of data that is used to determine the direction of the exchange as well as the content to exchange. Note that the format of the data is specific to the channel.

Remarks

If parameter *Channel* specifies a value unknown to the implementation then the AAM will abnormally end the application.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0x85

Example

The following example imports data from a non-MULTOS application to the address space of a MULTOS application.

```
prmExchangeData EQU 0x85

SrcChannel       EQU  0x01

start
    PUSHB   SrcChannel     // ID of exchange channel
    LOADA   PB[0]          // address of control data
    PRIM    prmExchangeData
    EXIT                   // Exit
```

Exit to MULTOS and Restart

This primitive informs MULTOS that when the currently selected application exits (via the SYSTEM instruction), MULTOS should process the contents of Public as if it has been passed from an IFD rather than provide a response to the IFD. Such processing shall include the processing of a MSM command APDU placed in Public by the currently selected application (or any other APDU other than a valid SELECT command APDU). Following such processing, the response APDU from the command processing is placed in Public and the currently selected application shall be restarted.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
✗	✓	✓	✓	✓	✓

Syntax

```
PRIM 0x17
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

There are no input or output parameters for this primitive.

Remarks

This primitive sets the most significant bit, b7, of ProtocolFlags to indicate to the application that it has been restarted rather than called from the IFD. The application is responsible for clearing this bit.

As of MULTOS 4.5.4, if the calling application is currently being delegated to then it will return to the delegator before MULTOS processes the command.

If the 6th (CCR6) bit of the CCR register is set, then the command will be processed immediately and the calling application will then resume.

If the 5th (CCR5) bit of the CCR register is set, then the delegated application will not return to the delegator before MULTOS processes the command. The delegated application will then be executed after the command has been process and will return to the delegator after it has finished executing.

This primitive will reset bit 5 to bit 8 of the CCR register after they have been checked.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, Number 0x17

Example

This is a C code fragment showing how an application could construct an OPEN MEL APP command and get MULTOS to execute it.

```
// Construct MULTOS Open MEL APP command to run later
CLA = 0xBE;
INS = 0x12;
P1 = 0x00;
P2 = 0x00;
Lc = 0x9D;
ProtocolFlags |= 0x02; // Lc valid
ProtocolFlags &= ~0x04; // Le not used
memcpy(abPublic,abOpenMelAppData,Lc);

__code(PRIM, 0x17);
Exit();
```

Flush Public

This primitive allows an application to return more bytes to the IO device than the size of the public memory area.

The application sets La to the total number of bytes to return (which is greater than the size of public), copies the first block of bytes to be returned to public then calls this primitive. The word at the top of the stack gives the number of bytes to flush to the IO from the start of public. The application calls this primitive multiple times for each block until just the last block of data is in public. When the application returns to MULTOS, MULTOS will transmit the final response data held in Public (as indicated by La) and then transmit SW12.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☒	☑	☑	☑

Syntax

```
PRIM 0xEC
```

Arguments

None.

Stack Usage

Stack In	BlockSize
Stack Out	{empty}

BlockSize is a 2 bytes value giving the number of bytes in public to transmit to the IO..

Remarks

The primitive reduces La by *BlockSize* at the end of each call.

The primitive will cause an abend if *BlockSize* is larger than the size of the public memory area.

It's important to note that if the application calls Flush Public to flush the final block of response data then MULTOS will only return SW12 when the application returns back to MULTOS and MULTOS sends the final command response

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged

V Unchanged
N Unchanged
Z Set to 1 if La > 0 following the call to this primitive.

Primitive Set and Number

Set Zero, Number 0xEC

Example

In the following fragment of 'C' code, the maximum public size is 1024 bytes. The application wishes to return 3200 bytes. **doFlushPublic** is a macro that calls the primitive. **buff** is an array of BYTEs in static memory. **pub** is a pointer to the beginning of public memory.

```
La = 3200;

// Send first block
memcpy(pub,buff,1000);
doFlushPublic(1000);

// Second block
memcpy(pub,buff+1000,1000);
doFlushPublic(1000);

// Third block
memcpy(pub,buff+2000,1000);
doFlushPublic(1000);

// Remaining bytes
memcpy(pub,buff+3000,200);
multosExit();
```

Generate Asymmetric Hash General

This primitive generates an Asymmetric Hash Digest using as input a block of memory of arbitrary size.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xC4, Mode
```

Arguments

The 1-byte argument Mode is used to indicate which stack based parameters are required.

Stack Usage

See the Remarks section below for details of the stack usage.

All parameters are 2 bytes in size. The possible parameters are:

- *IVAddr* indicates the location of an initial vector with a size equal to the hash chain length
- *dataLength* gives the size of the input data block
- *resAddr* is the location where the resulting asymmetric hash should be written
- *dataAddr* is the location of the input data block that is of size *dataLength*.
- *hmLen* indicates the size of the hash modulus supplied
- *hmAddr* indicates the location of the hash modulus supplied
- *appHcl* gives an application supplied hash chain length value

Remarks

For MULTOS 4 implementations the hash chain length is always 16 bytes in length. In MULTOS 4.2 this value is a fixed, platform specific value or the length can be supplied depending on the mode employed.

When an IV is not supplied, a default value is used. That value's length is the hash chain length and each byte is 0x55. Similarly, when a hash modulus is not supplied, the hash modulus value of the platform is used. Details of this value are available by request from the KMA, but is only available to MULTOS Issuers.

The following table provides an overview of all possible *Mode* values, their support by MULTOS 4 and MULTOS 4.2 and what application supplied values are required. In all cases the length of data and the address of the data that serves as input must be supplied as must the result address.

Mode	4?	4.2?	IV Supplied	HM Supplied	HCL Supplied
0	Y	N	N	N	N
1	Y	N	Y	N	N
2	Y	Y	N	Y	N

3	Y	Y	Y	Y	N
4	N	Y	N	Y	Y
5	N	Y	Y	Y	Y

For MULTOS 4 there are two *Mode* values defined, 0 and 1, that are not used in MULTOS 4.2 or later. They are included here for completeness.

A *Mode* value of 0 indicates that the default IV should be used and that no hash modulus value is supplied. The stack for this mode would then be:

Stack In	dataLength	resAddr	dataAddr
Stack Out	{empty}		

A *Mode* value of 1 indicates that the IV is supplied and that no hash modulus value is supplied. The stack for this mode would then be:

Stack In	IVAddr	dataLength	resAddr	dataAddr
Stack Out	{empty}			

Mode values of 2 and 3 are supported by both MULTOS 4 and MULTOS 4.2.

A *Mode* value of 2 indicates that the default IV should be used and that a hash modulus value is supplied. The stack for this mode would then be:

Stack In	dataLength	resAddr	dataAddr	hmLen	hmAddr
Stack Out	{empty}				

A *Mode* value of 3 indicates that the IV is supplied and that a hash modulus value is supplied. The stack for this mode would then be:

Stack In	IVAddr	dataLength	resAddr	dataAddr	hmLen	hmAddr
Stack Out	{empty}					

As of MULTOS 4.2 modes 4 and 5 have been added.

A *Mode* value of 4 indicates that the default IV should be used ,a hash modulus value is supplied as is an application specified hash chain length. The stack for this mode would then be:

Stack In	dataLength	resAddr	dataAddr	hmLen	hmAddr	appHcl
Stack Out	{empty}					

A *Mode* value of 5 indicates that the IV, hash modulus and application specified hash chain length are supplied. The stack for this mode would then be:

Stack In	IVAddr	dataLength	resAddr	dataAddr	hmLen	hmAddr	appHcl
Stack Out	{empty}						

Any other value for *Mode* is undefined

If any of the required components are not present or if a combination of a component's start address and length yields an address outside the application's data space, the application calling this primitive will abnormally end processing.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set one, number 0xc4

Example

The following code fragment shows the recommended declarations and usage for this primitive.

```
prmGenerateAHashGeneral     EQU   0xC4
```

The following example generates the asymmetrical hash of a variable sAUCode.

```
sLCode      STATIC WORD = 0x000A
sAUCode     STATIC BYTE 0x0A = "1234567890"
//Calculate the A-Hash of sAUCode
   LOAD     sLCode,2
   LOADA    PB[0000]
   LOADA    sAUCode
   PRIM     prmGenerateAHashGeneral,0
```

```
    EXITLA  0x0010
```

The next example uses the default IV value, but supplies a hash modulus and hash chain length value.

```
INPUTSIZE   EQU  64
HMSIZE EQU  72
APPHCL EQU  20

dDataToBeHashed  DYNAMIC BYTE 64
dHashDigest      DYNAMIC BYTE 20
sMyHashModulus   STATIC BYTE 72

   // Populate Mode 4 Stack
   // size of data
   PUSHW    INPUTSIZE
   // address of result
   LOADA    dHashDigest
   // address of input data
   LOADA    dDataToBeHashed
   // hash modulus length
   PUSHW    HMSIZE
   // hash modulus address
   LOADA    sMyHashModulus
   // application specific hash chain length
   PUSHW    APPHCL
   // call primitive using mode 4
   PRIMprmGenerateAHashGeneral, 4
```

Generate Asymmetric Signature General

This primitive generates an asymmetric signature over a message of arbitrary length.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xE1, Mode
```

Arguments

The 1-byte argument Mode indicates what type of modular exponentiation is to be used. A value of 0 indicates the full exponentiation is required, while a value of 2 indicates that the exponentiation is to be performed using Chinese Remainder Theorem (CRT).

Stack Usage

When the *Mode* value is set to 0, full exponentiation, the stack usage is:

Stack In								
msgLen	modLen	eAddr	modAddr	sigAddr	msgAddr	cerType	hmLen	hmAddr
Stack Out	{empty}							

The parameters are as follows:

- 2-byte *msgLen* indicating the length of the message to be signed
- 2-byte *modLen* indicating the size of the modulus used to sign the hash digest
- 2-byte *eAddr* indicating the address of the exponent, where the data is of size *modLen*
- 2-byte *modAddr* indicating the address of the modulus of size *modLen* used to sign the hash digest
- 2-byte *sigAddr* indicating the location where to write the resulting signature and where the data area is of size *modLen*
- 2-byte *msgAddr* indicating the location of the data to be signed, where the data is of size *msgLen*
- 1-byte *cerType* indicating the type of MULTOS certificate to produce
- 2-byte *hmLen* indicating the size of the hash modulus used in the calculation of the hash digest
- 2-byte *hmAddr* indicating the location of the hash modulus of size *hmLen* to use when calculating the hash digest

When the *Mode* value is set to 2, modular exponentiation using CRT, the stack usage is:

Stack In

msgLen	modLen	dpdqAddr	pquAddr	sigAddr	msgAddr	cerType	hmLen	hmAddr

Stack Out {empty}

The parameters are as follows:

- 2-byte *msgLen* indicating the length of the message to be signed
- 2-byte *modLen* indicating the size of the modulus used to sign the hash digest
- 2-byte *dpdqAddr* indicating the address of the concatenation of *dp* and *dq*, where the data is of size *modLen / 2*
- 2-byte *pquAddr* indicating the address of the concatenation of the values *p*, *q* and *u* each of size *modLen / 2* used to sign the hash digest
- 2-byte *sigAddr* indicating the location where to write the resulting signature and where the data area is of size *modLen*
- 2-byte *msgAddr* indicating the location of the data to be signed, where the data is of size *msgLen*
- 1-byte *cerType* indicating the type of MULTOS certificate to produce
- 2-byte *hmLen* indicating the size of the hash modulus used in the calculation of the hash digest
- 2-byte *hmAddr* indicating the location of the hash modulus of size *hmLen* to use when calculating the hash digest

In this mode it is assumed that the modulus length given in *modLen* is even. The factors *p* and *q* are prime, can both be expressed in *modLen / 2* bytes and the relationship $p < q$ holds.

Remarks

The hashing algorithm used by this primitive is the MULTOS asymmetric hash and the certificates produced are in a MULTOS format. The format is given in the 1-byte *cerType* parameter, where a value of 3 indicates that a MULTOS 3 certificate should be produced and a value of 4 means that the certificate should be in a MULTOS 4 format.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set one, number 0xE1

Generate DES CBC Signature

This primitive generates an 8-byte DES CBC Signature over a block of memory.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
//Stack Length, IVAddr, KeyAddr, SigAddr, InputAddr
PRIM 0xC6
```

Arguments

None.

Stack Usage

Stack In	Length	IVAddr	KeyAddr	SigAddr	InputAddr
Stack Out	{empty}				

All the parameters are 2-bytes in size. The parameter *Length* is the size of the plaintext used as input to the signature generation process. The value *IVAddr* is the location of an 8-byte initial vector, *KeyAddr* is the location of an 8-byte DES key, *SigAddr* is the location where the 8-byte signature is written and *InputAddr* is the location of data of size *Length* to be signed.

Remarks

This primitive uses a single 8-byte DES key and operates in CBC mode. At each step the DES encipher operation is performed.

The primitive operates only on complete 8-byte blocks in the plaintext. If *Length* is not an integer multiple of 8, trailing bytes are ignored. For example, if *Length* was 17 bytes, the 16 most significant bytes would serve as input to the algorithm and the last byte would be ignored.

The parity bits of the key are ignored.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0xC6

Example

The following example generates the DES CBC Signature over the contents of sAUCode and writes it to the base of public.

```
prmGenDESCBCSignature          EQU 0xC6

sLCode   STATIC WORD    = 16
sIV      STATIC BYTE 8  = 1,2,3,4,5,6,7,8
sDESKey  STATIC BYTE 8  = 1,2,3,4,5,6,7,8
sAUCode  STATIC BYTE 16 = "1, 2, 3, 4, 5, 6, 7, 8, 9,  10, 11,
12, 13, 14, 15, 16"

//Calculate the signature sAUCode
   LOAD    sLCode,2
   LOADA   sIV
   LOADA   sDESKey
   LOADA   PB[0000]
   LOADA   sAUCode
   PRIM    prmGenDESCBCSignature
   EXITLA  0x008
```

Generate MAC

This primitive generates a MAC according to the required algorithm.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

PRIM 0xC6, *Algorithm*

Arguments

The 1 byte argument *Algorithm* is used to specify the MAC algorithm as follows.

Algorithm = 0: DES MAC according to EMV 2000, Version 4.0 : December 2000. Integrated Circuit Card Specification for Payment Systems Book 2 – Security and Key Management, appendix A1.2 (see also ISO9797-1 algorithm 3).

Algorithm = 1: DES CBC MAC according to ISO9797-1 algorithm 1. If the input data is a multiple of the DES block length (8-bytes) then no padding is applied. This can be used to provide an IV to the Generate MAC primitive Algorithm 0. This could also be used as a substitute for the Generate DES CBC Signature or Generate Triple DES CBC signature primitives.

Algorithm = 2: AES CMAC according to ISO9797-1 MAC Algorithm 5 and in NIST SP 800-38B.

Algorithm = 3: AES CBC MAC according to ISO9797-1 algorithm 1. If the input data is a multiple of the AES block length (16-bytes) then no padding is applied. This can be used to provide an IV to the Generate MAC primitive Algorithm 2.

Algorithm = 4: HMAC according to ISO9797-2 MAC Algorithm 2.

Stack Usage

Algorithm 0:

Stack In	PadByte	MsgLength	IVAddr	KeyAddr	MACAddr	MsgAddr
Stack Out	{empty}					

Algorithm 1, 2, & 3:

Stack In	PadByte	MsgLength	IVAddr	KeyAddr	MACAddr	MsgAddr	KeyLength
Stack Out	{empty}						

Algorithm 4:

Stack In	HashAlgo	MsgLength	KeyAddr	MACAddr	MsgAddr	KeyLength
Stack Out	{empty}					

Where:

- PadByte: 1-byte parameter specifying the value of padding byte used to pad out the input message upto a multiple of the algorithm block length.
  Eg: for a padding byte = 0x80
  DES MAC: Msg | 0x80, 0x00..0x00 making the total message a multiple of 8-bytes.
  AES CMAC: Msg | 0x80, 0x00..0x00 making the total message a multiple of 16-bytes.
- MsgLength: 2-byte parameter specifying the input message length.
- IVAddr: 2-byte parameter specifying the location of the Initial Vector. The IV Length is dependent on the algorithm, ie: 8-bytes for DES, 16-bytes for AES.
- KeyAddr: 2-byte parameter specifying the address of the key.
- MACAddr: 2-byte parameter specifying the address to store the result. The length of the result will be 8-bytes for a DES based algorithm, 16-bytes for AES, and dependent on the hash result length for HMAC.
- MsgAddr: 2-byte parameter specifying the address of the input message.
- KeyLength: 1-byte parameter specifying the keylength. Valid values are:
  - Algorithm 0: 16-byte 3DES key assumed. This parameter should not be supplied for Algorithm 0.
  - Algorithm 1: 8/16/24
  - Algorithm 2: 16/24/32
  - Algorithm 3: 16/24/32
  - Algorithm 4: upto the hash block size. If less than the hash block size is used then the key is padded with 00’s.
- HashAlgo: The following hash algorithms can be used for HMAC
  - HashAlgo = 0: SHA-1; hash block length = 64; hash result length = 20
  - HashAlgo = 1: SHA-256; hash block length = 64; hash result length = 32
  - HashAlgo = 2: SHA-512; hash block length = 128; hash result length = 64

Remarks

IMPORTANT: Consult the MULTOS Implementation Report for the device you are developing for as not all implementations support all algorithms.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set one, number 0xC6

Generate Random Prime

This primitive generates a random prime value

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
//Stack holds flag, conf, timeout, rgExp, rgMinAddr, rgMaxAddr
outAddr
PRIM 0xCC
```

Arguments

None.

Stack Usage

Stack In	gcdFlag	conf	timeout	rgExp	rgMinLoc	rgMaxLoc	outAddr
Stack Out	{empty}						

The most significant bit of the 1-byte parameter *gcdFlag* is set if the prime to generate must meet the condition that 3 and the prime value minus one are co-prime; i.e., the greatest common divisor of *3* and *prime -1* must be *1*.

The 2-byte parameter *conf* is used to set the level of confidence that the number generated is prime. The value must be greater than zero and indicates that the probability that the result is composite is less than or equal to 2^{-conf}. For example, if *conf* was set to 4, then the probability that the number is composite would be
$2^{-4} = 1/16$.

The 2-byte parameter *timeout* is the approximate time in hundredths of a second within which the primitive should return a value. If the value is zero, then the primitive will not return until a prime number is found.

The 2-byte parameter *rgExp* is the desired length of the prime expressed in bytes, while *rgMinLoc* is the address of a 4-byte value giving the minimum value of the four most significant bytes of the modulus and *reMaxLoc* is the address of a 4-byte value giving the maximum value of the four most significant bytes of the modulus.

The 2-byte parameter *outAddr* is the location where the generated prime of size *rgExp* is to be written.

Remarks

This primitive generates a random prime in the range

$[rgMin * 256^{rgExp-4}, rgMax * 256^{rgExp-4}]$.

If the parameter *conf* is set to zero the application calling the primitive will abnormally end if the implementation uses a probabilistic primality test.

It is expected that implementations will select a candidate number and check if it prime. If it is not, a new candidate is chosen and the process is repeated. The implementation will translate the timeout value to a maximum number of candidates to try, which must be at least one, based on an average time to check a candidate.

If no prime is generated the CCR Z flag is cleared and no value is written to *outAddr*.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Z is set if the prime is returned and cleared on timeout.

Primitive Set and Number

Set zero, number 0xCC

Example

The following code fragment generates a 576-bit prime for an RSA key set with a public exponent of 3. The chance that the result is not actually prime is less than 1 in a billion. The operation cancels if it takes longer than 1 minute.

```
PrmGenerateRandomPrime EQU 0xCC

abyPrime STATIC BYTE 72
abyRgMin STATIC BYTE  4 = { 0x80, 0x00, 0x00, 0x00 }
abyRgMax STATIC BYTE  4 = { 0xFF, 0xFF, 0xFF, 0xFF }

//---------------------------------------------------
//Call generate random prime
//   (byte) flag
//   (word) conf     confidence of prime being composite
//   (word) timeout  approximate maximal time to search
//   (word) length   of prime
//   (word) Address of abyRgMin
//   (word) Address of abyRgMax
//   (word) Address of abyPrime (output)
//---------------------------------------------------

  PUSHB  0x80        //gcd(3, prime-1)=1
  PUSHW  30       //confidence 10-9 ≈ 2-30
  PUSHW  6000        //timeout
  PUSHW  64
  LOADA  abyRgMin    //Address of rgMin
  LOADA  abyRgMax    //Address of rgMax
  LOADA  abyPrime    //Address of result
  PRIM   prmGenerateRandomPrime
```

Generate RSA Key Pair

This primitive generates an RSA key pair for application usage.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xE0, Method, Mode
```

Arguments

The 1-byte parameter method specifies the algorithm used to generate the key pair.

- 0x00: The key pair is generated using the default method defined by the MULTOS implementation. This method and algorithm used is decided upon by the MULTOS Implementer to ensure quality of keys generated and performance. This method may use proprietary mechanisms dependent upon the hardware platform and cryptographic co-processor features.
- 0x01: The key pair is generated using the method defined by [X9.31].
- 0x80: The protected key pair is generated using the default method.
- 0x81: The protected key pair is generated using the method defined by [X9.31].

The 1-byte parameter mode specifies the manner in which the key pair will be generated. This parameter applies only to method 0x00. For method 0x01, any value is ignored.

- 0x00: Performance. A key pair will be generated in a manner that will optimise performance of the generation process.
- 0x01: Balanced. A key pair will be generated in a manner that balances performance against confidence in the prime numbers used to generate the key pair.
- 0x02: Confidence. A key pair will be generated in a manner that maximises the confidence in the prime numbers used to generate the key pair.

Stack Usage

Stack In	keyLen	eLen	eAddr	dpdppquAddr	mAddr	mLen
Stack Out	{empty}					

- The 2-byte parameter keyLen is the length in bytes of the key to be generated.
- The 2-byte parameter eLen is the length of the public exponent.
- The 2-byte parameter eAddr is the segment address of the public exponent.
- The 2-byte parameter dpdqAddr is the segment address of dp concatenated to dq, p, q and u.
- The 2-byte parameter mAddr is the segment address of the modulus, if to be returned.
- The 2-byte parameter mLen is the length of the modulus (equal to keyLen), or zero if the modulus is not to be returned.

Remarks

This primitive calculates an RSA key pair.
Implementations may only support a selection of method and mode arguments. Please see the MIR for details.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	-

C Set if the generation of the key pair fails, cleared if the generation of the key pair succeeds.
V Unchanged
N Unchanged
Z Unchanged.

Primitive Set and Number

Set Two, number 0xE0

Example

The following example uses the Generate RSA Key Pair primitive to generate a 1024-bit / 128-byte key pair.

```
prmGenRSAKeyPair    EQU  0xE0

sMod   STATIC BYTE
sDPDQ  STATIC BYTE 96
sP     STATIC BYTE 32
sQ     STATIC BYTE 32
sU     STATIC BYTE 32
sBase  STATIC BYTE 64

//--------------------------------------------------
//Call primitive to protect the keys
//   (word) Length of Modulus
//   (word) Address of dp|dp
//   (word) Address of p|q|u
//   (word) Address of dp|dq
//   (word) Address of p|q|u
//--------------------------------------------------

     PUSHW   0x0080      //Length of key to be generated
     PUSHW  0x0002       //Length of public exponent length
     LOADA  sE      //Address of public exponent
     LOADA  sDPDQPQU     //Address of dp|dq|p|q|u
     LOADA  sM      //Address of modulus
     PUSHW 0x0080        //Length of Modulus
     PRIM   prmGenRSAKeyPair  // call primitive

//--------------------------------------------------
```

Generate Triple DES CBC Signature

This primitive generates an 8-byte Triple DES CBC Signature over a block of memory.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
//Stack Length, IVAddr, KeyAddr, SigAddr, InputAddr
PRIM 0xC7
```

Arguments

None.

Stack Usage

Stack In	Length	IVAddr	KeyAddr	SigAddr	InputAddr
Stack Out	{empty}				

All the parameters are 2-bytes in size. The parameter *Length* is the size of the plaintext used as input to the signature generation process. The value *IVAddr* is the location of an 8-byte initial vector, *KeyAddr* is the location of two 8-byte DES key, *SigAddr* is the location where the 8-byte signature is written and *InputAddr* is the location of data of size *Length* to be signed.

Remarks

This primitive uses two 8-byte DES keys and operates in CBC mode. The 16-byte key value assumes that the most significant 8 bytes are "Key 1" and the least significant 8 bytes are "Key 2". At each step the DES operations performed are: encipher using the Key 1, decipher using Key 2, encipher using Key 1.

The primitive operates only on complete 8-byte blocks in the plaintext. If *Length* is not an integer multiple of 8, trailing bytes are ignored. For example, if *Length* was 17 bytes, the 16 most significant bytes would serve as input to the algorithm and the last byte would be ignored.

The parity bits of the key are ignored.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged

Z Unchanged

Primitive Set and Number

Set zero, number 0xC7

Example

The following example generates the DES CBC Signature over the contents of sAUCode and writes it to the base of public.

```
prmGenTripleDESCBCSignature          EQU 0xC7
LCODE   EQU 16

sIV       STATIC BYTE 8  = 1,2,3,4,5,6,7,8
sDESKeys  STATIC BYTE 8  = 0x01, 0x02, 0x03, 0x04, 0x05, 0x06,
0x07, 0x08,
            0x09, 0x0A, 0x0B, 0x0C, 0x0D, 0x0E, 0x0F
sAUCode  STATIC BYTE 16 = 1, 2, 3, 4, 5, 6, 7, 8, 9,  10, 11, 12,
13, 14, 15, 16

//Calculate the signature sAUCode
   PUSHW   LCODE
   LOADA   sIV
   LOADA   sDESKeys
   LOADA   PB[0000]
   LOADA   sAUCode
   PRIM    prmGenTripleDESCBCSignature
   EXITLA  0x008
```

Get Configuration Data

This primitive allows applications to access exactly the same configuration as can be accessed via the Get Configuration Data APDU command.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

PRIM 0x15

Arguments

None.

Stack Usage

Stack In	outAddr	Token
Stack Out	BytesRead	

All the parameters are two bytes in size.

Token takes the same values defined in the Remarks table for the Get Configuration Data command. *outAddr* points to a buffer to contain the requested data. *bytesRead* returns the number of bytes written by the primitive to *outAddr* or zero if an error condition occurred (invalid token or attempt to write to invalid address).

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0x15

Get AID

This primitive gets the AID of the calling application or any other loaded application.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1 / 2	MULTOS 4.5.x
✗	✗	✗	✗	✗	✓

Syntax

PRIM 0xDD

Arguments

None.

Stack Usage

Stack In	Dest	AppNumber
Stack Out	Result	

The one-byte AppNumber specifies the number of the application to get the AID of. An application number of zero refers to the executing application.

The two-byte Dest defines the destination address of the 17-byte AID (one byte length followed by a 16-byte body).

The one-byte Result holds the result of the operation: 0 indicates that an application with the specified application number does not exist and 1 indicates that the application does exist. The AID is only saved in the destination if Result equals 1.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set zero, number 0xDD

Get Available Interface Types

This primitive returns information on the interfaces supported by the MCD.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1/2/3	MULTOS 4.5.4 onwards
☒	☒	☒	☒	☒	☑

Syntax

PRIM 0x17, type

Arguments

type (a single byte) specifies the type of interfaces as follows.

- 0x00 - standard interfaces
- 0x01 - proprietary interfaces
- All other values - RFU

Stack Usage

Stack In	{empty}
Stack Out	SupportedInterfaces

Remarks

SupportedInterfaces is a 16-bit bit field that indicates which interfaces are supported by the MULTOS platform as follows.

- type = 0x00 (standard interfaces)
  - bit 0: 1 = contact ISO smartcard interface supported, 0 = not supported
  - bit 1: 1 = contactless ISO smartcard interface supported, 0 = not supported
  - bits 2-15: RFU
- type = 0x01 (proprietary interfaces)
  - bits 0-15: implementation-specific.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set one, number 0x17

Get Data

This primitive retrieves the Data Objects (DO) of a generic MAOS device. Specifically for MULTOS, this command returns data objects to identify the platform type and other objects as agreed with Global Platform.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
//Stack holds Addr parameter
PRIM 0x87, ReadLength
```

Arguments

The value *ReadLength* specifies the maximum number of bytes to read from the Data.

Stack Usage

Stack In	outAddr
Stack Out	BytesRead

The 2-byte parameter *outAddr* indicates the location where the data returned is to be written. While the 1-byte *BytesRead* values indicates the total number of bytes actually read.

Remarks

The *ReadLength* value is specified using a single byte. Therefore, the maximum length of a returned data is 255 bytes. Note that the effect of the primitive is undefined if *ReadLength* is zero.

The Data Object is copied to the segment address specified by the application. The number of bytes copied is the lesser of the number requested and the actual length of the Data.
The number of bytes copied is returned on the stack. The exact effect of this primitive is undefined if the destination area includes the top one or two bytes of the stack.

This primitive allows an application to obtain the Data Objects of the MCD. The data structure returned by this primitive is given as part of the 'Get Data' command in the 'APDU Commands' section.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	-

C Set if data retrieved was less than requested, cleared otherwise
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set one, number 0x87

Get Delegator AID

This primitive permits an application to ascertain the Application ID of the application that delegated to it, if any.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
//Stack holds AIDAddr parameter
PRIM 0x81, ReadBytes
```

Arguments

The argument *ReadBytes* indicates the maximum number of bytes of the AID to write.

Stack Usage

Stack In	AIDAddr
Stack Out	{empty}

The 2-byte parameter *AIDAddr* holds the address where *ReadBytes* number of the Application ID is to be written.

Remarks

The *ReadLength* value is specified using a single byte. Therefore, the maximum length of a returned data is 255 bytes. Note that the effect of the primitive is undefined if *ReadLength* is zero.

The AID, preceded by its length expressed as a byte, is copied to the segment address specified by the application. The number of bytes copied is the lesser of the number requested or the actual length of the AID plus one for the length byte.

If the application calling the primitive was not delegated to, then the CCR Z flag is set.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if data retrieved was less than requested, cleared otherwise
V Unchanged
N Unchanged
Z Set if there is no Delegator, cleared otherwise

Primitive Set and Number

Set one, number 0x81

Example

The following example checks that the application has been delegated to by another application, and that the AID of that application is 0xF0000000000002; otherwise the application exits.

```
prmGetDelegatorID    EQU 0x81

sAID      STATIC BYTE 8 = 7,0xF0,0,0,0,0,0,2
dTemp     DYNAMIC BYTE 8

  LOADA  dTemp
  PRIM   prmGetDelegatorID,0x08
  JEQ    ValidAID
  LOAD   sAID,7
  CMPN   dTemp,7
  JNE    InvalidAID
  JMP    Continue

ValidAID
  EXIT

InvalidAID
  EXIT

Continue
  //Continue processing
```

Get DIR File Record

This primitive retrieves a record from the Directory File, also referred to as the DIR File, stored in a root directory of the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Addr, RecNo parameters
PRIM 0x09, ReadLength
```

Arguments

The argument *ReadLength* specifies the number of bytes to read from the DIR File record.

Stack Usage

Stack In	Addr	RecNo	
Stack Out	Addr	RecNo	BytesRead

The 2-byte parameter *Addr* indicates the address where the retrieved DIR File record should be written. The 1-byte parameter *RecNo* is the record number to be retrieved and *BytesRead* is the actual number of bytes read from the DIR File record.

A *RecNo* of zero indicates the current application's DIR file record (supported from MULTOS 4.5).

Remarks

The *ReadLength* value is specified using a single byte. Therefore, the maximum length of a returned data is 255 bytes. Note that the effect of the primitive is undefined if *ReadLength* is zero.

The DIR File record numbers are indexed from 1.

The DIR file record is copied to the segment address specified by the application. The number of bytes copied is the lesser of the number requested and the actual length of the record.

If a record does not exist the CCR Z flag is set.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if data retrieved was less than requested, cleared otherwise.
V Unchanged
N Unchanged
Z Set if the specified record does not exist, cleared otherwise

Primitive Set and Number

Set one, number 0x09

Example

The following example reads in the whole of the first DIR File record into the base of public and sets La to the number of bytes read.

```
prmGetDIRFileRecord   EQU  0x09
pLa EQU PT[-4]

  LOADA PB[0000]  // Load address of public base to stack
  PUSHB 1         // We want record no 1

  PRIM prmGetDIRFileRecord, 64

  STORE pLa,1     // Copy bytes read into La
```

Get FCI State

This primitive returns whether the currently selected application has a normal or dual FCI.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1	MULTOS 4.5.x
✗	✗	✗	✗	✗	✓

Syntax

```
PRIM  0x87
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	Result

Result is one byte and holds the result of the operation as follows:

- *0 = The executing application has a normal FCI*
- *1 = The executing application has a dual FCI*

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set zero, number 0x87

Get File Control Information

This primitive retrieves the File Control Information corresponding to an application loaded onto a MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Addr,RecNo parameter
PRIM 0x0A, ReadLength
```

Arguments

The argument *ReadLength* specifies the number of bytes to read from the FCI record.

Stack Usage

Stack In	Addr	RecNo	
Stack Out	Addr	RecNo	BytesRead

The 2-byte parameter *Addr* indicates the address where the retrieved FCI record should be written. The 1-byte parameter *RecNo* is the record number to be retrieved and *BytesRead* is the actual number of bytes read from the FCI record.

A *RecNo* of zero indicates the current application's DIR file record (supported from MULTOS 4.5).

Remarks

The *ReadLength* value is specified using a single byte. Therefore, the maximum length of a returned data is 255 bytes. Note that the effect of the primitive is undefined if *ReadLength* is zero.

The FCI record numbers are indexed from 1.

The FCI record is copied to the segment address specified by the application. The number of bytes copied is the lesser of the number requested and the actual length of the record.

If a record does not exist the CCR Z flag is set.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if data retrieved was less than requested, cleared otherwise.
V Unchanged
N Unchanged
Z Set if the specified record does not exist, cleared otherwise

Primitive set and number

Set one, number 0x0A

Example

The following example reads in the whole of the first FCI record into the base of public and sets pLa to the number of bytes read.

```
prmGetFCIControlInformationEQU  0x0A
pLA EQU    PT[-4]

    LOADA  PB[0000]  //Load address of public base to stack
    PUSHB  1         //We want record no 1
    PRIM   prmGetFCIControlInformation, 64
    STORE  pLa, 1   //Copy bytes read into La
```

Get Manufacturer Data

This primitive retrieves the Manufacturer Data of a MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Addr parameter
PRIM 0x0B, ReadLength
```

Arguments

The argument *ReadLength* specifies the number of bytes to read from the manufacturer data returned.

Stack Usage

Stack In	Addr
Stack Out	BytesRead

The 2-byte parameter *Addr* holds the address where the retrieved bytes of Manufacturer Data should be written. The 1-byte parameter *BytesRead* is the actual number of Manufacturer Data bytes read.

Remarks

The *ReadLength* value is specified using a single byte. Therefore, the maximum length of a returned data is 255 bytes. Note that the effect of the primitive is undefined if *ReadLength* is zero.
The Manufacturer Data is copied to the segment address specified by the application. The number of bytes copied is the lesser of the number requested and the actual length of the data returned. Note that the exact effect of this primitive is undefined if the destination area includes the top one or two bytes of the stack.

The structure of the data returned is explained in the 'APDU Commands' section under 'Get Manufacturer Data'.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	-

C Set if data retrieved was less than requested, cleared otherwise
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set one, number 0x0B

Example

The following example gets the Manufacturer Data, writes it to the base of public and sets La to the number of bytes read.

```
prmGetManufacturerData EQU 0x0B
pLa EQU PT[-4]

  LOADA   PB[0000]    //Load public base address to stack
  PRIM    prmGetManufacturerData, 22
  STORE   pLa,1       //Copy bytes read into La
```

The following example defines offsets within the returned data and extracts the 6-byte MCD ID from the data held in dynamic memory. That value is then copied to public.

```
EXPECTEDLENGTH          EQU  22
IC_Maufacturer_ID       EQU  0x0000
IC_Type                 EQU  0x0001
ROM_IC_Details          EQU  0x0003
MCD_ID                  EQU  0x0005
Initialisation_Date     EQU  0x000B
Processor_Page_Size     EQU  0x0012
Max_Tx_TPDU_Size        EQU  0x0013
Max_Rx_TPDU_Size        EQU  0x0015
prmMemoryCopy           EQU  0x0C

  // stack empty
  LOADA     DB[0000]    // write data to stack
  PRIM    prmGetManufacturerData, EXPECTEDLENGTH
  // copy MCD_ID to Public via Memory Copy Primitive
  PUSHW     6          // length of MCD_ID
  LOADA     PB[0000]    // destination address
  LOADA     DB[MCD_ID] // source address
  PRIM      prmMemoryCopy
  // exit setting La to length of MCD ID
  EXITLA 6
```

Get Memory Reliability

This primitive requests the status of the current reliability of the non-volatile memory within the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3	MULTOS 4.3.1	MULTOS 4.3.2 onwards
☑	☑	☑	☑	☑

Syntax

```
PRIM 0x09
```

Arguments

None.

Stack Usage

None.

Remarks

The non-volatile memory technology currently used in smart cards Electrically Erasable Programmable Read-Only Memory, sometimes referred to as EEPROM, has finite life and reliability may vary slightly from manufacturer to manufacturer. This primitive adds an additional layer of safety for end-of-card handling on devices that monitor memory reliability. Detecting that memory is only marginally reliable or unreliable allows applications to handle such situations. The actual mechanism used to monitor memory reliability varies from implementation to implementation.

There are three possible states. They are:

- Memory is reliable: C and Z are both cleared.
- Memory is marginally reliable: C is cleared and Z is set.
- Memory is unreliable: C is set and Z is cleared.

All MULTOS implementations support this primitive. However, not all implementations monitor memory reliability. In those cases were memory reliability is not monitored the implementation will always return the response, "memory is reliable".

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C	See Remarks for information on interpreting the value of this flag.
V	Unchanged
N	Unchanged
Z	See Remarks for information on interpreting the value of this flag.

Primitive Set and Number

Set Zero, number 0x09

Example

The following example calls the Get Memory Reliable primitive and returns a response in SW according to the current level of reliability. This could typically be used either as a specific command, or as a self-check performed by the application.

```
prmGetMemoryReliabLe field EQU  0x09

  PRIM  prmGetMemoryReliable
  BEQ   errMemMarginal
  BLT   errMemUnreliable

MemReliable
  //Memory is reliable
  EXIT

errMemMarginal
  //Memory is marginally reliable
  EXITSW 0x65, 0x01

errMemUnreliable
  //Memory is unreliable
  EXITSW 0x65, 0x02
```

Get MULTOS Data

This primitive retrieves the MULTOS Data of a MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Addr parameter
PRIM 0x0C, ReadLength
```

Arguments

The argument *ReadLength* specifies the number of bytes to read from the manufacturer data returned.

Stack Usage

Stack In	Addr
Stack Out	BytesRead

The 2-byte parameter *Addr* holds the address where the retrieved bytes of Manufacturer Data should be written. The 1-byte parameter *BytesRead* is the actual number of Manufacturer Data bytes read.

Remarks

The *ReadLength* value is specified using a single byte. Therefore, the maximum length of a returned data is 255 bytes. Note that the effect of the primitive is undefined if *ReadLength* is zero.

The MULTOS Data is copied to the segment address specified by the application. The number of bytes copied is the lesser of the number requested and the actual length of the data returned. Note that the exact effect of this primitive is undefined if the destination area includes the top one or two bytes of the stack.

The structure of the data returned is explained in the ‘APDU Commands’ section under ‘Get MULTOS Data’.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	-

C Set if data retrieved was less than requested, cleared otherwise
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set One, number 0x0C

Example

The following example reads in the first 10 bytes of the MULTOS Data into the base of public and sets La to the number of bytes read.

```
prmGetMULTOSData fieldEQU  0x0C
pLa   EQU PT[-4]

    LOADA   PB[0000]  //Load address of public base to stack
    PRIM    prmGetMULTOSData, 10
    STORE   pLa,1//Copy bytes read into La
```

Get PIN Data

Gets data relating to the PIN which is either the local application PIN or the Global PIN depending on the access_list bit settings in the ALC. See Initialise PIN for details.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
✗	✗	✓	✓	✓	✓

Syntax

```
PRIM 0x86, ElementId
```

Arguments

ElementId can take the following values:

0x00: PIN Try Counter
0x01: PIN Try Limit
0x02: PIN Status
0x03: PIN Verification Status (new in MULTOS 4.5.2)

Stack Usage

Stack In	{empty}
Stack Out	Value

Value is the one byte value of the PIN data element selected.

PIN Status has the values

- 0x00 = PIN not initialize
- 0x01 = PIN has been initialized with pin_access_level = 01
- 0x02 = PIN has been initialized with pin_access_level = 00,10 or 11
- 0x03 = PIN status error, implementer specific.

PIN Verification Status has the values

- 0x5A = PIN is unverified
- 0xA5 = PIN is verified

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set one, number 0x86

Get Process Event

The Get Process Event primitive can be called by any application to get the number of the application process event that caused the application to be executed by MULTOS. See the [MDG] for a description of *Application Process Events*.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☒	☑	☑	☑

Syntax

```
PRIM 0xE8
```

Stack Usage

Stack In	{empty}
Stack Out	EventID

Remarks

This primitive returns the id of the *Application Process Event*. Valid values are between 0 and 6 where 0 is the default. 0 is the only possible value for applications that do not have the required *access_list* bit set.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, Number 0xE8

Get Purse Type

This primitive returns a value indicating the type of Mondex Purse that the device can support.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Addr parameter
PRIM 0x0D, ReadLength
```

Arguments

The argument *ReadLength* specifies the number of bytes to read from the manufacturer data returned.

Stack Usage

Stack In	Addr
Stack Out	BytesRead

The 2-byte parameter *Addr* holds the address where the retrieved bytes of Purse Type information should be written. The 1-byte parameter *BytesRead* is the actual number of bytes read.

Remarks

The *ReadLength* value is specified using a single byte. Therefore, the maximum length of a returned data is 255 bytes. Note that the effect of the primitive is undefined if *ReadLength* is zero.

The purse type data is copied to the segment address specified by the application. The number of bytes copied is the lesser of the number requested and the actual length of the data returned. Note that the exact effect of this primitive is undefined if the destination area includes the top one or two bytes of the stack.

The structure of the data returned is explained in the 'APDU Commands' section under 'Get Purse Type'.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	-

C Set if data retrieved was less than requested, cleared otherwise
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set One, number 0x0D

Get Random Number

This primitive places an eight byte random number onto the stack.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xC4
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	Bytes

The output parameter *Bytes* holds the 8-byte block of random data returned by the primitive.

Remarks

The method of random number generation is implementation specific. So, it may be generated using a hardware assisted 'true' random number generator or it may be generated as a pseudo-random number from a seed value. In either case, the process is performed in such a way that the secrecy of the number is guaranteed. It is not possible for any coresident application to determine what number was provided or will be provided subsequently.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0xC4

Example

The following example calls the Get Random Number primitive and stores the eight byte random number in a variable called sDESKey

```
prmGetRandomNumber    EQU  0xC4

sDESKey   STATIC BYTE 8

  PRIM prmGetRandomNumber
  STORE     sDESKey, 8
  EXIT
```

Get Replaced Application State

This primitive returns the state of the application that the currently executing application is replacing, if any.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1 / 2	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

```
PRIM   0xDB
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	State

State is one byte and holds the state of the replaced application as follows:

- 0 = No replaced application exists
- 1 = Replaced application exists but is not readable (bit 13 of its access_list is not set)
- 2 = Replaced application exists and is readable (bit 13 of its access_list is set)

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set one, number 0xDB

Get Session Size

This primitive returns the size of the application's session data. It is useful for applications that intend to call the Update Session Size primitive.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1 / 2	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

```
PRIM  0x03
```

Arguments

None

Stack Usage

Stack In	{empty}
Stack Out	SessionSize

The primitive returns the two-byte value SessionSize being the size of the application's session data.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set zero, number 0x03

Get Static Size

This primitive returns the total size of the application's Static memory.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM   0xDF, Options
```

Arguments

The 1 byte argument *Options* is used to specify the size of the returned Static size as follows.

- *Options* = 0: 32-bit (4-byte) Static size returned.
- *Options* = 1: 64-bit (8-byte) Static size returned.

Stack Usage

Stack In	{empty}
Stack Out	StaticSize

StaticSize specifies the total size of Static in bytes. *StaticSizet* can either be a 32-bit (4-byte) or a 64-bit (8-byte) value depending upon the value of *Options*.

Remarks

The Z flag is cleared to zero if the number of Static bytes is too large to be held in the returned StaticSize, otherwise it is set to 1.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	x

C Unchanged.
V Unchanged
N Unchanged
Z Set if no overflow occurred, cleared otherwise.

Primitive set and number

Set one, number 0xDF

Get Transaction State

This primitive returns whether transaction protection is currently enabled.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

```
PRIM  0x16
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	Result

Result is one byte and holds the result of the operation as follows:

- *0 = Transaction protection off*
- *1 = Transaction protection on*

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set zero, number 0x16

GSM Authenticate

This primitive performs the A3A8 algorithm (the default algorithm implemented by MULTOS, if supported, is the Comp-128 version 2 algorithm) that is used by a SIM application whilst authenticating to the GSM network.

It is possible that a network-specific algorithm may replace the standard Comp-128 version 2 algorithm by the loading of a network-specific AMD into the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xCB
```

Arguments

None.

Stack Usage

Stack In	RANDAddr	KeyAddr	sreskcAddr
Stack Out	{empty}		

The 2 byte parameter RANDAddr is the starting address of the 16-byte random challenge to be used.
The 2 byte parameter KeyAddr is the starting address of the 16-byte key to be used.
The 2 byte parameter sreskcAddr is the starting address of the 12-byte result containing the 4-byte SRES and 8-byte Kc values.

Remarks

This primitive performs the Comp-128 version 2 algorithm as standard but may be replaced by an alternative network-specific algorithm.

This primitive is only available to an application if "GSM Authenticate" is set on in the application's access_list when loaded. This permits a network to restrict the use of the algorithm by third-party applications.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged

N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0xCB

Example

The following example declares 16 bytes of static memory to hold the 16 byte Key, the RAND, SRES and Kc values are held in session. The address for each of these is loaded onto the stack and the GSM Authenticate primitive is called.

```
prmGSMAuthenticate  EQU  0xCB

sKey  STATIC BYTE 16 =
0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08,0x09,0x0A,0x0B,0x0C,0x0D
,0x0E,0x0F,0x10
dsreskc DYNAMIC BYTE 16
dRAND  DYNAMIC BYTE 16

    LOADA   dRAND
    LOADA   sKEY
    LOADA   dsreskc
    PRIM    prmGSMAuthenticate
```

Initialise PIN

This primitive initialises either the application's PIN or the Global PIN, depending on the *access_list* bits of the ALC.

bit9*	bit8*	Meaning
0	0	Application PIN / Full access
0	1	Global PIN / Basic access
1	0	Global PIN / Write access
1	1	Global PIN / Full access

* Indexed from bit0

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☑	☑	☑	☑

Syntax

```
PRIM 0xE5
```

Arguments

None.

Stack Usage

Stack In	InitDataAddr
Stack Out	{empty}

The 2 byte parameter *InitDataAddr* is the start address of the following data block:

a) PIN Reference Data (8 bytes)
b) PIN Length (1 byte)
c) PIN Try Counter (1 byte)
d) PIN Try Limit (1 byte)
e) Checksum (4 bytes).

Checksum is the MULTOS Checksum calculated over fields a-d inclusive.

Remarks

An application is only allowed to Initialise the Global PIN in "Global Basic" mode when it has not been already initialised.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0xE5

Example

```
typedef struct
{
      BYTE amPinValue[8];
      BYTE bPinLength;
      BYTE bPinTryCounter;
      BYTE bPinTryLimit;
      BYTE amChecksum[4];
} INITIALISE_PIN_PARAMETERS;

#pragma melstatic
INITIALISE_PIN_PARAMETERS params;

// Default PIN value 1234
BYTE defaultPIN[4] = { 0x00, 0x01, 0x02, 0x03 };

void main(void)
{
      //… set params to required values
      memcpy(params.amPinValue,defaultPIN,4);
      params.bPinLength = 4;
      params.bPinTryCounter = 3;
      params.bPinTryLimit = 3;

      // Calculate checksum
      multosChecksum(11,params,params.amChecksum);

      // Call primitive
      __push (__typechk (INITIALISE_PIN_PARAMETERS *, params));
      __code (__PRIM, 0xE5);

      //…
}
```

Initialise PIN Extended

This is similar to *Initialise PIN* but allows for alternative PIN data block formats.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

PRIM 0xE4, *ElementId*

Arguments

ElementId can take the following values:
0x00: Initialise Pin Extended

Stack Usage

Stack In	InitDataAddr
Stack Out	{empty}

The 2 byte parameter *InitDataAddr* is the start address of either the following data blocks:

a) PIN Length (1 byte)
b) PIN Reference Data (PIN Length bytes)
c) PIN Try Counter (1 byte)
d) PIN Try Limit (1 byte)
e) Checksum (4 bytes).

Checksum is the MULTOS Checksum calculated over fields a-d inclusive.

Remarks

An application is only allowed to Initialise the Global PIN in "Global Basic" mode when it has not been already initialised.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged
Z Unchanged.

Primitive set and number

Set one, number 0xE4

Load CCR

This primitive pushes the Condition Code register onto the stack.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x05
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	CCR

The 1-byte output parameter *CCR* holds a byte whose value is the same as that of the CCR.

Remarks

This primitive pushes one byte to the stack that contains the same bit settings as the Condition Code Register.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C	Unchanged
V	Unchanged
N	Unchanged
Z	Unchanged

Primitive set and number

Set Zero, Number 0x05

Example

The following example performs an operation which will have different results on a MULTOS device that supports signed arithmetic than one which does not. It then loads the Condition Control register onto the stack and then performs a bit manipulation to determine if bit 1, the Negative Flag, is set. The code jumps to a label called exitSigned if it is.

```
prmLoadCCR  EQU  0x05
prmAND EQU  0xC0   // 00000011b
prmCMP EQU  0x00   // 00000000b

  PUSHB 0x00
  PUSHB 0x01
  SUBN  ,1
  PRIM  prmLoadCCR
  PRIM  prmBitManipulateByte, prmAND + prmCMP ,0x06
  BNE   isSigned

isNotSigned
  //The MULTOS device does not support signed arithmetic
isSigned
  //The MULTOS device supports signed arithmetic
```

Lookup

This primitive searches a byte array for the first instance of a specific byte value.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds ByteValue and Address of the search array
PRIM 0x0A
```

Arguments

None.

Stack Usage

Stack In	ByteValue	ArrayAddr
Stack Out	Offset	

The 1-byte parameter *ByteValue* is the value for which to search within the array. The 2-byte parameter *ArrayAddr* is the location of the array to be searched. Finally, the 1-byte output parameter Offset is the location within the array where the first instance of *ByteValue* was found.

Remarks

The primitive expects that the first byte of the search array indicates the total length in bytes of the remainder of the array. For example,

```
Length, Byte1, Byte2, … ByteN
```

where the value of *Length* is *N*.

The value *Offset* returned from this primitive is zero based and, continuing from the example above, counting begins with Byte1.

The CCR Z flag is set to indicate if an instance of *ByteValue* has been found.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged

N Unchanged

Z Set if the byte is found in the array, cleared otherwise

Primitive Set and Number

Set Zero, Number 0x0A

Example

The following example searches for the first instance of the byte 0x02 in the array.

```
prmLookup   EQU  0x0A

// Declare the array
//  Number of bytes in the array
//  Byte Values for the array

sArray      STATIC BYTE 5 = 0x04, 0x01, 0x02, 0x03, 0x55

  PUSHB     0x02 //byte value to find
  LOADA     sArray    //address of the array
  PRIM      prmLookup

// Stack now equals: 0x01
```

To cater for the case where a value is not found, the following could be used:

```
  PUSHB     0xFF // byte value to find
  LOADA     sArray    // address of the array
  PRIM      prmLookup
  // CCR Z flag is cleared if the value is not found
  JNE  Not_Found

Not_Found
  // handling here
```

Lookup Word

This primitive searches a byte array for the first instance of a specific 2 byte value.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☒	☑	☑	☑

Syntax

```
// Stack holds WordValue and Address of the search array
PRIM 0x14
```

Arguments

None

Stack Usage

Stack In	WordValue	ArrayAddr
Stack Out	Offset	

The 2-byte parameter *WordValue* is the value for which to search within the array. The 2-byte parameter *ArrayAddr* is the location of the array to be searched. Finally, the 2-byte output parameter *Offset* is the location within the array where the first instance of *WordValue* was found (or the first instance of either a LSB or MSB match of *WordValue* if no full match was found).

Remarks

The primitive expects that the first word of the search array indicates the number of words in the remainder of the array. For example,

Length, Word1, Word2, … WordN

where the value of Length is N.

The value *Offset* returned from this primitive is zero based and, continuing from the example above, counting begins with Word1.

The CCR Z and C flags are changed to indicate whether a full or partial match was founds as follows. Note that a full match takes precedence over a partial match.

- Full match of WordValue: C = 1 and Z = 1
- Partial match of LSB of WordValue only: C = 0 and Z = 1
- Partial match of MSB of WordValue only: C = 1 and Z = 0
- No match (full or partial): C = 0 and Z = 0

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Changed as described above
V Unchanged
N Unchanged
Z Changed as described above

Primitive Set and Number
Set Zero, Number 0x14

Manage Stack

This primitive manages the stack belonging to the executing application. It is intended to be used in conjunction with the *Exit to MULTOS and Restart* primitive.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1 / 2	MULTOS 4.5.x
✗	✗	✗	✗	✗	☑

Syntax

```
PRIM  0x07, Options
```

Arguments

Options defines the operation to perform on the stack as follows:

0 = Save the application's stack to an internal temporary buffer
1 = Restore the application's stack from the saved copy

Stack Usage

Stack In	{empty}
Stack Out	{empty}

Remarks

An application can call this primitive after calling Exit to MULTOS and Restart but before exiting back to MULTOS to save the contents of the application's stack. When the application restarts it can call this primitive again to restore the state of its stack. This allows the application to resume execution at the point just after when it exited to MULTOS.

To prevent stack data leakage between applications MULTOS automatically deletes the saved stack if the exit to MULTOS results in the executing application being deleted.

This primitive abends under the following conditions:

- Options = 0 (save stack) and the application has not called Exit to MULTOS and Restart previously.
- Options = 1 (restore stack) and the application has not saved the stack previously.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set one, number 0x07

Memory Compare

This primitive compares two blocks of bytes to determine if they hold the same data.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds length, addr1 and addr2 parameters
PRIM 0x0B
```

Arguments

None.

Stack Usage

Stack In	Length	Addr1	Addr2
Stack Out	{empty}		

The 2-byte parameter *Length* gives the size of the memory areas to be compared. The 2-byte values *Addr1* and *Addr2* are the locations of the areas.

Remarks

The comparison performed by this primitive is based on subtraction. The second operand, the area corresponding to the address on the top of the stack, is subtracted from the first. No data is modified, but the Condition Code Register is set according to the result of the operation.

There are three possible results of the comparison of blocks of size *Length*. They and the CCR setting used to indicate that result are:

- When the byte block at *Addr1* > the byte block at *Addr2*, both CCR C and CCR Z flags are cleared.
- When the byte block at *Addr1* = the byte block at *Addr2*, the CCR C flag is cleared and CCR Z flag is set
- When the byte block at *Addr1* < the byte block at *Addr2*, the CCR C flag is set and CCR Z flag is cleared.

Where the number of bytes to be compared is a compile time constant and *Length* is no more than 255 bytes the primitive Memory Compare Fixed Length may be used.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set or cleared as above
V Unchanged
N Unchanged
Z Set or cleared as above

Primitive Set and Number

Set Zero, Number 0x0B

Example

The following example declares two four byte blocks which in a real application would represent PIN numbers. sPIN is the copy of the PIN in the applications static and pPIN is the copy of the PIN in the public segment sent as part of an APDU. The memory compare primitive is called to compare whether the two PIN numbers are the same.

```
prmMemoryCompare EQU  0x0B

pPIN  PUBLIC BYTE 2
sPIN  STATIC BYTE 2 = 0x12, 0x34

  PUSHW   2
  LOADA   sPIN
  LOADA   pPIN
  PRIM    prmMemoryCompare
  JNE     errPINdoesNotMatch
  EXIT

errPINdoesNotMatch
  EXITSW  0x65,0x81
```

Memory Compare Enhanced

This primitive compares two blocks of bytes.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1	MULTOS 4.5.x
✗	✗	✗	✗	✗	✓

Syntax

```
PRIM  0x05, Mode
```

Arguments

Mode defines the comparison mode as follows:

0 = Equality only test
1 = Equality and greater/less than test.

Stack Usage

Stack In	Length	Addr1	Addr2
Stack Out	Result		

The 2-byte parameter Length gives the size of the memory areas to be compared. The 2-byte values Addr1 and Addr2 are the locations of the areas. The 2-byte Result is the result of the comparison.

Remarks

The operation of this primitive is controlled by the Mode value.

<u>Equality Only Test</u>
The two memory areas are tested for equality and the Result can be one of the following two values.

0x5555 = blocks not equal
0xAAAA = blocks equal

<u>Equality and Greater/Less Than Test</u>
The comparison performed by this primitive is based on subtraction. The second operand, the area corresponding to the address on the top of the stack, is subtracted from the first (no data is modified) and the Result can be one of the following two values.

0x5A5A = byte block at Addr1 > byte block at Addr2
0xA5A5 = byte block at Addr1 < byte block at Addr2
0xAAAA = blocks equal

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set one, number 0x05

Memory Compare Fixed Length

This primitive is used to compare two blocks of bytes of a fixed length.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Addr1, Addr2 parameter
PRIM 0x0F, Length
```

Arguments

The argument *Length* is the number of bytes in each of the byte blocks.

Stack Usage

Stack In	Addr1	Addr2
Stack Out	{empty}	

The 2-byte values *Addr1* and *Addr2* are the locations of the areas to be compared.

Remarks

The *Length* value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes.

The comparison performed by this primitive is based on subtraction. The second operand, the area corresponding to the address on the top of the stack, is subtracted from the first. No data is modified, but the Condition Code Register is set according to the result of the operation.

There are three possible results of the comparison of blocks of size *Length*. They and the CCR setting used to indicate that result are:

- When the byte block at *Addr1* > the byte block at *Addr2*, both CCR C and CCR Z flags are cleared.
- When the byte block at *Addr1* = the byte block at *Addr2*, the CCR C flag is cleared and CCR Z flag is set
- When the byte block at *Addr1* < the byte block at *Addr2*, the CCR C flag is set and CCR Z flag is cleared.

The primitive works correctly even if the blocks overlap

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set or cleared as above
V Unchanged
N Unchanged
Z Set or cleared as above

Primitive Set and Number

Set One, Number 0x0F

Example

The following example declares two four byte blocks which in a real application would represent PIN numbers. sPIN is the copy of the PIN in the applications static and pPIN is the copy of the PIN in the public segment sent as part of an APDU. The Memory Compare Fixed Length primitive is called to compare whether the two PIN numbers are the same.

```
prmMemoryCompareFixedLengthEQU  0x0F

pPIN  PUBLIC BYTE 2
sPIN  STATIC BYTE 2 = 0x12, 0x34


  LOADA   sPIN
  LOADA   pPIN
  PRIM    prmMemoryCompareFixedLength, 2
  JNE     errPINdoesNotMatch
  EXIT

errPINdoesNotMatch
  EXITSW  0x65,0x81
```

Memory Copy

This primitive copies a block of bytes from one location to another.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Length, DestAddr, SourceAddr parameters
PRIM 0x0C
```

Arguments

None.

Stack Usage

Stack In	Length	DestAddr	SourceAddr
Stack Out	{empty}		

All of the parameters are 2 bytes in size. The value *Length* is the number of bytes to copy. The values *DestAddr* and *SourceAddr* are, respectively, the locations to where and from where the data is copied.

Remarks

Where the number of bytes to be copied is a compile time constant and *Length* is no more than 255 bytes the primitive Memory Copy Fixed Length may be used.

This primitive works correctly even if the source and destination blocks overlap.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, number 0x0C

Example

The following example copies a byte block from the bottom of Public to a variable called sName.

```
prmMemoryCopy EQU 0x0C
pLc   EQU PT[-8]
sName STATIC BYTE 0x20

  LOAD   pLc,2        //Length of byte block to copy
  LOADA  sName        //Address to copy to (destination)
  LOADA  PB[0000]     //Address to copy from (source)
  PRIM   prmMemoryCopy
```

Memory Copy Additional Static

This primitive copies a block of memory from a segment address to an area of Static, from an area of Static to a segment address or from one area of Static to another area of Static. Either 32-bit or 64-bit Static addressing is supported.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM   0xDD, Options
```

Arguments

The 1 byte argument *Options* is used to specify the direction of the copy, whether the copy is atomic and the Static addressing mode as follows.

b7	b6	b5	b4	b3	b2	b1	b0	Meaning
x	x	RFU	RFU	RFU	RFU	0	0	Copy data from segment address to Static offset
x	x	RFU	RFU	RFU	RFU	0	1	Copy data from Static offset to segment address
x	x	RFU	RFU	RFU	RFU	1	0	Copy data from Static offset to Static offset
x	x	RFU	RFU	RFU	RFU	1	1	RFU
0	x	RFU	RFU	RFU	RFU	x	x	Non-atomic copy
1	x	RFU	RFU	RFU	RFU	x	x	Atomic copy
x	0	RFU	RFU	RFU	RFU	x	x	32-bit Static addressing mode
x	1	RFU	RFU	RFU	RFU	x	x	64-bit Static addressing mode

Stack Usage (copy from segment address to Static offset)

If *Options* indicates that the copy is from a segment address to a Static offset then the stack will contain the following:

Stack In	*Length*	*StaticOffset*	*SegAddr*
Stack Out	{empty}		

The 2-byte *Length* identifies the number of bytes to copy.

StaticOffset specifies the Static offset of the destination. *StaticOffset* can either be a 32-bit (4-byte) or a 64-bit (8-byte) value depending upon the specified Static addressing mode.

The 2-byte SegAddr specifies the segment address of the source.

Stack Usage (copy from Static offset to Segment address)

If *Options* indicates that the copy is from a Static offset to a segment address then the stack will contain the following:

Stack In	*Length*	*SegAddr*	*StaticOffset*
Stack Out	{empty}		

The 2-byte *Length* identifies the number of bytes to copy.

The 2-byte SegAddr specifies the segment address of the destination.
StaticOffset specifies the Static offset of the source. *StaticOffset* can either be a 32-bit (4-byte) or a 64-bit (8-byte) value depending upon the specified Static addressing mode.

Stack Usage (copy from Static offset to Static offset)

If *Options* indicates that the copy is from a Static offset to a Static offset then the stack will contain the following:

Stack In	*Length*	*StaticOffset2*	*StaticOffset1*
Stack Out	{empty}		

Length identifies the number of bytes to copy. This length can either be a 32-bit (4-byte) or a 64-bit (8-byte) value depending upon the specified Static addressing mode.

StaticOffset2 specifies the Static offset of the destination and *StaticOffset1* specifies the Static offset of the source. *StaticOffset1* and *StaticOffset2* can be a 32-bit (4-byte) or a 64-bit (8-byte) value depending upon the specified Static addressing mode.

Remarks

Invalid segment or Static addresses will cause an abend. The copy is successful even if the source and destination areas overlap.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged.

Primitive set and number

Set one, number 0xDD

Memory Copy Fixed Length

This primitive copies a block of bytes of a fixed length from one location to another.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds DestAddr, SourceAddr parameters
PRIM 0x0E, Length
```

Arguments

The argument *Length* is the number of bytes to copy.

Stack Usage

Stack In	DestAddr	SourceAddr
Stack Out	{empty}	

All of the parameters are 2 bytes in size. The values *DestAddr* and *SourceAddr* are, respectively, the locations to where and from where the data is copied.

Remarks

The *Length* value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes.

This primitive works correctly even if the blocks overlap.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set One, Number 0x0E

Example

The following example copies the 32 bytes at the bottom of Public to a variable called sName.

```
prmMemoryCopyFixedLength   EQU 0x0E

sName STATIC BYTE 32

  LOADA   sName  //Address to copy to (destination)
  LOADA   PB[0000]    //Address to copy from (source)
  PRIM    prmMemoryCopyFixedLength, 32
```

Memory Copy From Replaced Application

This primitive allows for the currently executing application to copy the Session or Static data belonging to the application that it is replacing.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1/2	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

```
// Stack holds Length, Destination, Offset parameters
PRIM 0x06 Options
```

Arguments

Options:

- Bit 0: source data (0 = session, 1 = Static)
- Bit 6: Static addressing mode (0 = 32 bit, 1= 64 bit)
- Bit 7: atomicity (0 = non-atomic, 1 = atomic)

Stack Usage

Stack In	Length	DestAddr	SourceAddr
Stack Out	{empty}		

Offset is the offset into the replaced application's session or Static data. If the session data is being read then the offset is a 16-bit value, otherwise its size depends upon the addressing mode (32-bit or 64-bit).

Destination is a 16-bit value and holds the destination segment address. Length is a 16-bit value and holds the length of the data to read.

This primitive abends if no readable replaced application exists or if the offset/length values are invalid for the replaced application.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set one, number 0x06

Memory Copy Non-Atomic

This primitive copies a block of bytes from one location to another. If the byte block is copied into the static area, data item protection function will be disabled if possible.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Length, DestAddr, SourceAddr parameters
PRIM 0x0F
```

Arguments

None.

Stack Usage

Stack In	Length	DestAddr	SourceAddr
Stack Out	{empty}		

All of the parameters are 2 bytes in size. The value *Length* is the number of bytes to copy. The values *DestAddr* and *SourceAddr* are, respectively, the locations to where and from where the data is copied.

Remarks

This primitive works correctly even if the source and destination blocks overlap.

Where the number of bytes to be copied is a compile time constant and *Length* is no more than 255 bytes the primitive Memory Copy Non-Atomic Fixed Length may be used.

When copying into the static memory area with this primitive, the copying will be performed more quickly than with Memory Copy primitive as the data items are not protected.

This primitive is a request for a non-atomic memory copy. Non-atomic means that the data will be written in EEPROM page size blocks (see [MIR] for page size information for a specific implementation) when complete pages are available. If the data being copied results in writing to only a part of a page, then MULTOS will revert to an atomic copy. Whilst this copy operation may be faster the data in the destination will not be protected if power-off occurred during the copying to the static area. MULTOS will always guarantee the integrity of data other than the data being copied.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, number 0x0F

Example

The following example shows how the primitive can be used as well as explaining how the copy takes place. The example will assume a page size of 32 bytes and that the copy destination is at the start of a page.

```
prmMemoryCopyNonAtomic EQU 0x0F

sDataBlock STATIC BYTE 270
pData PUBLIC BYTE 270

  PUSHW  0x010E      // length of 270 bytes to be copied
  LOADA  sDataBlock       // Address to copy to (destination)
  LOADA  pData field    // Address to copy from (source)
  PRIM   prmMemoryCopyNonAtomic
```

The memory copy would then copy 8 pages of data as 32 byte blocks. The remaining 24 bytes do not constitute a full page and would be copied atomically.

Memory Copy Non-Atomic Fixed Length

This primitive copies a block of bytes of a fixed length from one location to another. If the byte block is copied into the static area, data item protection function will be disabled if possible.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
// Stack holds estAddr, SourceAddr parameters
PRIM 0x13, Length
```

Arguments

The argument *Length* is the number of bytes to copy.

Stack Usage

Stack In	DestAddr	SourceAddr
Stack Out	{empty}	

All of the parameters are 2 bytes in size. The values *DestAddr* and *SourceAddr* are, respectively, the locations to where and from where the data is copied.

Remarks

This primitive works correctly even if the source and destination blocks overlap.

When copying into the static memory area with this primitive, the copying will be performed more quickly than with Memory Copy primitive as the data items are not protected.

This primitive is a request for a non-atomic memory copy.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, number 0x13

Example

The following example shows how the primitive can be used as well as explaining how the copy takes place. The example will assume a page size of 32 bytes and that the copy destination is at the start of a page.

```
prmMemoryCopyNonAtomicFixedLength EQU 0x13

sDataBlock STATIC BYTE 120
pData PUBLIC BYTE 120

  LOADA  sDataBlock       // Address to copy to (destination)
  LOADA  pData field    // Address to copy from (source)
  PRIM   prmMemoryCopyNonAtomicFixedLength, 0x78
```

The memory copy would then copy 3 pages of data as 32 byte blocks. The remaining 24 bytes do not constitute a full page and would be copied atomically.

Memory Fill

This primitive fills a block of memory with a specific byte value.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

```
PRIM  0x19
```

Stack Usage

Stack In	*Value*	*Length*	*Address*
Stack Out	{empty}		

The 1-byte *Value* identifies the value to fill the specified block with.

The 2-byte *Length* identifies the number of bytes to fill.

The 2-byte *Address* specifies the segment address of the block to be filled

Remarks

Invalid block will cause an abend.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged.

Primitive set and number

Set zero, number 0x19

Memory Fill Additional Static

This primitive fills a block of Static memory with a specific byte value. Either 32-bit or 64-bit Static addressing is supported.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM   0xDE, Options
```

Arguments

The 1 byte argument *Options* is used to specify whether the fill is atomic and the Static addressing mode as follows.

b7	b6	b5	b4	b3	b2	b1	b0	Meaning
0	x	RFU	RFU	RFU	RFU	RFU	RFU	Non-atomic fill
1	x	RFU	RFU	RFU	RFU	RFU	RFU	Atomic fill
x	0	RFU	RFU	RFU	RFU	RFU	RFU	32-bit Static addressing mode
x	1	RFU	RFU	RFU	RFU	RFU	RFU	64-bit Static addressing mode

Stack Usage

Stack In	*Value*	*Length*	*StaticOffset*
Stack Out	{empty}		

The 1-byte *Value* identifies the value to fill the specified area of Static with.

Length identifies the number of bytes to fill. This length can either be a 32-bit (4-byte) or a 64-bit (8-byte) value depending upon the specified Static addressing mode.

StaticOffset specifies the Static offset of the destination. *StaticOffset* can either be a 32-bit (4-byte) or a 64-bit (8-byte) value depending upon the specified Static addressing mode.

Remarks

Invalid Static addresses will cause an abend.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged.

Primitive set and number

Set one, number 0xDE

Modular Exponentiation / RSA Sign

This primitive performs a modular exponentiation operation, the basis of the RSA algorithm. This version of the primitive will execute with full countermeasures to protect the algorithm.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack: eLen, mLen, eAddr, mAddr, inAddr, outAddr
PRIM 0xC8
```

Arguments

None.

Stack Usage

Stack In	eLen	mLen	eAddr	mAddr	inAddr	outAddr
Stack Out	{empty}					

All parameters are 2 bytes in size. The values *eLen* and *mLen* represent the length of the exponent and modulus respectively. These lengths represent the size in bytes. The value *eAddr* is the location of the exponent of size *eLen*, while *mAddr* is the location of the modulus of size *mLen*. The addresses *inAddr* and *outAddr* are the location of the input to the modular exponentiation operation and the address to where the output will be written.

Remarks

This primitive performs modular exponentiation operation and the result is written at the specified address *outAddr*.

Moduli with length that is not a multiple of 8 bits are padded at the least significant end with bits 0. So, a 1023-bit modulus would have the least significant bit of the least significant byte set to 0.

The size of the input and output is considered to the same as that of the modulus. They are all *mLen* in size.

The primitive will function normally if *inAddr* and *outAddr* point to the same memory area. That is to say the output can overwrite the input.

In order to enable modular exponentiation to operate correctly there are a number of general conditions that must be met:

- The modulus must be odd.
- The base value must be less than the modulus.
- The exponent must be less than the modulus.
- The length of the exponent must be less than or equal to the length of the modulus.

There are some implementation specifics that may impact on the usage of this primitive. For example, the most significant byte of the modulus should not be zero although some platforms may permit it. As another example, some implementations may only work on fixed key lengths. It may also be the case that an implementation may provide optimised support for an exponent length of 1 with a value of 3 and from MULTOS 4.2 one may also provide optimised support for an exponent length of 3 and a value of 65537. See the MULTOS Implementation Report [MIR] for specific information.

Primitive set and number

Set zero, number 0xC8

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example shows how to use the modular exponentiation primitive to encrypt input using the private exponent. Here the 72-byte input value is found in public and the output overwrites it.

```
prmModularExponentiation         EQU 0xC8


sD   STATIC BYTE 64  // 64-byte private exponent
sN   STATIC BYTE 72  // 72-byte modulus

  PUSHW     64          // exponent size
  PUSHW     72          // modulus size
  LOADA     sD          // exponent location
  LOADA     sN          // modulus location
  LOADA     PB[0]       // input location
  LOADA     PB[0]       // output location
  PRIM prmModularExponentiation

  EXITLA    72
```

Modular Exponentiation CRT / RSA Sign CRT

This primitive performs a modular exponentiation using the Chinese Remainder Theorem algorithm.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack: dpdqLen, dpdqAddr pquAddr, inAddr, outAddr
PRIM 0xC9
```

Arguments

None.

Stack Usage

Stack In	dpdqLen	dpdqAddr	pquAddr	inAddr	outAddr
Stack Out	{empty}				

All of the parameters are 2 bytes in size. The value held in *dpdqLen* is the size in bytes of the area located at *dpdqAddr*, where the dp value concatenated to the dq value is held. The parameter *pquAddr* is the location of the memory area where the values p, q and u are concatenated in that order. The parameters *inAddr* and *outAddr* are respectively the location of the input and the location where the output of the operation is written.

Remarks

This primitive performs modular exponentiation operation, where the operands are held in CRT format, and the result is written at the specified address *outAddr*.

Moduli with length that is not a multiple of 8 bits are padded at the least significant end with bits 0. So, a 1023-bit modulus would have the least significant bit of the least significant byte set to 0.

The size of the input, output and public modulus is considered to the value given in dpdqLen.

The primitive will function normally if *inAddr* and *outAddr* point to the same memory area. That is to say the output can overwrite the input.

In order to enable modular exponentiation CRT to operate correctly there are a number of general conditions that must be met:

- The public modulus size as measured in bytes and given in *dpdqLen* must be even
- p and q must be odd primes of size *dpdqLen / 2*
- The public modulus is equal to p * q
- u is the inverse of q modulo p; i.e., (q * u) modulo (p) ≡1 modulo (p). This means that u < p. The value u is held in a memory area of size *dpdqLen / 2*
- dp is the value of the secret exponent modulo (p – 1) and is of size *dpdqLen / 2*
- dq is the value of the secret exponent modulo (q – 1) and is of size *dpdqLen / 2*

The most significant byte of p and q should not be zero. Some platforms may permit leading zero bytes, but this cannot be guaranteed.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, Number 0xC9

Example

The following example uses the modular exponentiation CRT primitive to encrypt a 72-byte value held in public memory. The result of the operation overwrites the input.

```
ModularExponentiationCRT   EQU  0xC9

sMod   STATIC BYTE 72
sDPDQ  STATIC BYTE 108
// following areas considered adjacent: sP | sQ | sU
sP     STATIC BYTE 36
sQ     STATIC BYTE 36
sU     STATIC BYTE 36


  PUSHW  72         // Length of modulus
  LOADA  sDPDQ      // Address of dp|dq
  LOADA  sP         // Address of p|q|u
  LOADA  PB[0]      // Address of base
  LOADA  PB[0]      // Address of result
  PRIM   ModularExponentiationCRT
```

Modular Exponentiation CRT Protected / RSA Sign CRT Protected

This primitive performs a modular exponentiation using the Chinese Remainder Theorem. The keys used however are stored in an enciphered form in memory and must be deciphered before use. It also provides a means to protect plaintext keys for subsequent use.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xDC
```

Arguments

None.

Stack Usage

Stack In	dpdqLen	dpdqAddr	pquAddr	inAddr	outAddr
Stack Out	{empty}				

The 2-byte parameter dpdqLen is the length in bytes of the modulus, which is even.
The 2-byte parameter dpdqAddr is the segment address of dp concatenated to dq.
The 2-byte parameter pquAddr is the segment address of p, q and u.
The 2-byte parameter inAddr is the segment address of the base bytes OR the address of dpdq if the keys are to be protected for subsequent use by the primitive.
The 2-byte parameter outAddr is the segment address to write the result to OR the address of pqu if the keys are to be protected for subsequent use by the primitive.

Remarks

This primitive calculates an exponent modulo a modulus, using the Chinese Remainder Theorem (CRT). The result (the base to the power of the exponent, modulo the modulus) is written at the specified segment address. The values of p and q are the two large prime numbers that were originally chosen to generate the key. The size of p and q is equal to half the length of the modulus. The remaining parameters for this primitive may be calculated from the values of p and q.

u	inverse of q modulo p, of length dpdqLen / 2
dp	secret exponent modulo p - 1, of length dpdqLen / 2
dq	secret exponent modulo q - 1, of length dpdqLen / 2

A complete description of the Chinese Remainder Theorem and Cryptography is beyond the scope of this document. Please refer to a more specialised book on cryptography for more details on Chinese Remainder Theorem.

In order for Chinese Remainder Theorem to operate correctly there are certain conditions that must be satisfied.

1. N = p * q
2. q>2 & p>2
3. p and q must both be odd.
4. The most significant byte of p and q should not be zero. Some platforms may permit leading zero bytes, but this cannot be guaranteed on each platform. Primes with length not a multiple of 8 bits are left padded with bits 0.
5. u must be less than p
6. u = (q * u) mod (p) = 1

The keys used (p,q,u,dp,dq) are stored as protected data items (for example enciphered). The method used is implementation specific and not described here. Before use, the implementation will reverse the effects of this encipherment to recover the actual keys to be used. This will be done without changing the stored value of the keys.
In order to protect the keys in the first place however, it is necessary for the application to ask the implementation to perform the necessary transformation and store the keys in the protected form. This is done by calling the primitive where the inAddr is set to dpdqAddr AND outAddr is set to pquAddr. When this happens, the implementation does NOT invoke the modular exponentiation function but instead simply transform the keys into their protected form and writes them back to the addresses specified by inAddr and outAddr.

If the primitive is called with inAddr set to pguAddr and outAddr set to dpdqAddr and passed protected keys, the original unprotected keys are be obtained and written back over the corresponding input data.

If inAddr points to dpdqAddr (or pquAddr) but outAddr does not point to pquAddr (or dpdqAddr) or outAddr points to pquAddr (or dpdqAddr) but inAddr does not point to dpdqAddr (or pquAddr) then the primitive will perform a Modular Exponentiation using the protected keys specified in pquAddr and dpdpAddr and either exponentiating the protected input keys to produce the output result (if inAddr is pquAddr or dpdqAddr) or overwriting the protected keys with the result (if outAddr is pquAddr or dpdqAddr)

Note: Modular Exponentiation CRT in some implementations may only work on fixed key lengths. See the MULTOS Implementation Report for more details.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged.

Primitive Set and Number

Set Zero, number 0xDC

Example

The following example uses the modular exponentiate CRT primitive to perform an encipher or decipher.

```
prmModExpCRTProtected    EQU  0xDC

sMod   STATIC BYTE 64
sDPDQ  STATIC BYTE 96
sP     STATIC BYTE 32
sQ     STATIC BYTE 32
sU     STATIC BYTE 32
sBase  STATIC BYTE 64

//--------------------------------------------------
//Call primitive to protect the keys
//   (word) Length of Modulus
//   (word) Address of dp|dp
//   (word) Address of p|q|u
//   (word) Address of dp|dq
//   (word) Address of p|q|u
//--------------------------------------------------

     PUSH   0x64         //Length of modulus
     LOADA  sDPDQ        //Address of dp|dq
     LOADA  sP           //Address of p|q|u
     LOADA  sDPDQ        //Address of dp|dq
     LOADA  sP           //Address of p|q|u
     PRIM   prmModExpCRTProtected // call primitive

//--------------------------------------------------
//Now call the primitive to perform a CRT exponentiation
//using the previously protected keys

     PUSH   0x64         //Length of modulus
     LOADA  sDPDQ        //Address of dp|dq
     LOADA  sP           //Address of p|q|u
     LOADA  sBase        //Address of base
     LOADA  PB[0]        //Address of result
     PRIM   prmModExpCRTProtected // call primitive
```

Modular Inverse

This primitive calculates the modular inverse of a value. A modular inverse of an integer *b (modulo m)* is the integer b^{-1} such that $b\ b^{-1} = 1 \ (mod\ m)$.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD0, Prime
```

Arguments

The 1-byte argument Prime is set to 1 if the modulus used is prime. Otherwise, it is set to 0.

Stack Usage

Stack In	mLen	modulusAddr	inLen	inAddr	outAddr
Stack Out	{empty}				

All the parameters are 2 bytes in size. The parameter *mLen* states the length in bytes of the modulus value, which can be found at *modulusAddr*. The value *inLen* gives the length of the input data found at *inAddr*. The result of the modular inverse calculation is written to *outAddr*.

Remarks

The size of the output held at *outAddr* is considered to the value given in *mLen*.

The value calculated is one such that the value stored at the segment address *inAddr* modulo the modulus stored at the segment address *modulusAddr* is congruent to 1 modulo the supplied modulus.

In order to calculate the modular inverse the input value and the modulus must be co-prime. If they are not the CCR Z flag is set and no value is written to *outAddr*.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the modular inverse cannot be calculated, cleared otherwise

Primitive Set and Number

Set One, Number 0xD0

Example

The following example shows how to use the Modular Inverse primitive to calculate the secret key of an RSA key set with a 128-byte modulus and a public exponent of 3. The primitive call below calculates the modular inverse of 3 with respect to the modulus ((P – 1) * (Q – 1)).

```
prmModInv EQU 0xD0
prmMultiplyN EQU 0x10

dModulus DYNAMIC BYTE 128
sPrimeP STATIC BYTE 64 // The first prime
sPrimeQ STATIC BYTE 64 // The second prime

  LOAD sPrimeP, 64          // Load P
  DECN ,64             // P - 1
  LOAD sPrimeQ, 64          // Load Q
  DECN ,64             // Q -1
  PRIM prmMultiplyN, 64     // (P – 1) * (Q – 1)
   STORE dModulus, 128// move result to variable
//---------------------------------------------------
//Call Modular Inverse to calculate secret key
//---------------------------------------------------
  PUSHB 3              // Public Exponent
  PUSHW 128            // Size of modulus
  LOADA dModulus       // Address of modulus
  PUSHW 1              // Size of input
  LOADA DT[-7]         // Address of input
  LOADA PB[0]               // Address of destination
  PRIM prmModInv, 0x00      // Calculate inverse
  BEQ Invalid               // Invalid if no inverse
  EXITLA 128                // Return result
Invalid
  EXITSW 0x9E, 0x20         // No inverse possible
```

Modular Multiplication

This primitive multiples two operands and reduces the result of the multiplication modulo a given modulus.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xC2
```

Arguments

None.

Stack Usage

Stack In	lenMod	addrOp1	addrOp2	addrMod
Stack Out	{empty}			

All the parameters are 2 bytes in size. The parameter *lenMod* is the size of the modulus supplied and located at *addrMod*. The parameters *addrOp1* and *addrOp2* are the locations of the multiplicands.

Remarks

This primitive calculates a product modulo a modulus, that is (Operand1 * Operand2) mod modulus. The result overwrites the first operand.

Both operands must represent values that are less than that of the modulus.

The modulus and both operands are considered to be of size *lenMod*.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, Number 0xC2

Examples

The following example uses modular multiplication where the operands are in public memory.

```
prmModularMultiplication   EQU  0xC2
MODSIZE                   EQU  72

sModulus STATIC BYTE MODSIZE

     PUSHW  MODSIZE
     LOADA  sModulus
     LOADA  PB[0]
     LOADA  PB[MODSIZE]
     PRIM   prmModularMultiplication
     EXITLA MODSIZE
```

Modular Reduction

This primitive reduces an operand with respect to a modulus.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xC3
```

Stack Usage

Stack In	lenOp	lenMod	addrOp	addrMod
Stack Out	{empty}			

All parameters are 2 bytes in size. The parameters *lenOp* and *lenMod* state the size of the operand to be reduced and the modulus respectively. The location of the operand is given in *addrOp* while the modulus location is given in *addrMod*.

Remarks

This primitive calculates Operand mod Modulus. The result is written to *addrOp* and will be of length *lenMod*.

If *lenOp* is less than *lenMod* the result is undefined.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, Number 0xC3

Example

The following example reduces a value with respect to a 96-byte modulus. The value to be reduced is sent as command data.

```
prmModReduction   EQU   0xC3
pLC               EQU   PT[-8]
MODSIZE           EQU   96

sModulus STATIC BYTE MODSIZE

// check that incoming data length >= 96
CMPW   pLC, MODSIZE
JLT    err_OperandSize
// stack parameters set
LOAD   pLC, 2
PUSHW  MODSIZE
LOADA  PB[0]
LOADA  sModulus
PRIM   prmModReudction
```

MultiplyN

This primitive multiplies two unsigned blocks of bytes from the stack together and leaves the result on the stack.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds Operand1, Operand2
PRIM 0x10, Length
```

Arguments

The argument *Length* indicates the size of the multiplicands.

Stack Usage

Stack In	Operand1	Operand2
Stack Out	Output	

The parameters *Operand1* and *Operand2* are the values of size *Length* that are to be multiplied. The output parameter *Output* holds the result of the multiplication is twice the size of *Length*.

Remarks

This primitive performs unsigned multiplication of two numbers. The result replaces the two operands at the top of stack.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Primitive Set and Number

Set One, Number 0x10

Example

The following example pushes two words onto the stack and multiplies them together. The result is left on the stack at the end of the example.

```
prmMultiplyN      EQU   0x10

PUSHW   0x0100         //Stack: 01,00
PUSHW   0x0002         //Stack: 01,00,00,02
PRIM    prmMultiplyN, 2     //Stack: 00,00,02,00
```

Pad

This primitive adds padding to a non-padded message.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x15, PadScheme
```

Arguments

The 1-byte argument PadScheme specifies the padding scheme, as follows.

- 0x01: The message is appended with the byte 0x80 and it is then padded with zero or more bytes of 0x00 to the next multiple of BlockLen bytes.
- 0x02: The message is appended with the byte 0x80 and it is then padded with one or more bytes of 0x00 to the next multiple of BlockLen bytes.

Stack Usage

Stack In	BlockLen	lenMsg	addrMsg
Stack Out	lenMsgPadded		

The 1-byte parameter BlockLen specifies the padding block length in bytes.
The 2-byte parameter lenMsg specifies the length of the message to be padded in bytes.
The 2-byte parameter addrMsg specifies the segment address of the message to be padded.
The 2-byte result lenMsgPadded is the length in bytes of the padded message.

Remarks

This primitive pads a message to a specific block size according to a specified padding scheme.
The padding is added to the end of the specified block.
The calling application needs to ensure that the total size of the memory area in which the message is held in sufficiently large to allow the padding to be added.
The primitive supports block lengths of 8 and 16 bytes.
The primitive abends, if an invalid PadScheme value is supplied or if BlockLen is not supported by the implementation.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C	Unchanged
V	Unchanged
N	Unchanged
Z	Unchanged

Primitive Set and Number

Set One, Number 0x15

Platform Optimised Checksum

This primitive calculates a checksum using a platform-specific optimised algorithm.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM  0x89
```

Arguments

None.

Stack Usage

Stack In	Length	BlockAddr
Stack Out	Checksum	

The 2-byte parameter Length specifies the length in bytes of the block of memory to be checksummed.
The 2-byte parameter BlockAddr specifies the segment address of the block of memory to be checksummed.
The 4-byte parameter Checksum is the resultant four byte checksum.

Remarks

This primitive generates a four byte checksum over the block of memory starting at *BlockAddr* and of length *Length* using a performance optimised platform specific method.

If the block is in Static, and transaction protection is on, the checksum calculation takes pending writes into account. This is an exception to the general rule that pending writes are not visible to the application until they are committed.

There are no specific guarantees about the properties of the checksum algorithm, however, MULTOS implementations should aim to ensure that the checksum calculated has the full strength of a four byte checksum (i.e. there should be a 1/2^32 probablity that the checksums calculated over two different random blocks of data have the same value). The exact algorithm implemented by this primitive on a particular platform may be specified in the MULTOS Implementation Report but otherwise application developers cannot assume the results of this primitive will conform to any particular algorithm and should assume that the result calculated on different platforms will be different.

The checksum is returned in Dynamic, where it overwrites the length and segment address of the checksummed area.

It is valid to calculate the checksum of a block of length zero.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set One, Number 0x89

Example

The following example performs a checksum over a block of the Static area. The Static area is declared as a number of variables, however, the checksum is performed over all of the variables. Typically this may be used to verify that data has been loaded into the variables correctly.
The correct value for the checksum is held in the bottom four byte of Public.

```
prmPlatOptCheckSum    EQU    0x17
sName   STATIC BYTE 10
sVariable2 STATIC BYTE 5
sVariable3 STATIC BYTE 5

    PUSHW  20
    LOADA  sName
    PRIM   prmPlatOptCheckSum
    CMPN   PB[0000],4
    JNE    InvalidCheckSum

ValidCheckSum
    EXIT

InvalidCheckSum
    EXIT
```

Query0, Query1, Query2, Query3

These primitives check that a specific primitive from the sets 0 to 3 is available.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

There are four different primitive numbers assigned depending on which primitive set is being queried. They are:

```
PRIM 0x00, primNo// Check Set 0 primitive
PRIM 0x01, primNo// Check Set 1 primitive
PRIM 0x02, primNo// Check Set 2 primitive
PRIM 0x03, primNo// Check Set 3 primitive
```

Arguments

The 1-byte parameter *primNo* is the number of the primitive whose existence is being checked.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

There are no input or output parameters for these primitives.

Remarks

This group of primitives allows an application to query the availability of other primitives. Query0 is used to query the existence of primitives in set zero, Query 1 in set one, and so on.

The set of a primitive is given in the Primitive and Set Number section of each primitive documented in this document.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the desired primitive exists, cleared otherwise

Primitive Set and Number

Set One, numbers 0x00, 0x01, 0x02 and 0x03

Example

The following example tests for the implementation of the Query2 primitive.

```
prmQuery1    EQU  0x01
prmQuery2    EQU  0x02

     PRIM    prmQuery1, prmQuery2
     JNE          PrimNotSupported
     //Continue normal execution
  ...
PrimNotSupported
      EXIT
```

Query Channel

This primitive allows a MULTOS application to determine whether a channel is supported by the platform.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x86
```

Arguments

None.

Stack Usage

Stack In	ChannelID
Stack Out	{empty}

The 1-byte parameter *ChannelID* indicates which non-MULTOS application channel should be queried.

Remarks

If the specified channel is supported then the Z flag is set, otherwise it is cleared.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z set if the channel number is supported by the platform, cleared otherwise.

Primitive set and number

Set zero, number 0x86

Query Codelet

This primitive queries the existence of a specific codelet on the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x84
```

Arguments

None.

Stack Usage

Stack In	CodeletID
Stack Out	CodeletID

The 2-byte parameter *CodeletID* gives the globally unique identification number of the codelet to be queried.

Remarks

A codelet is code that has been included in ROM during the masking process. The code, which can be a complete application or a library of functions, is available to all applications on the device. Support for any particular codelet is at the discretion of the implementor. However, all codelets are registered with the MULTOS Key Management Authority and each has a unique identifier.

The purpose of this primitive is to determine if a codelet with the indicated ID is available on the MULTOS device. If the codelet with ID *CodeletID* is present in the device, the CCR Z flag is set.

The 2-byte value *CodeletID* remains on the stack after the primitive executes. This can be used by a following 'Call Codelet' primitive.

Note that a codelet ID of 0 is valid and refers to the executing application. Given that the executing application must exist, the codelet exists and the CCR Z flag is set accordingly. See the remarks section of the primitive 'Call Codelet' for further information.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the Codelet ID was found, cleared otherwise.

Primitive Set and Number

Set Zero, Number 0x84

Example

The following example checks that a particular codelet exists and if so proceeds to call the codelet. Note that the codelet ID used below is fictitious.

```
prmCallCodelet        EQU  0x83
prmQueryCodelet  EQU  0x84
CODELETID        EQU  0xF1F2

      PUSHW CODELETID
      PRIM  prmQueryCodelet
      // CCR Z flag cleared if does not exist
      BEQ   warning_CodeletUnsupported
      // otherwise call the codelet from start
      // codelet ID remained on stack
      PUSHZ 2
      PRIM  prmCallCodelet
```

Query Cryptographic Algorithm

This primitive allows a MULTOS application to determine whether a cryptographic algorithm is supported by the implementation. The primitive cannot be used to determine any restrictions in the use of the algorithm on any implementation.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x8A
```

Arguments

None.

Stack Usage

Stack In	AlgorithmID
Stack Out	{empty}

The 1-byte parameter *AlgorithmID* indicates which cryptographic algorithm should be queried.

AlgorithmID	Algorithm
0x03	DES [FIPS46-3]
0x04	Triple DES [FIPS46-3]
0x05	SEED [KISA]
0x06	AES [FIPS197]
0x07	RSA
0x08	Comp-128
0x09	ECC

Remarks

If the specified algorithm is supported then the Z flag is set, otherwise it is cleared.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z set if the algorithm is supported by the platform, cleared otherwise.

Primitive set and number

Set zero, number 0x8A

Query Interface Type

This primitive indicates the type of interface is being used to communicate to the device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x0D
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

There are no input or output parameters for this primitive.

Remarks

The primitive allows an application to determine if the terminal is communicating to the device using a contact or contactless interface. The CCR Z flag is updated depending on the result of the primitive processing.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the interface was contactless, cleared if contact

Primitive Set and Number

set zero, number 0x0D

Example

The following example exits indicating that a function is not supported if the interface type is contactless.

```
prmQueryInterfaceEQU  0x0D

      PRIM  prmQueryInterface
      JNE   err_FuncNotSupported
      // normal functioning if interface is contact

err_FuncNotSupported
     EXITSW 0x6A81
```

Read PIN

Returns the clear PIN which is either the local application PIN or the Global PIN depending on the access_list bit settings in the ALC. See Initialise PIN for details.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☑	☑	☑	☑

Syntax

```
PRIM 0xE6
```

Arguments

None.

Stack Usage

Stack In	OutAddr
Stack Out	PinLength

OutAddr is a 2 byte address of a buffer to contain the returned PIN.
PinLength (1 byte) is the length of the PIN returned in OutAddr

Remarks

This primitive will abend if the ALC Permission is either Global/Basic or Global/Write or if the PIN has not yet been initialised.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

set zero, number 0xE6

Reject Process Event

The Reject Process Event primitive can be called by any application to request that the current application process event is rejected by MULTOS. The application continues to execute normally, with MULTOS processing the request when the application exits. The effect of calling this primitive depends upon the event that is being rejected (see [MDG] for more information).

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
✗	✗	✗	✓	✓	✓

Syntax

```
PRIM 0xE9
```

Stack Usage

Stack In	{empty}
Stack Out	{empty}

Remarks

This primitive has no effect if the required *access_list* bit is not set.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, Number 0xE9

Reset Session Data

This primitive allows a shell application to reset the session data of all other applications on the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x81
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

There are no input or output parameters for this primitive.

Remarks

If the calling application is not executing as a shell, this primitive has no effect.

This primitive clears the session data of all other applications. The session data of the shell application is unaffected.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, Number 0x81

Reset WWT

This primitive sends a work wait time extension request to the terminal.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x02
```

Arguments

None.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

There are no input or output parameters for this primitive.

Remarks

This primitive causes a message to be sent to the terminal to inform it that more time is required for processing to complete. The nature of the message is protocol-dependent in accordance with [ISO7816-3]. Under T=0, for example, a NULL byte is sent while under T=1 an S-Block, Supervisor Wait Time Extension, is sent.

Most MULTOS implementations send work wait extension requests automatically and the frequency of the resets is implementation specific. This automatic functioning can be disabled using the Control Auto Reset WWT Primitive.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, Number 0x02

Return from Codelet

This primitive is used when a codelet based function finishes executing and returns control to the calling application. It allows input to be removed from and output left on the stack.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x80, BytesIn, BytesOut
```

Arguments

The 1-byte parameter *BytesIn* indicates the number of bytes to be removed from the stack upon returning from the codelet. The 1-byte sized *BytesOut* parameter indicates the number of bytes to be left on the stack as output from the codelet processing.

Stack Usage

Stack In	[n]
Stack Out	[m]

Both the input and out parameters *n* and *m* are variable in size. The size can range from 0 to 255 bytes. The input parameter *n* is of size *BytesIn* and *m* is of size *BytesOut*.

The input and output can also consist of several variables of differing size, but this primitive does not concern itself with the data structure, but rather the total length.

Remarks

This primitive is used to return control from a codelet to the application that invoked it. The two arguments are used to discard parameters passed to the codelet and return result bytes in the same way as the PRIMRET Return instruction operates.

This primitive is expecting linkage data to be on the stack. These bytes are automatically placed there by the primitive 'Call Codelet'.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

set two, number 0x80

RSA Verify

This primitive performs a modular exponentiation operation, the basis of the RSA algorithm. This version of the primitive is optimised for use with Public key operations only and platform countermeasures that protect the RSA algorithm may be disabled. For Private key operations the Modular Exponentiation / RSA Sign primitive should be used.

IT IS STRONGLY ADVISED THIS PRIMITIVE IS USED WITH PUBLIC KEYS ONLY.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☑	☑	☑	☑

Syntax

```
// Stack: eLen, mLen, eAddr, mAddr, inAddr, outAddr
PRIM 0xEB
```

Arguments

None.

Stack Usage

Stack In	eLen	mLen	eAddr	mAddr	inAddr	outAddr
Stack Out	{empty}					

All parameters are 2 bytes in size. The values *eLen* and *mLen* represent the length of the exponent and modulus respectively. These lengths represent the size in bytes. The value *eAddr* is the location of the exponent of size *eLen*, while *mAddr* is the location of the modulus of size *mLen*. The addresses *inAddr* and *outAddr* are the location of the input to the modular exponentiation operation and the address to where the output will be written.

Remarks

This primitive performs modular exponentiation operation and the result is written at the specified address *outAddr*.

Moduli with length that is not a multiple of 8 bits are padded at the least significant end with bits 0. So, a 1023-bit modulus would have the least significant bit of the least significant byte set to 0.

The size of the input and output is considered to the same as that of the modulus. They are all *mLen* in size.

The primitive will function normally if *inAddr* and *outAddr* point to the same memory area. That is to say the output can overwrite the input.

In order to enable modular exponentiation to operate correctly there are a number of general conditions that must be met:

- The modulus must be odd.
- The base value must be less than the modulus.
- The exponent must be less than the modulus.
- The length of the exponent must be less than or equal to the length of the modulus.

There are some implementation specifics that may impact on the usage of this primitive. For example, the most significant byte of the modulus should not be zero although some platforms may permit it. As another example, some implementations may only work on fixed key lengths. It may also be the case that an implementation may provide optimised support for an exponent length of 1 with a value of 3 and from MULTOS 4.2 one may also provide optimised support for an exponent length of 3 and a value of 65537. See the MULTOS Implementation Report [MIR] for specific information.

Primitive set and number

Set zero, number 0xEB

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Example

The following example shows how to use the modular exponentiation primitive to encrypt input using the private exponent. Here the 72-byte input value is found in public and the output overwrites it.

```
prmModularExponentiation         EQU 0xEB


sD   STATIC BYTE 64  // 64-byte private exponent
sN   STATIC BYTE 72  // 72-byte modulus

  PUSHW     64          // exponent size
  PUSHW     72          // modulus size
  LOADA     sD          // exponent location
  LOADA     sN          // modulus location
  LOADA     PB[0]       // input location
  LOADA     PB[0]       // output location
  PRIM prmModularExponentiation

  EXITLA    72
```

Secure Hash

This primitive calculates the SHA-1, SHA-224, SHA-256, SHA-384 or SHA-512 digest of a message of arbitrary length in accordance with [FIPS180-3].

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xCF
```

Arguments

None.

Stack Usage

Stack In	lenMsg	lenHash	addrHash	addrMsg
Stack Out	{empty}			

Each of the input parameters is 2-bytes in size. The value *lenMsg* is the size in bytes of the input to the Secure Hash algorithm. The value *lenHash* is either 20, 28, 32, 48 or 64 and is the size of the resultant hash digest. The parameter *addrHash* is the location where the hash digest will be written. The parameter *addrMsg* is the location of the input of size *lenMsg*.

Remarks

The primitive uses the appropriate Secure Hash algorithm according to the length of the hash digest requested, i.e.

lenHash	Algorithm used	Algorithms supported (when primitive is implemented)	
		MULTOS 4.2	MULTOS 4.3/4.4
20	SHA-1	Optional	Supported
28	SHA-224	Optional	Optional
32	SHA-256	Supported	Supported
48	SHA-384	Optional	Optional
64	SHA-512	Optional	Optional

Unsupported values of lenHash will cause an abend.
The primitive functions properly even if *lenMsg* is zero.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set zero, number 0xCF

Secure Hash IV

This primitive calculates the SHA-1, SHA-224, SHA-256, SHA-384 or SHA-512 digest of a message of arbitrary length in accordance with [FIPS180-3] with the ability to pass a previously calculated intermediate hash value and message remainder (where the previous message was not block-aligned) to the algorithm.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xE4
```

Arguments

None.

Stack Usage

Stack In	lenMsg	lenHash	addrHash	addrMsg	addrIntermediateHash	addrPrevHashedBytes	lenMessageRemainder	addrMessageRemainder
Stack Out	lenMessageRemainder		addrMessageRemainder					

Each of the input parameters is 2-bytes in size.
The value lenMsg is the size in bytes of the input to the Secure Hash algorithm.
The value lenHash is either 20, 28, 32, 48 or 64 and is the size of the resultant hash digest.
The parameter addrHash is the location where the hash digest will be written.
The parameter addrMsg is the location of the input message of size lenMsg.
The parameter addrIntermediateHash is the location of the previously calculated intermediate hash value input to the algorithm and output from the algorithm. It is 20, 32 or 64 bytes in length dependent upon the algorithm requested.
The parameter addrPrevHashedBytes is the location of the 4 byte (32-bit) counter indicating the number of bytes previously input to the hashing algorithm, including previous calculations.
The parameter lenMessageRemainder is the number remaining non-block aligned bytes from a previously hashed message.
The parameter addrMessageRemainder is the address of the remaining non-block aligned bytes of a previously hashed message, of length lenMessageRemainder.

Remarks

The primitive uses the appropriate Secure Hash algorithm according to the length of the hash digest requested, i.e. The length of the intermediate hash value passed to the algorithm and maximum length of the message remainder (if present) depends upon the algorithm to be used.

lenHash	Length of intermediate hash value (in bytes)	Maximum length of message remainder (in bytes)	Algorithm used	Algorithms supported (when primitive is implemented)	
				MULTOS 4.2	MULTOS 4.3/4.4
20	20	32	SHA-1	Optional	Supported
28	32	32	SHA-224	Optional	Optional
32	32	32	SHA-256	Supported	Supported
48	64	64	SHA-384	Optional	Optional
64	64	64	SHA-512	Optional	Optional

Unsupported values of lenHash will cause an abend.

The primitive functions properly even if lenMsg is zero.

If the value at addrIntermediateHash is all zeros, then the algorithm shall replace this value with the standard IV value used by the algorithm, as specified in [FIPS180-3].

The 32-bit value at addrPrevHashedBytes is the number of bytes previously hashed by a call to this primitive or an alternative calculation method. If the value at this address is zero, the primitive will start a new hash calculation and ignore the values contained at addrIntermediateHash and addrMessageRemainder. This value is updated by the primitive and may serve as input to a subsequent call to the primitive.

If lenMessageRemainder is zero, the value at addrMessageRemainder will be ignored, but value at addrIntermediateHash will still be used as the input value to the algorithm.

Following calculation, the memory at location addrIntermediateHash shall contain the last intermediate hash value H(n) calculated by the algorithm prior to any truncation when performing a SHA-224 or SHA-384 algorithm. This value may serve as input to a subsequent call to the primitive. The memory at addrHash will always contain a final hash value complete with truncation if applicable.

If the message hashed (the value at addrMessageRemainder prepended to the value at addrMsg) is not block aligned (i.e. not a multiple of either 32 or 64 bytes depending upon the hash algorithm), following calculation of the intermediate value, the remainder of the message of length lenMessageRemainder shall be pointed to by addrMessageRemainder and will be placed on the returned stack. This memory address may be within the area starting at addrMsg for length lenMsg or it may be at the address passed to the primitive.

Developers should ensure that there is sufficient memory at address addrMessageRemainder to contain the message remainder of the appropriate block size, as the returned message remainder can be longer than the input message remainder. If a developer does not allocate such a memory area, then the primitive may overwrite memory beyond addrMessageRemainder + lenMessageRemainder or abend.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged

N	Unchanged
Z	Unchanged

Primitive set and number

Set zero, number 0xE4

SEED ECB Decipher

This primitive performs SEED ECB Decipher on a sixteen byte block of memory using a sixteen byte key.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xCD
```

Stack Usage

Stack In	KeyAddr	OutputAddr	InputAddr
Stack Out	{empty}		

Each input parameter is 2 bytes in size. The value *KeyAddr* is the location of the key used in the SEED algorithm, *InputAddr* is the location of the data block that serves as input to the decipher operation and *OutputAddr* is the location where the output should be written.

Remarks

SEED is a 128-bit symmetric key block cipher that had been developed by KISA , the Korea Information Security Agency.

This primitive recovers 16-byte plaintext from a SEED ECB ciphertext.

The result may overwrite the input; i.e., *OutputAddr* and *InputAddr* may point to the same location.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, number 0xCD

Example

The following example declares 48 bytes of static memory to hold the SEED Key, the plaintext block and the ciphertext block. The address for each of these is loaded onto the stack and the SEED ECB Decipher primitive called.

```
prmSEEDECBDecipher  EQU  0xCD

sSEEDKey     STATIC BYTE 16 =
0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0A, 0x0B, 0x0C, 0x0D, 0x0E, 0x0F
sPlaintext   STATIC BYTE  16
sCiphertext STATIC BYTE  16

             LOADA  sSEEDKey
             LOADA  sPlaintext
             LOADA  sCiphertext
             PRIM   prmSEEDECBDecipher
```

SEED ECB Encipher

This primitive performs SEED ECB Encipher on a sixteen byte block of memory using a sixteen byte key.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
✗	✓	✓	✓	✓	✓

Syntax

```
PRIM 0xCE
```

Stack Usage

Stack In	KeyAddr	OuputAddr	InputAddr
Stack Out	{empty}		

Each input parameter is 2 bytes in size. The value *KeyAddr* is the location of the key used in the SEED algorithm*, InputAddr* is the location of the data block that serves as input to the encipher operation and *OutputAddr* is the location where the output should be written.

Remarks

SEED is a 128-bit symmetric key block cipher that had been developed by KISA , the Korea Information Security Agency.

This primitive generates a SEED ECB ciphertext output from an 16-byte plaintext input.

The result may overwrite the input; i.e., *OutputAddr* and *InputAddr* may point to the same location.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, number 0xCE

Example

The following example declares 48 bytes of static memory to hold the SEED Key, the plaintext block and the ciphertext block. The address for each of these is loaded onto the stack and the SEED ECB Encipher primitive called.

```
prmSEEDECBEcnipher  EQU  0xCE

sSEEDKey     STATIC BYTE 16 =
0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0A, 0x0B, 0x0C, 0x0D, 0x0E, 0x0F
sPlaintext   STATIC BYTE  16
sCiphertext STATIC BYTE  16

             LOADA  sSEEDKey
             LOADA  sCiphertext
             LOADA  sPlaintext
             PRIM   prmSEEDECBEncipher
```

Set AFI

This primitive sets the value of the Application Family Indicator for the current application.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑ *	☑	☑ *	☑ *	☑ *

*This primitive is mandatory if the device supports ISO/IEC 14443 Type B contactless communication.

Syntax

```
// Stack holds AFI value
PRIM 0x12
```

Arguments

None.

Stack Usage

Stack In	AFIvalue
Stack Out	{empty}

The input parameter *AFIvalue* is 1-byte in size and holds the value to which the AFI will be set.

Remarks

The AFI may be specified by a contactless ISO/IEC 14443 Type B terminal during anti-collision processing. If a device contains an application that has the same AFI, then the device will respond otherwise the device will not respond.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Zero, Number 0x12

Set ATR File Record

This primitive writes a record into the ATR File record.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds ATRAddr parameter
PRIM 0x07
```

Arguments

None.

Stack Usage

Stack In	ATRAddr
Stack Out	Length

The 2-byte *ATRAddr* is the address of the record that will be written to the ATR File. The output parameters *Length* is 1-byte in size and indicates the actual number of bytes written.

Remarks

The ATR file is an elementary file held in the root directory of the MULTOS device. Inside the file is one record per application loaded onto the MULTOS device. An application may write data to its own record using this primitive, but cannot effect the records of other applications.
Note that the ATR File does not get returned by the MULTOS device as part of the Answer To Reset

The ATR file record pointed to by *ATRAddr* must be formatted with the first byte giving the number of bytes in the record followed by the record itself. For example.

```
0x05,0x01,0x02,0x03,0x04,0x05
```

The ATR file data is copied from the byte after the segment address specified by the application.

The ATR record should not occupy the top byte of the stack.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if the amount of data written is less than requested
V Unchanged
N Unchanged
Z Set if no data is written, cleared otherwise

Primitive Set and Number

Set Zero, Number 0x07

Example

The following example sets the ATR File record corresponding to the application to ten bytes that are held in the variable sATR.

```
prmSetATRFileRecord   EQU  0x07

sATR STATIC BYTE 7 = 0x06,0x01,0x02, 0x03, 0x04, 0x05, 0x06
  LOADA   sATR
  PRIM    prmSetATRFileRecord
```

Set ATR Historical Characters

This primitive writes data to the historical characters an ATR.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds HistAddr parameter
PRIM 0x08
```

Arguments

None.

Stack Usage

Stack In	HistAddr
Stack Out	Length

The 2-byte input parameter *HistAddr* is the address from which to copy those bytes that will be written to the historical characters of the ATR. The 1-byte output parameter *Length* indicates the total number of bytes actually written.

Remarks

The ATR Historical Characters at *HistAddr* must be formatted with the first byte giving the number of bytes in the record followed by the record itself. For example, if the value to be written was 0x01, 0x02, 0x03, 0x04, 0x05, then the value should be

```
0x05,0x01,0x02,0x03,0x04,0x05
```

A write of zero is acceptable and will erase any historical characters present in the ATR. The maximum write size is 15 bytes.

As of MULTOS 4 there is a primary and secondary ATR values. The first is returned on a cold reset and the second on a warm reset. An application may request permission to write to the historical characters of one of those ATR. An application can not request control of both ATR historical characters nor can multiple applications control them. The request for control is contained in the application load certificate used.

If an application attempts to write to the historical characters of an ATR controlled by another application, the write request will not be honoured and the CCR Z flag will be set.

.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if the amount of data written is less than requested
V Unchanged
N Unchanged
Z Set if no data is written, cleared otherwise

Primitive Set and Number

Set Zero, Number 0x08

Example

The following example sets the ATR Historical Characters to the application to eight bytes that are held in the variable sATR.

```
prmSetATRHistoricalCharacters    EQU  0x08

sHistATR    STATIC BYTE 9 = 0x08, 0x01, 0x02, 0x03, 0x04, 0x05,
0x06, 0x07, 0x08
  LOADA     sHistATR
  PRIM prmSetATRHistoricalCharacters
```

Set ATS Historical Characters

This primitive writes data to the Historical Characters of the MULTOS device's ATS for ISO/IEC 14443 Type A contactless operation.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑*	☑	☑*	☑*	☑*

*This primitive is mandatory if the device supports ISO/IEC 14443 Type A contactless communication.

Syntax

```
// Stack holds HistAddr parameter
PRIM 0x0E
```

Arguments

None.

Stack Usage

Stack In	HistAddr
Stack Out	Length

The 2-byte input parameter *HistAddr* is the address from which to copy those bytes that will be written to the historical characters of the ATR. The 1-byte output parameter *Length* indicates the total number of bytes actually written.

Remarks

The ATS Historical Characters at *HistAddr* must be formatted with the first byte giving the number of bytes in the record followed by the record itself. For example, if the value to be written was 0x01, 0x02, 0x03, 0x04, 0x05, then the value should be

```
0x05,0x01,0x02,0x03,0x04,0x05
```

A write of zero is acceptable and will erase any historical characters present in the ATS. The maximum write size is implementation specific. The ATS historical characters should not occupy the top byte of the stack.

Permission to update the ATS historical characters is requested in the application load certificate. Only one application can control them. If an application attempts to write to the historical characters of an ATS controlled by another application, the write request will not be honoured and the CCR Z flag will be set.

If the an application on a device that is configured to work over a contact interface only, then the CCR C flag is cleared and the CCR Z flag is set.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if the amount of data written is less than requested
V Unchanged
N Unchanged
Z Set if no data is written, cleared otherwise

Primitive Set and Number

Set Zero, Number 0x0E

Example

The following example sets the ATS Historical Characters for the application to the ten bytes that are held in the variable sHistATS.

```
prmSetATSHistoricalCharacters    EQU  0x0E
sHistATS    STATIC    BYTE 11 = 0x0A,1,2,3,4,5,6,7,8,9,A

  LOADA          sHistATS
  PRIM      prmSetATSHistoricalCharacters
  // Check CCR for result
  // CCR.C set if bytes copied < bytes requested
  // CCR.Z set if no bytes copied.
  JLE       err_incompletecopy
  // error handling code would be found after the label
```

An alternative method of checking how much data was written is to compare the length byte left on the stack with the expected length. The following example shows this.

```
sHistATS    STATIC    BYTE 11 = 0x0A,1,2,3,4,5,6,7,8,9,A

  LOADA          sHistATS
  PRIM      prmSetATSHistoricalCharacters
  // primitive leaves one byte length value on stack
  // to check: load static length byte to stack
  // and compare to length byte on stack

  LOAD      sHistATS, 1
  CMPN       , 1
  JNE       err_incompletecopy
  // error handling code would be found after the label
```

Set FCI File Record

This primitive writes to the File Control Information (FCI) associated with the calling application.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
// Stack holds address of record
PRIM 0x11
```

Arguments

None.

Stack Usage

Stack In	FCIAddr
Stack Out	Length

The 2-byte input parameter *FCIAddr* is the location of the data to be written to the FCI. The data at *FCIaddr* must be formatted with the first byte indicating the length of the record in bytes, followed by the record itself. The 1-byte output parameter *Length* indicates the actual number of bytes written.

Remarks

This primitive allows an application to change the file control information available in a response to a SELECT FILE command when the application is selected.

The FCI record should not occupy the top byte of the stack.

No more than the specified number of bytes is written. The actual number written is returned on the stack. Note that the length of the FCI record is limited to the length given by the ALC.

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if the amount of data written is less than requested
V Unchanged
N Unchanged
Z Set if no data is written, cleared otherwise

Primitive Set and Number

Set zero, number 0x11

Example

The following example sets the FCI File record corresponding to the application to ten bytes that are held in the variable sFCI.

```
prmSetFCIFileRecord    EQU  0x11
sFCI STATIC BYTE 11 = 0x0A, 1,2,3,4,5,6,7,8,9,A

  LOADA   sFCI
  PRIM    prmSetFCIFileRecord
```

Set PIN Data

Sets data relating to the PIN which is either the local application PIN or the Global PIN depending on the access_list bit settings in the ALC. See Initialise PIN for details.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☑	☑	☑	☑

Syntax

```
PRIM 0x85, ElementId
```

Arguments

ElementId can take the following values:

0x00: Set the PIN Try Counter
0x01: Set the PIN Try Limit
0x03: PIN Verification Status (new in MULTOS 4.5.2)

Stack Usage

Stack In	Value
Stack Out	{empty}

Value is the one byte value to set. PIN verification Status must be given the values

- 0x5A = PIN is unverified
- 0xA5 = PIN is verified

Remarks

This primitive will abend if the PIN has not yet been initialised.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set one, number 0x85

Set Silent Mode

This primitive switches the MULTOS device into or out of silent mode. Silent mode ensures that no device unique information is returned by MULTOS' card edge API. The "suspend" option switches off Silent mode temporarily until the next reset, when it will be reinstated.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☑	☑	☑	☑

Syntax

```
PRIM  0xE3, Mode
```

Arguments

The 1 byte argument *Mode* is used to specify whether Silent Mode should be turned on or off or suspended as follows.

- *Mode* = 0: Turn off silent mode completely.
- *Mode* = 1: Turn silent mode on permanently on all interfaces.
  --- The following options are now available in MULTOS 4.3.1 --
- *Mode* = 2: Turn permanent silent mode on for contact and off for contactless
- *Mode* = 3: Turn permanent silent mode on for contactless and off for contact
- *Mode* = 4: Temporarily turn silent mode off
- *Mode* = 5: Turn silent mode back on after temporary disablement

Stack Usage

Stack In	{empty}
Stack Out	{empty}

Remarks

Silent mode only affects information returned directly from MULTOS via the card edge API in GET CONFIGURATION DATA, GET MANUFACTURER DATA, GET MULTOS DATA and OPEN MEL commands. It does not affect the information returned by MULTOS to applications using primitives.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.

V	Unchanged
N	Unchanged
Z	Unchanged.

Primitive set and number

Set one, number 0xE3

Set Transaction Protection

This primitive permits a series of writes to be treated as a single entity, which is then written or discarded in its entirety.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x80, Options
```

Arguments

The 1-byte argument *Options* is used to turn transaction protection on and off as well as indicating if the writes should be committed or discarded. See the Remarks section for the bit flag settings.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

Remarks

The value of the *Options* argument is a bitmap as follows.

7	6	5	4	3	2	1	0	Comments
0	0	0	0	0	0	-	-	Any other values are undefined
-	-	-	-	-	-	0	-	Transaction protection off
-	-	-	-	-	-	1	-	Transaction protection on
-	-	-	-	-	-	-	0	Discard changes
-	-	-	-	-	-	-	1	Commit changes

The bit 0 flag is only interrogated if transaction protection has been switched on in a previous call to the primitive. The bit 1 flag is always interrogated and sets transaction protection on or off.

Transaction protection is a mechanism that allows an application to commit several writes to non-volatile memory in an atomic fashion. When transaction protection is off, the default setting, each write is applied as the instruction is executed. However, when transaction protection is on writes to non-volatile memory are not applied immediately as is normally the case. They are only applied when the application explicitly commits the writes. If the application exits, delegates, or abnormally ends, then all uncommitted writes are discarded.

Uncommitted writes are not visible to the application.

Transaction protection applies to writes to Static and writes performed to system memory by any relevant primitive. It does not affect writes to Public and Dynamic, nor does it affect any writes that MULTOS may need to perform in order to support the cryptographic primitives or the Get Random Number primitive.

There may also be a limitation on the number of transactions which may be held pending at any one point in time. Again, this is dependent upon the memory availability within the platform.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set one, number 0x80

Examples

The following example shows two similar code snippets. The first does not make use of transaction protection, the second does.

```
prmTransactionProtection    EQU  0x80
TPOn                     EQU  2
TPOffandCommit           EQU  1
TPOffandDiscard          EQU  0

     // Transaction protection off
     SETB   SB[0], 3
     ADDB   SB[0], 1
     ADDB   SB[0], 1
     // result at SB[0] now 5

     SETB   SB[0], 3
     PRIM   prmTransactionProtection, TPOn
     ADDB   SB[0], 1
     ADDB   SB[0], 1
     PRIM   prmTransactionProtection, TPOffandCommit
     // result at SB[0] now 4 as uncommitted writes
     // are not available to an application
```

Set Contactless Select SW

This primitive sets the value of the status word returned by MULTOS in the future when the application is selected on the contactless interface.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☒	☑	☑	☑

Syntax

```
PRIM 0x06, SW1, SW2
```

Arguments

There are two 1-byte sized arguments. The value *SW1* is the most significant byte of the status word and *SW2* is the least significant byte.

Stack Usage

Stack In {empty}
Stack Out {empty}

There are no input or output parameters.

Remarks

When an application is successfully selected MULTOS returns a status word of 90 00. This primitive allows an application to set a different status word value to return on the contactless interface. It can only be reset by another call to this Primitive.

The existing SetSelectSW functionality remains unchanged and sets the SW1SW2 for both the contact and contactless response. If the application then wishes to distinguish between the two interfaces then it must call the new primitive to update the contactless select SW1SW2.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Two, Number 0x06

Set Select SW

This primitive sets the value of the status word returned by MULTOS when the application is selected in the future.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x04, SW1, SW2
```

Arguments

There are two 1-byte sized arguments. The value *SW1* is the most significant byte of the status word and *SW2* is the least significant byte.

Stack Usage

Stack In	{empty}
Stack Out	{empty}

There are no input or output parameters.

Remarks

When an application is successfully selected MULTOS returns a status word of 90 00. This primitive allows an application to set a different status word value to return. Note that MULTOS will still route commands to the selected application, regardless of the SW set using this primitive.

The application's Select SW will be retained after the MULTOS device is powered-off and can only be reset by another call to this Primitive.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set Two, Number 0x04

SHA-1

This primitive calculates the SHA-1 hash digest of a message of arbitrary length.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xCA
```

Arguments

None.

Stack Usage

Stack In	lenMsg	addrHash	addrMsg
Stack Out	{empty}		

Each of the input parameters is 2-bytes in size. The value *lenMsg* is the size of the input to the SHA-1 algorithm. The second parameter *addrHash* is the location where the 20-byte hash digest will be written. The parameter *addrMsg* is the location of the input of size *lenMsg*.

Remarks

The primitive functions properly even if *lenMsg* is zero.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive set and number

Set zero, number 0xCA

Shift Left

This primitive performs a bitwise shift left on a block of bytes.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds BytesIn parameter
PRIM 0x02, Length, ShiftBits
```

Arguments

Both arguments are 1-byte in size. *Length* gives the size of the data block to be shifted and *ShiftBits* indicates the number of bits to shift.

Stack Usage

Stack In	BytesIn
Stack Out	BytesOut

The input parameter *BytesIn* is of size *Length* and is the byte block to be shifted. The output parameter *BytesOut* is the byte block of size *Length* that holds the result of *ShiftBits* shift operations on *BytesIn*.

Remarks

This primitive bit-shifts data leftwards, filling the least significant bits with zeroes.

The effect of the primitive is undefined if any of the following is true:

- *ShiftBits* is zero
- *Length* is zero
- *ShiftBits* >= 8 * *Length*

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if the last bit shifted out is a one, cleared otherwise
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Primitive Set and Number

Set two, number 0x02

Example

The following example pushes a word onto the stack and shows how the word is affected by successive calls to the Shift Left primitive.

```
prmShiftLeft      EQU   0x02

  PUSHW     0x0001
  PRIM prmShiftLeft,2,4 //Stack=0x0010
  PRIM prmShiftLeft,2,4 //Stack=0x0100
  PRIM prmShiftLeft,2,4 //Stack=0x1000
```

Shift Right

This primitive performs a bitwise shift right on a block of bytes.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
// Stack holds ByteIn parameter
PRIM 0x03, Length, ShiftBits
```

Arguments

Both arguments are 1-byte in size. *Length* gives the size of the data block to be shifted and *ShiftBits* indicates the number of bits to shift.

Stack Usage

Stack In	BytesIn
Stack Out	BytesOut

The input parameter *BytesIn* is of size *Length* and is the byte block to be shifted. The output parameter *BytesOut* is the byte block of size *Length* that holds the result of *ShiftBits* shift operations on *BytesIn*.

Remarks

This primitive bit-shifts data rightwards, filling the most-significant bits with zeroes.

The effect of the primitive is undefined if any of the following is true:

- *ShiftBits* is zero
- *Length* is zero
- *ShiftBits* >=8 * *Length*

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if the last bit shifted out is a one, cleared otherwise
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise

Primitive Set and Number

Set two, number 0x03

Example

The following example pushes a word onto the stack and shows how the word is affected by successive calls to the Shift Right primitive.

```
prmShiftRight    EQU  0x03

  PUSHW     0x1000    //Stack=0x1000
  PRIM prmShiftRight,2,4   //Stack=0x0100
  PRIM prmShiftRight,2,4   //Stack=0x0010
  PRIM prmShiftRight,2,4   //Stack=0x0001
```

Shift Rotate

This primitive provides an efficient way of shifting and rotating a block of data by a *variable* number of bits.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
✗	✗	✗	✗	✗	✓

Syntax

```
PRIM 0x07, Mode, Direction
```

Arguments

Both arguments are 1-byte in size. *Mode* defines the function (0x01 = Shift, 0x02 = Rotate) and *Direction* defines the sense of the function (0x01 = Left, 0x02 = Right).

Stack Usage

Stack In	NumBits	DataLen	DataAddr
Stack Out	{empty}		

All parameters are 2 bytes long. *NumBits* is the number of bits to shift / rotate by. *DataLen* is the length of the data (in bytes) of the data pointed to by *DataAddr* that is to be shifted / rotated.

Remarks

When shifting, vacated bits are filled with zero.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set two, number 0x07

Store CCR

The byte at the top of the stack is moved to the Condition Code Register.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑	☑	☑	☑

Syntax

```
PRIM 0x06
```

Arguments

None.

Stack Usage

Stack In	setCCR
Stack Out	{empty}

The 1-byte input parameter setCCR is the value that will be stored in the condition control register byte.

Remarks

This primitive moves one byte from the stack to the CCR.

Condition Code

The bit flag values will be those specified by the value on the stack.

				C	V	N	Z
-	-	-	-	X	X	X	X

Primitive Set and Number

Set zero, number 0x06

Example

The following example sets the Condition Code Register to 00001001b by pushing 0x09 to the stack and then calling the primitive to move that value. This will now set the CCR C and the CCR Z bit flags. The branch instruction BLE will fire resulting in the code pointer moving to the address of LessThan label.

```
prmStoreCCR EQU  0x06

  PUSHB     0x09
  PRIM prmStoreCCR
  BLE  LessThan

  // This line will not be executed

       LessThan
  // Example code jumps here.
```

Subtract BCDN

This primitive subtracts two stack resident unsigned byte blocks of the same size, where the blocks hold binary coded decimal (BCD) values. The result is placed on the stack.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
//Stack  holds  Operand1,  Operand2  bytes
PRIM  0x12,  length
```

Arguments

The argument *length* gives the size of the byte blocks to be added.

Stack Usage

Stack In	Operand1	Operand2
Stack Out	Output	

The parameters *Operand1* and *Operand2* are both of size *length* and these are the values that will be added. The parameter *Output* is of size *length* and holds the result of the addition.

Remarks

The *length* value is specified using a single byte. Therefore, the maximum length of a block is 255 bytes

The value designated by an operand should be in BCD format. If not in BCD format, the processing in MULTOS device will abnormally end the application.

The CCR C flag is set if the result of the operation is greater than that which can be held in *length* bytes. The Z flag is set if the result is zero.

The operation performed is *Output = Operand1 – Operand2*

Condition Code

				C	V	N	Z
-	-	-	-	X	-	-	X

C Set if a carry occurs, cleared otherwise.
V Unchanged
N Unchanged
Z Set if the result is zero, cleared otherwise.

Primitive Set and Number

Set one, number 0x12

Examples

The following examples illustrate how to use the primitive as well as the CCR settings.

```
prmSubtractBCDN   EQU   0x12

   PUSHB          0
   PUSHB          1
   PRIM      prmSubtractBCDN, 1
   // result on stack is 99 CCR C set and CCR Z cleared
   PUSHW          0x0150
   PUSHW          0x0100
   PRIM      prmSubtractBCDN, 2
   // result on stack 0x0100 CCR C and CCR Z both cleared
```

Triple DES Decipher

This primitive performs a Triple DES Decipher on an eight byte block of memory in accordance with [FIPS46-3].

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD8
```

Arguments

None.

Stack Usage

Stack In	KeyAddr	KeyLen	OutputAddr	InputAddr
Stack Out	{empty}			

The 2 byte parameter KeyAddr is the starting address of the Triple DES keys to be used.
The 1 byte parameter KeyLen is the length in bytes of the Triple DES keys at address KeyAddr.
The 2 byte parameter OutputAddr is the starting address of the resultant 8-bytes of plaintext.
The 2 byte parameter InputAddr is the starting address of the 8-bytes of ciphertext.

Remarks

This primitive performs the Triple DES decipher operation on an 8-byte block of memory. The Triple DES keys K_1 , K_2 and optional K_3 are held in an 16 or 24 byte block. If KeyLen is 16 then K_3 shall equal K_1.

The output is written at the specified segment address and this may be the same as the address of the input; i.e., the output overwrites the input.

This primitive is only available to an application if “Strong Cryptography” is set on in the application’s access_list when loaded.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged

Z Unchanged

Primitive Set and Number

Set zero, number 0xD8

Example

The following example declares 16 bytes of static memory to hold the two Keys (128-bits), the ciphertext is held as session data, while the resulting plaintext will be written to public. The address for each of these is loaded onto the stack and the Triple DES Decipher primitive is called.

```
prm3DESDecipher  EQU  0xD8
KEYLEN  EQU  16

sKey  STATIC BYTE 16 =
0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08,0x09,0x0A,0x0B,0x0C,0x0D
,0x0E,0x0F,0x10
dCiphertext  DYNAMIC BYTE 16
pPlaintext PUBLIC BYTE 16

    LOADA   sKey
    PUSHB   KEYLEN
    LOADA   pPlaintext
    LOADA   dCiphertext
    PRIM    prm3DESDecipher
```

Triple DES Encipher

This primitive performs Triple DES Encipher on an eight byte block of memory in accordance with [FIPS46-3].

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xD9
```

Arguments

None.

Stack Usage

Stack In	KeyAddr	KeyLen	OutputAddr	InputAddr
Stack Out	{empty}			

The 2 byte parameter KeyAddr is the starting address of the Triple DES keys to be used.
The 1 byte parameter KeyLen is the length in bytes of the Triple DES keys at address KeyAddr.
The 2 byte parameter OutputAddr is the starting address of the resultant 8-bytes of ciphertext.
The 2 byte parameter InputAddr is the starting address of the 8-bytes of plaintext.

Remarks

This primitive performs the Triple DES encipher operation on an 8-byte block of memory. The Triple DES keys K_1 , K_2 and optional K_3 are held in a 16 or 24 byte block. If KeyLen is 16 then K_3 shall equal K_1.

The output is written at the specified segment address and this may be the same as the address of the input; i.e., the output overwrites the input.

This primitive is only available to an application if “Strong Cryptography” is set on in the application’s access_list when loaded.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged

Z Unchanged

Primitive Set and Number

Set zero, number 0xD9

Example

The following example declares 24 bytes of static memory to hold the three Keys (192-bits), the plaintext is held as session data, while the resulting ciphertext will be written to public. The address for each of these is loaded onto the stack and the Triple DES Encipher primitive is called.

```
prm3DESEncipher  EQU  0xD9
KEYLEN          EQU  24

sKey  STATIC BYTE 24 =
0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08,0x09,0x0A,0x0B,0x0C,0x0D
,0x0E,0x0F,0x10, 0x11, 0x12, 0x13, 0x14, 0x15, x016, 0x17, 0x18
dPlaintext  DYNAMIC BYTE 16
pCiphertext PUBLIC BYTE 16

    LOADA   sKey
    PUSHB   KEYLEN
    LOADA   pPlaintext
    LOADA   dCiphertext
    PRIM    prm3DESEncipher
```

Unpad

This primitive identifies an un-padded message from a padded message.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM  0x16, PadScheme
```

Arguments

The 1-byte parameter PadScheme specifies the unpadding scheme, as follows.

- 0x01 and 0x02: Zero or more bytes of 0x00 are searched from the end of the message until an 0x80 is encountered or there are no more bytes to search. The length of the resultant unpadded message is then returned.

Stack Usage

Stack In	LenMsg	AddrMsg
Stack Out	LenMsgUnPadded	

- The 2-byte parameter LenMsg specifies the length in bytes of the padded message.
- The 2-byte parameter AddrMsg specifies the segment address of the padded message.

- The 2-byte result LenMsgUnpadded is the length in bytes of the unpadded message.

Remarks

The padded block is not modified in any way. The result lenMsgUnpadded contains the length of the unpadded message within the padded message and the calling application is responsible for manipulating the unpadded part of the message as required.

If no 0x80 byte is encountered within the padded message, then lenMsgUnpadded is zero.

The primitive abends, if an invalid PadScheme value is supplied.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged

N	Unchanged
Z	Unchanged

Primitive Set and Number

Set zero, number 0x16

Update Process Events

This primitive enables or disables individual events for an application according to the mask provided.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1 / 2 / 3	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

```
PRIM 0x18
```

Arguments

None.

Stack Usage

Stack In	Mask
Stack Out	{empty}

Mask specifies a two byte bitmap as follows (bit15 is the leftmost, most significant bit)

- bit0 = APDU event mask.
- bit1 = SELECT event mask.
- bit2 = Automatic SELECT event mask.
- bit3 = RESELECT event mask.
- bit4 = DESELECT event mask.
- bit5 = CREATE event.
- bit6 = DELETE event.
- bit7 – bit15: RFU

Remarks

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged.
V Unchanged
N Unchanged
Z Unchanged.

Primitive set and number

Set zero, number 0x18

Update Session Size

This primitive temporarily updates the total size of the application's session memory.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.x	MULTOS 4.4	MULTOS 4.5.1	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

```
PRIM 0x04
```

Arguments

None.

Stack Usage

Stack In	SessionSize
Stack Out	Result

SessionSize specifies the total size of session data in bytes. *SessionSize* is a 2-byte value.

Result holds the result of the operation as follows:

- 0 = update failed as either *SessionSize* is either more than the session size held in the application's ALC or there is insufficient free RAM to accommodate the increase in the size of the application's session.
- 1 = update succeeded.

Remarks

1. As of MULTOS 4.5.3 the check against the ALC size is optional.
2. After calling this primitive, function call returns are not possible.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set zero, number 0x04

Update Static Size

This primitive updates the total size of the application's Static memory allowing you to free up space no longer required or allocate more space if needed.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☒	☒	☒	☑

Syntax

```
PRIM 0x04, Options
```

Arguments

The 1 byte argument *Options* is used to specify the size of the stack parameter *StaticSize*.

Options = 0: 32-bit (4-byte) *StaticSize*.
Options = 1: 64-bit (8-byte) *StaticSize*.

Stack Usage

Stack In	StaticSize
Stack Out	Result

StaticSize specifies the total size of Static in bytes. *StaticSize* can either be a 32-bit (4-byte) or a 64-bit (8-byte) value depending upon the value of *Options*.

Result holds the result of the operation as follows:

- 0 = update failed as either StaticSize is either more than the Static size specified in the application's ALC or there is insufficient free NVM to accommodate the increase in the size of the application's Static.
- 1 = update succeeded

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

Set one, number 0x04

Verify Asymmetric and Retrieve General

This primitive verifies an asymmetric signature of a message of arbitrary length.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☑	☑	☑	☑	☑

Syntax

```
PRIM 0xE2, Mode
```

Arguments

The argument *Mode* indicates whether a protected or unprotected variant of RSA is to be used. Defined values for *Mode* are 0x01 for standard mode with a public exponent of 3 and 0x81 for standard mode with a public exponent of 3 using an "unprotected" variant. The effect of any other value is undefined.

Stack Usage

Stack In

MsgLen	ModLen	ModAddr	InAddr	CertType	HashLen	HashAddr

Stack Out {empty}

All the parameters except *CertType* are 2 bytes in size. The value *MsgLen* is either the size in bytes of the data that has been signed and the signature or the length of data to recover, while *ModLen* is the length in bytes of the public key modulus value to use in order to verify the signature. *ModAddr* and *InAddr* are the locations of the public key modulus and message respectively. The 1-byte parameter *CertType* indicates whether the signature to verify is in MULTOS 3 or MULTOS 4 format. The parameter *HashLen* indicates the size in bytes of the modulus value used in calculating the asymmetric hash digest value. Finally *HashAddr* is the location of the hash modulus of size *HashLen*.

Remarks

The *CertType* can take a value of 0x03 indicating a MULTOS 3 certificate format or 0x04 indicating a MULTOS 4 certificate format. Any other value is undefined. A MULTOS 4 signature block consists of:

- 16-byte asymmetric hash digest
- *n*-byte data
- 8-byte random padding
- 8-byte fixed padding

The value *n* is found by subtracting 32 from the modulus length.

A MULTOS 3 signature block consists of:

- 16-byte asymmetric hash digest
- *n*-byte data

Here the value *n* is found by subtracting 16 from the modulus length.

When *MsgLen* is less than or equal to *ModLen*, *MsgLen* is interpreted to be the length of data to recover from the signature component. The signature component is found at *InAddr* and is considered to be of size *ModLen*. The data recovered of size *MsgLen* is returned starting at the least significant end of decrypted signature block.

When *MsgLen* is greater than *ModLen*, the value at *InAddr* is considered to consist of a plaintext header and signature, where the signature is of size *ModLen*. The data recovered will include the plaintext followed by the recovered data. Note that the data will not include the asymmetric hash digest value.

RSA is the only supported signature verification algorithm. The public exponent is always considered to have a value of 3.

The recovered message will overwrite the input message.

The unprotected variant has some restrictions. They are:

- The public key modulus must be in static memory. If it is not, the results can not be guaranteed and may result in an abnormal end to application execution.
- The message must be either in static memory or in public memory. If it is not, the results can not be guaranteed and may result in an abnormal end to application execution.
- If the message is in public memory, it must start at the base of public

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	X

C Unchanged
V Unchanged
N Unchanged
Z Set if the signature is correct, cleared otherwise

Primitive Set and Number

Set One, Number 0xE2

Verify PIN

Verifies the PIN which is either the local application PIN or the Global PIN depending on the access_list bit settings in the ALC. See Initialise PIN for details.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☑	☑	☑	☑

Syntax

```
PRIM 0xE7
```

Arguments

None.

Stack Usage

Stack In	PINLen	PINAddr
Stack Out	Status	

PINAddr is a 2 byte address of a buffer containing the PIN to be verified.
PinLength (1 byte) is the length of the PIN pointed to by PINAddr.

Status is a 2 byte value, 0x5AA5 for PIN verified and 0xA55A for PIN NOT verified. A value of 0xAAAA indicates that verification has been disabled.

Remarks

This primitive will abend if the PIN has not yet been initialised.

This primitive does NOT maintain the value of the PIN Try Counter. The application must do this.

Condition Code

				C	V	N	Z
-	-	-	-	-	-	-	-

C Unchanged
V Unchanged
N Unchanged
Z Unchanged

Primitive Set and Number

set zero, number 0xE7

APDU Commands

This section provides an alphabetical listing of APDU commands defined for MULTOS. The APDU commands defined for MULTOS step/one are available under licence in a separate document [OFFCARD]. The areas covered here are:

Enablement

Enablement is the initialisation (or pre-personalisation) of a MULTOS device's configuration, ready for the loading and deleting of applications. The APDU command used is SET MSM CONTROLS.

Application Loading

An application is loaded to a MULTOS device using APDU commands, CREATE MEL APPLICATION, LOAD APPLICATION SIGNATURE, LOAD CODE, LOAD DATA, LOAD DATA (Extended), LOAD DIR FILE RECORD, LOAD FCI RECORD, LOAD KTU CIPHERTEXT and OPEN MEL APPLICATION.

Application Deletion

An application is deleted from a MULTOS device using the APDU command DELETE MEL APPLICATION.

ISO Commands

MULTOS devices also support ISO defined commands, GET RESPONSE, READ BINARY, READ RECORD and SELECT FILE.

Device Information

Details about a particular MULTOS device can be obtained by APDU commands, CHECK DATA, GET CONFIGURATION DATA, GET DATA, GET MANUFACTURER DATA and GET MULTOS DATA.

Other

Other APDU commands supported are CARD UNBLOCK and GET PURSE TYPE.

Usage Notes

The subsections that follow provide a list of status word values that can be returned in response to the command. There are two cases that have not been included due to their ubiquity. In every case successful completion is indicated by a status word value of 90 00. In those cases where data is returned it is also possible to receive a status word of 61 xx if the La value is greater than the Lc value.

The APDU command table values are all hexadecimal despite not having the '0x' prefix.

CARD UNBLOCK

The Card Unblock command is used by an IFD to unblock a MULTOS device.

Availability

MULTOS 3	MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.4	MULTOS 4.5
☒	☑	☑	☒	☒	☒

Conditional Usage and Security

The command is a Master File command and, therefore, is only available when the Master File has been selected.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
80	08	00	00	08	CUBMAC	-

The CUBMAC is an 8-byte value device unique value supplied by the KMA.

APDU Response

Status word values that can be returned are:

9D 60 MAC verification failed
9D 61 Maximum number of unblocks reached
9D 62 This is not a blocked device

No data is returned in response to this command.

Remarks

Card Unblock command unblocks a device that has been previously blocked by an application using the Card Block primitive.

This command requires a Card Unblock MAC, CUBMAC, to be sent as command data. The CUBMAC is specific to each MULTOS device and can be obtained by the MULTOS Issuer from the MULTOS KMA.

The Card Unblock command can only be used once during the lifetime of a MULTOS device.

The Card Unblock command has been removed from MULTOS 4.3 as the mechanism for blocking and unblocking a card has been revised.

Standards

MULTOS

CHECK DATA

The Check Data command checks a specified area of a MULTOS device's memory in order to prove its authenticity. The challenge value is a random number agreed upon by a Personalisation Bureaux and the MULTOS OS Implementer. Both parties then send the same command and parameters to their devices, if the responses match the MULTOS devices are genuine.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is only available before enablement.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	06	00 or 01	00 or 01	0C or 0E	challenge value + check data start address + check data length	10

See the Remarks section for more information on the permitted P1, P2 and Lc combinations.

The challenge value is an 8-byte data block. The start address and data length are variable in length as explained in the Remarks section.

APDU Response

Status word values that can be returned are:

9D 31 Check data parameter is incorrect (invalid length)
9D 32 Check data parameter is incorrect (illegal memory check area)
9D 63 Crypto function not supported
6A 83 Function not supported

A 16-byte check data digest is returned upon successful execution of the command.

Remarks

The CHECK DATA command takes as a parameter the physical address of the device memory being checked. In all cases the address offset specified is a logical offset from the beginning of the memory area to be checked.

The response “Crypto function not supported” is returned if the contactless interface is in use. If the command is issued after the device has been enabled, the response “Function not supported” will be returned.

As of MULTOS 4.2 the functionality has also been extended so that it can handle implementations which have more than 64K of ROM and EEPROM.

For devices where the combined ROM and EEPROM size is less than 64K:

- P1 must be set to 0x00
- P2 must be set to 0x00
- The command data field ‘check_data_start_address’ is a 16 bit value
- The command data field ‘check_data_length’ is a 16 bit value
- The Lc value must be 0x0C
- If P1 is set to 0x01, the response will be 9D63 ‘function not supported’
- Only APDU command possible is: BE 06 00 00 0C [data field] 10

For devices where the combined ROM and EEPROM size is greater than or equal to 64K:

- P1 must be set to 0x01
- P2 may be either 0x00 or 0x01, where 0x00 indicates that the check data operation should be done on the ROM area and where 0x01 indicates that the check data operation should be done on the EEPROM area
- The command data field ‘check_data_start_address’ is a 24 bit value
- The command data field ‘check_data_length’ is a 24 bit value
- The Lc value must be 0x0E
- If P1 is set to 0x00, the response will be 9D63 ‘function not supported’
- Possible APDU commands are:
    - BE 06 01 00 0E [data field] 10
    - BE 06 01 01 0E [data field] 10

Standards

MULTOS

CREATE MEL APPLICATION

This command is the last sent in the application loading process. The Application Load Certificate is sent as data, which allows MULTOS to retrieve and authenticate the application and associated data.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is always available.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	16	00	00	var.	Application Load Certificate	-

The data sent is the Application Load Certificate that corresponds to the application being loaded.

APDU Response

Status word values that can be returned are:

6A 81 Retry counter expired
9D 50 Invalid MCD Issuer Product ID
9D 51 Invalid MCD Issuer ID
9D 52 Invalid Set MSM Controls Data Date
9D 53 Invalid MCD number
9D 54 Reserved Field Error
9D 55 Reserved Field Error
9D 56 Reserved Field Error
9D 57 Reserved Field Error
9D 05 Incorrect certificate type
9D 15 Application not open
9D 19 Invalid certificate
9D 1A Invalid signature
9D 1B Invalid key transformation unit
9D 1E Application signature does not exist
9D 1F KTU does not exist
9D 63 Crypto function not supported

No data is returned in response to this command.

Remarks

Create MEL Application is an MSM command and is always available. However, in contactless mode, this command can only be executed when the cryptographic coprocessor is available. When it is not, the device will return "Crypto function not supported".

From MULTOS 4 the Application Load Certificate may be transmitted over several CREATE MEL APPLICATION commands. The device will build the certificate using the data components in the order in which they arrive.

If the CREATE MEL APPLICATION command fails then a retry counter is reduced by one. When the counter reaches 0 the device will not allow any further loads. Note that this counter value can not be incremented. See the MULTOS Implementation Report [MIR] to find out the retry counter value.

From MULTOS 4.2 there is an optional retry counter to limit the number of successful Application load operations a single device will perform. This prevents an attacker driving an unlimited number of operations using the device's secret key by repeatedly loading and deleting an application which could be a benefit for DPA attacks. To find out the retry counter value see the MULTOS Implementation Report [MIR].

When the function is not completed in a low power environment the device will abnormally end execution.

Standards

MULTOS

DELETE MEL APPLICATION

This command is used to delete an application from a MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is always available.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	18	00	00	var.	Application Delete Certificate	-

The data sent is the Application Delete Certificate that corresponds to the application to be removed from the MULTOS device.

APDU Response

Status word values that can be returned are:

6A 81 Retry counter has expired
9D 50 Invalid MCD Issuer Product ID
9D 51 Invalid MCD Issuer ID
9D 52 Invalid Set MSM Controls Data Date
9D 53 Invalid MCD number
9D 05 Incorrect certificate type
9D 15 Application not open
9D 19 Invalid certificate
9D 20 Application not loaded
9D 63 Crypto function not supported

No data is returned in response to this command.

Remarks

DELETE MEL APPLICATION is an MSM command and is always available. However, in contactless mode, this command can only be executed when the cryptographic coprocessor is available. When it is not, the device will return "Crypto function not supported".

From MULTOS 4 the Application Delete Certificate may be transmitted over several CREATE MEL APPLICATION commands. The device will build the certificate using the data components in the in which they arrive.

If the DELETE MEL APPLICATION command fails then a retry counter is reduced by one. When the counter reaches 0 the device will not allow any further deletions. Note that this counter value can not be incremented. See the MULTOS Implementation Report [MIR] to find out the retry counter value.

When the function is not completed in a low power environment the device will abnormally end execution.

Standards

MULTOS

FREEZE

This command can be used with MULTOS devices that support step/one application loading and deleting.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☒	☒	☒	☒	☑	☑

Conditional Usage and Security

The command is a Master File command and, therefore, is only available when the Master File has been selected.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
0xBE	0x1A	-	-	0x91 or 0xD8	freeze_certificate || certificate_signature	-

The freeze certificate and signature are generated by the step/one certificate generation tools appropriate to the product vendor.

APDU Response

Status word values that can be returned are:

0x9000 Success
0x6A81 Function not supported
0x9D05 Incorrect certificate type
0x9D19 Invalid certificate
0x9D1D Enablement data not set
0x9D64 No applications loaded

Standards

MULTOS
step/one

GET CONFIGURATION DATA

This command allows a terminal to retrieve extended information about the MULTOS device. The command assists device management by providing the immediate determination of a device's configuration and capabilities without reference to an alternate data source. Where appropriate, the data is available before and after a device is enabled.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☒	☑	☑	☑	☑	☑

Conditional Usage and Security

The command is a Master File command and, therefore, is only available when the Master File has been selected.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
80	10	Token MSB	Token LSB	-	-	00

The values in P1 and P2 represent the most significant byte and least significant byte of the request token. Acceptable token values are given in the table in the Remarks section.

APDU Response

Status word values that can be returned are:

61 xx   xx byte of data to retrieve using Get Response
6B 00   Wrong Parameters P1,P2

Data is returned in response to this command. See the table in the Remarks section for further details.

Remarks

The command returns data based on the P1 and P2 parameters. The table below has more details.

Token	Request	Data Returned
0x00 00	Platform Identification	os_type + os_version + supported_functions + product_name
0x01 00	Largest ALU Possible	max_alu_size
0x02 00	Communication Transfer Parameters	comms_tx_parameters
0x03 00	ATR Control	cold_reset_application_id + warm_reset_application_id
0x04 00	AMD Version Information	amd_version_data
0x05 00	Codelets available	codelet_list
0x06 00	Applications loaded*	{application_id + application_memory_allocated}
0x07 00	MKD_PKC*	MULTOS_pk_certificate
0x08 00	Codelet checksums*	The 4 byte MULTOS checksum for each codelet listed in the same orders as the codelets in token 0x0500
0x09 00	ATS Control*	application_ATS_selected.application_id **or** MULTOS_aid
0x0A 00	Build Number**	The build number of the implementation. Encoding defined by the implementer.
0x0B 00	Primitives Supported**	A list of bits, one bit per possible primitive (4 sets of 256 primitives, with a "1" indicating that the primitive is supported. The first byte contains the bits for set 0 primitives 0-7 (held in bits 0-7), the second byte for set 0 primitives 8-17 and so on.
0x0C 00	Chip Identity Data**	Silicon manufacturer specific chip identity data.

Starred token values are not implemented on all masks but are mandatory from MULTOS 4.5* and MULTOS 4.5.1** onwards.

The Platform Identification request returns product specific values.

The Largest ALU Possible request returns the maximum size of an ALU that can be loaded.

The Communications Transfer Parameters request returns the device's x and y parameters along with an indication of what contactless protocol, if any, is supported.

The ATR Control request returns two 17-byte AIDs. Both are formatted such that the first byte is the length of the following ATR value, the next bytes are the ATR and the field is padded with 0xFF up to the 17-byte size limit. If no application controls an ATR the length byte will be set to 0x00 followed by 17 bytes of 0xFF.

The AMD Version Information request returns a 2-byte AMD ID and a 2-byte AMD version value.

The Codelets available request returns a list of 2-byte Codelet IDs

The Applications loaded request returns a list of applications loaded and their memory allocations. Each entry in the list consists of a 17-byte application ID and 3-byte application_memory_allocated data field.

The MKD_PKC request returns the MCD's Certified Public Key.

Standards

MULTOS

GET DATA

This command allows an IFD to retrieve the Data Objects (DO) from any generic MAOS device. Specifically for MULTOS, this command returns data objects to identify the MULTOS platform type and other objects in a structure as agreed with Global Platform.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
✗	✓	✓	✓	✓	✓

Conditional Usage and Security

The command is a Master File command and, therefore, is only available when the Master File has been selected.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
00	CA	00	66	-	-	00

APDU Response

This command will always execute successfully. The card data DOs are returned in response to this command.

Remarks

The DO returned is of the form:

- card_data_Dos
  - 66 | Len | card_data_discretionary_DOs
    - 73 | Len | tag_issuing_authority | card_data_DO_items
      - tag_issuing_authority: 06 | Len | tag_issuing_authority_OID — TBA – MAOSCO / GP
      - card_data_DO_items: platform_identification | logical_id_qualifier
        - platform_identification: platform_id_tag (TBA) | Len | platform_id_value
          - platform_id_value: 06 | Len | platform_id_OID — e.g. {multos_OID, 0, 5, 01}
        - logical_id_qualifier: logical_id_tag (TBA) | Len | logical_id_value
          - logical_id_value: 06 | Len | multos_OID — TBA - MAOSCO

The usage of P1 and P2 is as specified in ISO/IEC 7816-4 Section 6.9.3.

Standards

ISO/IEC 7816-4, Section 6.9.
GlobalPlatform
MULTOS

GET MANUFACTURER DATA

This command allows a terminal to retrieve information about the hardware of the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

The command is a Master File command and, therefore, is only available when the Master File has been selected.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
80	02	00	00	-	-	16

APDU response

This command will always execute successfully. Data is returned by this command.

Remarks

The data returned by this command is of the form:

Field	Size(bytes)
IC Manufacturer ID	1
IC Type	1
ROM IC Details	2
MCD ID	6
Initialisation Date	7
Processor Page Size	1
Maximum Transmit TPDU Size	2
Maximum Receipt TPDU Size	2

Standards

MULTOS

GET MULTOS DATA

This command allows an IFD to retrieve information about the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

The command is a Master File command and, therefore, is only available when the Master File has been selected.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
80	00	00	00	-	-	7F

APDU response

This command will always execute successfully. Data is returned by this command

Remarks

The data returned is of the form:

Field	Size (bytes)
MULTOS Version Number	2
IC Manufacturer ID	1
Implementer ID	1
MCD ID	6
Product ID	1
Issuer ID	4
MSM Controls Data Date	1
MCD Number	8
RFU	80
Maximum Dynamic Size	2
Maximum Public Size	2
Maximum DIR File Record Size	2
Maximum FCI Record Size	2
Maximum ATR Historical Byte Record Size	2
Maximum ATR File Record Size	2
MULTOS Public Key Certificate Length	2
Security Level	1
Certification Method ID	2
Application Signature Method ID	2
Encipherment Descriptor	2
Hash Method ID	2

The fields Product ID, Issuer ID, MSM Controls Data Date, MCD Number and RFU can collectively be referred to MSM Issuer Permissions.

Standards

MULTOS

GET PURSE TYPE

This command identifies which Mondex Purse Type a MULTOS device can support: Originator or Non-originator.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☒	☑	☑	☑	☑	☑

Conditional Usage and Security

The command is a Master File command and, therefore, is only available when the Master File has been selected.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
80	04	00	00	-	-	01

APDU Response

This command will always execute successfully. One byte of data is returned by this command.

Remarks

A return value of 0x4F indicates that the device can support an originator purse, while a value of 0xB0 indicates a non-originator. Any other values are undefined.

Standards

MULTOS

GET RESPONSE

This command is issued by an IFD in response to a previous status word of 61 xx, where the xx indicates the number of bytes to retrieve.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is always available.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
00	C0	00	00	-	-	var.

The Le to use is dependent on the value given least significant byte of a 61 xx status word issued in response to the command immediately preceding.

APDU Response

Status word values that can be returned are:

62 81 Part of returned data may be corrupted
67 00 Wrong length, Le field incorrect
6A 86 Incorrect parameters P1,P2
6C xx Wrong length, xx indicates actual length

The data returned is of variable length.

Remarks

The class byte may also be set to the same value as the last command; i.e., the command that generated the response data.

In general, under the T = 0 transport protocol a status word of 61 xx is returned when the length of data to be returned is greater than the expected length; i.e., La > Le. When that status word is issued an IFD may send the command GET RESPONSE.

If MULTOS receives an unexpected GET RESPONSE command it will be routed to the currently selected application, or an error returned if no application is selected.

Standards

MULTOS
ISO 7816, Part 4

LOAD APPLICATION SIGNATURE

This command is used to load the Application Signature of an ALU. The Application Signature may be divided into component blocks, each of which is individually transmitted using this command.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is available after enablement and must follow the OPEN MEL APPLICATION command.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	28	MSB Starting Offset	LSB Starting Offset	var.	Application signature component	-

No data is returned in response to this command.

APDU Response

Status word values that can be returned are:

9D 15 Application not open
9D 17 Invalid offset

Remarks

The Application Signature components can be sent in any order. The parameter bytes P1 and P2 are used to indicate the address within the reserved application signature memory area to load the component of size Lc. P1 is the most significant byte, while P2 is the least significant byte of the address. Note that the addressing uses zero based counting.

Standards

MULTOS

LOAD CODE

This command is used to load the Code of an ALU. The Code may be divided into component blocks, each of which is individually transmitted using this command.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is available after enablement and must follow the OPEN MEL APPLICATION command.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	24	MSB Starting Offset	LSB Starting Offset	var.	Code component	-

No data is returned in response to this command.

APDU Response

Status word values that can be returned are:

9D 15 Application not open
9D 17 Invalid offset

Remarks

The Code components can be sent in any order. The parameter bytes P1 and P2 are used to indicate the address within the reserved Code memory area to load the component of size Lc. P1 is the most significant byte, while P2 is the least significant byte of the address. Note that the addressing uses zero based counting.

Standards

MULTOS

LOAD DATA

This command is used to load the Data of an ALU. The Data component may be divided into component blocks of data, each of which is individually transmitted using this command.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is available after enablement and must follow the OPEN MEL APPLICATION command.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	26	MSB Starting Offset	LSB Starting Offset	var.	Data component	-

No data is returned in response to this command.

APDU Response

Status word values that can be returned are:

9D 15 Application not open
9D 17 Invalid offset

Remarks

The Data components can be sent in any order. The parameter bytes P1 and P2 are used to indicate the address within the reserved Data memory area to load the component of size Lc. P1 is the most significant byte, while P2 is the least significant byte of the address. Note that the addressing uses zero based counting.

Standards

MULTOS

LOAD DATA (Extended)

Description

This command is used to load the Data of an Application or an Extended Data Application containing static data greater than 64k. The Data component may be divided into component blocks of data, each of which is individually transmitted using this command.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☒	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is available after enablement and must follow the OPEN MEL APPLICATION command.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	26	MSB Starting Offset	LSB Starting Offset	var.	Data component	-

No data is returned in response to this command.

APDU Response

Status word values that can be returned are:

9D 15 Application not open
9D 17 Invalid offset

Remarks

The Data components can be sent in any order.
For a normal Application, the parameter bytes P1 and P2 are used to indicate the address within the reserved Data memory area to load the component of size Lc. P1 is the most significant byte, while P2 is the least significant byte of the address. Note that the addressing uses zero based counting.

For an Extended Data Application, the parameter bytes P1 and P2 are used to indicate the block number of the 255-byte blocks within the reserved Data memory area to load the component of size Lc. P1 is the most significant byte, while P2 is the least significant byte of the block number. Note that the block number uses zero based counting.

Standards

MULTOS

LOAD DIR FILE RECORD

This command is used to load the Directory File Record of an ALU. The Directory File Record may be divided into component blocks of data, each of which is individually transmitted using this command.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is available after enablement and must follow the command OPEN MEL APPLICATION command.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	20	MSB Starting Offset	LSB Starting Offset	var.	DIR File Record component	-

No data is returned in response to this command.

APDU Response

Status word values that can be returned are:

9D 15 Application not open
9D 17 Invalid offset

Remarks

The Directory File Record components can be sent in any order. The parameter bytes P1 and P2 are used to indicate the address within the reserved Directory File Record memory area to load the component of size Lc. P1 is the most significant byte, while P2 is the least significant byte of the address. Note that the addressing uses zero based counting.

Standards

MULTOS

LOAD FCI RECORD

Description

This command is used to load the File Control Information Record of an ALU. The FCI Record may be divided into component blocks of data, each of which is individually transmitted using this command.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is available after enablement and must follow the OPEN MEL APPLICATION command.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	22	MSB Starting Offset	LSB Starting Offset	var.	FCI Record component	-

No data is returned in response to this command.

APDU Response

Status word values that can be returned are:

9D 15 Application not open
9D 17 Invalid offset

Remarks

The FCI Record components can be sent in any order. The parameter bytes P1 and P2 are used to indicate the address within the reserved FCI Record memory area to load the component of size Lc. P1 is the most significant byte, while P2 is the least significant byte of the address. Note that the addressing uses zero based counting.

Standards

MULTOS

LOAD KTU CIPHERTEXT

This command is used to load the Key Transformation Unit of an ALU. The KTU may be divided into component blocks of data, each of which is individually transmitted using this command.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is available after enablement and must follow the OPEN MEL APPLICATION command.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	2A	MSB Starting Offset	LSB Starting Offset	var.	KTU component	-

No data is returned in response to this command.

APDU Response

Status word values that can be returned are:

9D 15 Application not open
9D 17 Invalid offset

Remarks

The KTU components can be sent in any order. The parameter bytes P1 and P2 are used to indicate the address within the reserved KTU memory area to load the component of size Lc. P1 is the most significant byte, while P2 is the least significant byte of the address. Note that the addressing uses zero based counting.

Standards

MULTOS

OPEN MEL APPLICATION

This command reserves and initialises memory in order to load an application into the MULTOS device, checking that there is sufficient memory of each type for a successful load. If the load can proceed, the MULTOS device will return its certified public key.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is always available.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	12	00	00	var.	Open command data component	00

The device's unique certified public key is returned in response to this command.

APDU Response

Status word values that can be returned are:

9D 07 Incorrect session data size
9D 08 Incorrect DIR file record size
9D 09 Incorrect FCI record size
9D 10 Insufficient memory to load application
9D 11 Invalid Application ID
9D 12 Duplicate Application ID
9D 13 Application previously loaded
9D 14 Application history full
9D 1D MSM controls not set
9D 21 Invalid open command data length
9D 50 Invalid MCD Issuer Product Id
9D 51 Invalid MCD Issuer Id
9D 52 Invalid Set MSM Controls Data Date
9D 53 Invalid MCD number

Remarks

When the command is transmitted, any other currently open or partially loaded application is abandoned.

The Lc value is given as variable; however, there are only two permissible values. They are: 0x89, when no application code hash is present and 0x9D, when an application code hash (calculated using the SHA-1 algorithm) is present.

The Open command data component consists of:

Field	Size (bytes)
MCD Issuer Product IDs	32
MCD Issuer ID	4
Set MSM Controls Data Dates	32
MCD Number	8
RFU	18
Application ID	17
Random Seed	8
File Mode Type	1
Code Size	2
Data Size	2
Session Data Size	2
Application Signature Length	2
KTU Length	2
DIR File Record Size	2
FCI Record Size	2
Access List	2
Application Code Hash Length	1
Application Code Hash	Application Code Hash Length

The fields Random Seed and Access List were introduced as of MULTOS 4. Neither field is present for a MULTOS 3 OPEN MEL APPLICATION command.

In order to open an application successfully:

- the MULTOS device must have been enabled
- there must have enough free memory space of each type to load the ALU
- no application with the same Application ID (AID) as an already loaded application may be loaded.
- If the random seed is non-zero, then the combination of Application ID and Random Seed must not have previously been loaded to this MULTOS device.

Standards

MULTOS

READ BINARY

Description

This command reads a block of bytes from a transparent MULTOS elementary file or from an area of application Static memory previously specified by an application.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5.x
☑	☑	☑*	☑*	☑	☑

** reading from an area of application Static memory is an optional feature in MULTOS 4.3*

Conditional Usage and Security

This command is always available.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
00/0C	B0/B1	see below	see below	see below	see below	var.

If a MULTOS elementary file is being read then CLA must equal 0x00 and INS must equal 0xB0. In this case P1 and P2 contain the offset, the most significant bit of the offset must equal zero and no command data is supplied.

If an area of application Static memory is being read then CLA must equal 0x00 if secure messaging is not being used or 0x0C if secure messaging is being used. INS must equal 0xB0 if an offset of less than 32768 bytes is specified and in this case P1 and P2 contain the offset. If an offset of 32768 bytes or more is specified then INS must equal 0xB1 and the command data contains the offset in TLV format. If secure messaging is being used then the command data must contain the appropriate ciphertext and MAC.

APDU Response

If a MULTOS elementary file is being read then the response contains the file data.

Status word values that can be returned are:

62 81 Part of returned data may be corrupted
62 82 End of file reached
67 00 Wrong Le field
69 81 Command incompatible with file structure
69 82 Security status not satisfied
69 86 Command not allowed, no current EF
6A 81 Function not supported
6A 82 File not found
6B 00 Wrong parameters, offset outside EF
6C xx Wrong length, xx indicates actual length

If an area of application Static memory is being read then the response contains the area of Static being read, possibly in TLV format. If secure messaging is being used then the response data is encrypted and a MAC is also included.

Status word values that can be returned depend upon the functionality of the application that enabled the accelerated READ BINARY command.

Remarks

The operating system provides one transparent elementary file: the ATR File. This command must be used to read the data in that file.

Standards

ISO7816 Part 4, 6.1 Read Binary Command

READ RECORD(S)

This command reads a record from the currently selected fixed length elementary file.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is always available.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
00	B2	Record Number	0x04	-	-	var.

Upon successful execution of this command a record is returned.

APDU Response

Status word values that can be returned are:

62 81 Part of returned data may be corrupted
62 82 End of file reached
67 00 Wrong length, empty Le field
69 81 Command incompatible with file structure
69 82 Security status not satisfied
6A 81 Function not supported
6A 82 File not found
6A 83 Record not found
6C xx Wrong length, xx indicates actual length

Remarks

The response message gives the contents of the specified record(s) of an EF with record structure.

The operating system provides one fixed length elementary file: the DIR File. This command must be used to read the data in that file and the P2 value must be 0x04.

Standards

MULTOS Specification
ISO7816 Part 4 Section 6.5

SELECT FILE

This command is used to select the Master File (MF), the Directory File (DIR), the ATR File or an application loaded into the MULTOS device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is always available.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
00	A4	var.	var.	var.	var.	var.

See the remarks section for valid P1 P2 values.

Data may be returned in response to this command.

APDU Response

Status word values that can be returned are:

62 83 Selected File invalidated
62 84 FCI not formatted according to ISO 7816
67 00 Wrong length; invalid Lc or invalid command case
6B 00 Wrong Parameters
6A 81 Function not supported
6A 82 File not found
6A 86 Incorrect parameters P1,P2
6A 87 Lc inconsistent with P1,P2

Remarks

The following table shows all acceptable P1, P2 and Lc values that can be for the command Select File. MULTOS will not handle a Select File command with any other combinations. However, an application may use any combination.

P1	P2	LC	CMD DATA	SELECTS	IF FILE EXISTS, RETURNS
00	00	none	none	Master File	Success: 90 00
00	00	02	3F 00	Master File	Success: 90 00
00	00	02	2F 00	Directory File*	Success: 90 00
00	00	02	2F 01	ATR File	Success: 90 00
00	0C	02	2F 00	Directory File*	Success: 90 00
00	0C	02	2F 01	ATR File	Success: 90 00
04	00	01 - 10	AID or partial AID	Application (DF)	Success and FCI
04	02	01 - 10	AID or partial AID	Application (DF)	Success and FCI
04	0C	01 - 10	AID or partial AID	Application (DF)	Success: 90 00
08	00	02	3F 00	Master File	Success: 90 00
08	00	02	2F 00	Directory File**	Success: 90 00
08	0C	02	3F 00	Master File	Success: 90 00
08	0C	02	2F 00	Directory File**	Success: 90 00

The Lc listing for all the cases where P1 is 0x04 indicates that the Lc must have a value between 0x01 and 0x10.

The Le is given in APDU Command as variable. FCI data is returned only if it is present for an application and in the cases where P1 and P2 are 0x04 0x00 or 0x04 0x02.

If MULTOS cannot successfully process the command, and an application is currently selected, MULTOS passes the command to the selected application to handle or reject as appropriate.

The application selection process will operate over all of the loaded applications and not just the first application that has an AID that (partially) matches the AID in the SELECT command. The command will reply with “file not found” only if there are no loaded applications that have an AID that (partially) matches and which are permitted over the selected interface.

If the MULTOS device is blocked then the command is not available and a status response of 6A81 is returned.

If the application has the “Process Events” permission, MULTOS does not test the most significant 6 bits of P2. The processing of the least significant 2 bits of P2 remain unchanged. For more details on *Process Events* please see [MDG].

NOTE*: Processed by the currently selected application, if there is one.
NOTE**: Always processed by MULTOS and any currently selected application is deselected.

The MULTOS AID is 0xA0000001444D554C544F53.

Standards

MULTOS
ISO7816 Part 4

SET MSM CONTROLS

This command is used to transmit MSM Controls Data, also referred to as Enablement Data, to the target device.

Availability

MULTOS 4	MULTOS 4.2	MULTOS 4.3.1	MULTOS 4.3.2	MULTOS 4.4	MULTOS 4.5
☑	☑	☑	☑	☑	☑

Conditional Usage and Security

This command is always available.

APDU Command

CLA	INS	P1	P2	Lc	Data	Le
BE	10	00	00	var.	MSM Controls Data component	-

The Lc field gives the length of MSM Controls Data component transmitted in the command.

APDU Response

Status word values that can be returned are:

9D 40 Invalid MSM controls ciphertext OR
9D 40 Already enabled with step/one data (MULTOS products supporting step/one loading)
9D 41 MSM controls set

No data is returned in response to this command.

Remarks

The MSM Controls Data may be transmitted over several APDUs. The same CLA INS P1 and P2 values are used for each command sent. Note that the data must be transmitted sequentially so that the MSM Controls Data can be properly reconstructed on the device.

MSM Controls Data is specific to an individual MULTOS device. The same data cannot be used on different devices.

Standards

MULTOS

MULTOS Status Codes

The previous section listed the commands that are handled by MULTOS along with possible status word responses. A MULTOS specific status word always has the most significant byte set to 0x9D. The following table provides a comprehensive listing of all MULTOS specific status words and provides an explanation of each.

SW2	Description	Explanation
05	Incorrect certificate type	The MULTOS device was given an ADC when it expected an ALC or vice-versa.
07	Incorrect session data size	The session data size given in the ALC is larger than the maximum available on the device.
08	Incorrect DIR file record size	The DIR file record size given in the ALC is larger than the maximum available on the device.
09	Incorrect FCI record size	The FCI record size given in the ALC is larger than the maximum available on the device.
10	Insufficient memory to load application	The device is unable to allocate all the memory required to perform the application load
11	Invalid application id	The Application ID length is either 0 or greater than 16 bytes in size.
12	Duplicate application id	An application with the same AID is currently loaded. The AID value must be unique on the device.
13	Application previously loaded	The combination of AID and non-zero random seed value held in the ALC is already listed in the application history list.
14	Application history full	An attempt has been made to load or delete an application using a non-zero random seed value when the application history list is full. Loads or deletes that do not use the random seed value will be handled normally.
15	Application not open	An attempt has been made to send a LOAD … or CREATE MEL APPLICATION command prior to the successful execution of the OPEN MEL APPLICATION command.
17	Invalid offset	Given in response to a LOAD … command when the combination of the P1 P2 specified offset and Lc value result in an attempt to load data outside the area reserved for the component in the OPEN MEL APPLICATION command.
18	Application already loaded	An attempt has been made to load a shell or default application onto a MULTOS device that already has applications loaded. Or the application is in fact already on the device.
19	Invalid certificate	The ALC or ADC received by the MULTOS device was not successfully authenticated.
1A	Invalid signature	The Application Signature provided was not successfully verified.
1B	Invalid key transformation unit	The deciphered KTU contains data that does not match the corresponding values on the device.

		The KTU for the MULTOS device is invalid.
1D	MSM controls not set	The MULTOS device has not yet been enabled.
1E	Application Signature does not exist	The MULTOS device did not receive an Application Signature when it was expecting one.
1F	KTU does not exist	The MULTOS device did not receive a KTU when it was expecting one.
20	Application not loaded	An attempt has been made to delete an application from a MULTOS device that doesn't exist.
30	Check data parameter is incorrect (invalid start address)	The start address given is not found in the memory area to be checked.
31	Check data parameter is incorrect (invalid length)	The combination of start address and length is not found in the memory area to be checked.
32	Check data parameter is incorrect (illegal memory check area)	The address and length given represent a valid memory area, but it is not permitted to perform a check data over it.
40	Invalid MSM controls ciphertext	The format or unverified content of the MSM controls data
41	MSM controls set	An attempt has been made to enable a device that has already been enabled
42	Set MSM Controls data length less than 2 bytes	The very first command sent includes the total length of data to be sent. If the first command does not contain at least two bytes of data, this error is given.
43	Invalid msm controls data length	The data is less than an expected minimum, greater than an expected maximum or its size is not an integer multiple of 8
44	Excess msm controls ciphertext	More data has been sent to the device than was expected.
45	Verification of msm controls data failed	The MSM controls data was not successfully verified.
50	Invalid mcd issuer product id	The bit mapped product IDs in the ALC or ADC does not contain the MULTOS device's product ID.
51	Invalid mcd issuer id	The MULTOS device issuer ID does not match that given in the ALC or ADC.
52	Invalid set msm controls data date	The bit mapped MSM Controls Data Dates in the ALC or ADC does not contain the MULTOS device's date.
53	Invalid mcd number	The MULTOS device MCD Number does not match that given in the ALC or ADC.
54	Reserved field error	The reserved field in the ALC does not match the value given in the OPEN MEL APPLICATION command
55	Reserved field error	The reserved field in the ALC does not match the value given in the OPEN MEL APPLICATION command
56	Reserved field error	The reserved field in the ALC does not match the value given in the OPEN MEL APPLICATION command
57	Reserved field error	The reserved field in the ALC does not match the value given in the OPEN MEL APPLICATION command
60	MAC verification failed	Card block or unblock MAC did not verify.
61	Maximum number of unblocks reached	The device will not process this or any further Card Unblock commands because the limit has been reached
62	This is not a blocked device	An attempt to unblock a device that is not blocked has been made.

Instruction Map

Instructions may take their full form or a compacted form. In order to use their compacted form, the relevant conditions must be met.

The CEN pseudo instruction is used to tell the AAM that all instructions that follow will use their compacted form. The CDIS pseudo instruction cancels the use of compacted instructions. The COMPACT_OFF pseudo instruction turns the use of compacted instructions off for the next instruction only.

The C compiler automatically handles compaction when the –opt switch is used with an argument > 0.

Note: In the instruction table below, where the values of 'n' and 'offset' are encoded in a single byte 'b', the encoding of 'b' is **n (2bits) | offset (6 bits)** where

Encoding of n in binary	Value of n in decimal
00	1
01	2
10	4
11	8

The 6 bit **offset** values may represent values in the ranges -32 to +31, -64 to -1 or 0 to 63 depending on the instruction.

OpCode	Tag	Instruction	b1 w1	b2 w2	b3 w3	b4	Notes
0x00	0	SYSTEM					No Operation
	1		SW1	SW2			set SW1 and SW2
	2		La				Set La
	3		SW1	SW2	La		Set SW1, SW2 and La
	4						Exit
	5		SW1	SW2			set SW1, SW2 and exit
	6		La				Set La and exit
	7		SW1	SW2	La		Set SW1, SW2, La and exit
0x01	0	CEN/CDIS	b				If b == 0, instruction is Compact Enable (CEN). If b == 1, instruction is Compact Disable (CDIS). Otherwise an illegal instruction.
	1	BRANCH	RelCP				Branch RelCP if Equal
	2		RelCP				Branch RelCP if Less Than
	3		RelCP				Branch RelCP if Less/Equal
	4		RelCP				Branch RelCP if Greater Than
	5		RelCP				Branch RelCP if Greater/Equal
	6		RelCP				Branch RelCP if Not Equal
	7		RelCP				Branch RelCP
0x02	0	JUMP					Jump to CP on stack
	1		CP				Jump to CP if Equal
	2		CP				Jump to CP if Less Than
	3		CP				Jump to CP if Less/Equal
	4		CP				Jump to CP if Greater Than
	5		CP				Jump to CP if Greater/Equal
	6		CP				Jump to CP if Not Equal
	7		CP				Jump to CP
0x03	0	CALL					Call CP on stack
	1		CP				Call CP if Equal

OpCode	Tag	Instruction	b1 w1	b2 w2	b3 w3	b4	Notes
	2		CP				Call CP if Less Than
	3		CP				Call CP if Less/Equal
	4		CP				Call CP if Greater Than
	5		CP				Call CP if Greater/Equal
	6		CP				Call CP if Not Equal
	7		CP				Call CP
0x04	0	STACK	n				Push n bytes of zeroes onto the stack.
	1		b				push byte b onto the stack
	2		w				Push word w onto the stack
	3	COMPACT_ OFF					Temporarily suspend instruction compaction for the following instruction only.
	4	STACK	n				Pop n bytes from the stack
	5						Pop one byte from the stack
	6						Pop one word from the stack
	7	BITTEST	o				Reserved for prototype new instruction.
0x05	0	PRIMRET	p				Call Primitive p
	1		p	a			Call Primitive p with arg a
	2		p	a	b		Call Primitive p with args a,b
	3		p	a	b	c	Call Primitive p with args a,b,c
	4						Return from Call
	5		in				Return from Call discarding in bytes
	6		out				Return from Call with out bytes
	7		in	out			Return from Call discarding in bytes and returning out bytes.
0x06	0	unused					illegal instruction
	1						illegal instruction
	2						illegal instruction
	3						illegal instruction
	4						illegal instruction
	5						illegal instruction
	6						illegal instruction
	7						illegal instruction
0x07	0	LOAD	n				Duplicates top n bytes of stack
	1		n	offset			Push n bytes from SB[offset]
	2		n	offset			Push n bytes from ST[offset]
	3		n	offset			Push n bytes from DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Push n bytes from LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Push n bytes from DT[offset]
	6		n	offset			Push n bytes from PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Push n bytes from PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x08	0	STORE	n				Pop n bytes and store them to DT[-2*n]
	1		n	offset			Pop n bytes and store them to SB[offset]
	2		n	offset			Pop n bytes and store them to ST[offset]
	3		n	offset			Pop n bytes and store them to DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Pop n bytes and store them to LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Pop n bytes and store them to DT[offset]
	6		n	offset			Pop n bytes and store them to PB[offset]

OpCode	Tag	Instruction	b1 w1	b2 w2	b3 w3	b4	Notes
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Pop n bytes and store them to PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x09	0	LOADI	n				Load n bytes from the segment address at DT[-2] onto the stack
	1		n	offset			Load n bytes from the segment address at SB[offset] onto the stack
	2		n	offset			Load n bytes from the segment address at ST[offset] onto the stack
	3		n	offset			Load n bytes from the segment address at DB[offset] onto the stack
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Load n bytes from the segment address at LB[offset] onto the stack
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Load n bytes from the segment address at DT offset] onto the stack
	6		n	offset			Load n bytes from the segment address at PB[offset] onto the stack
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Load n bytes from the segment address at PT[offset] onto the stack
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x0A	0	STOREI	n				Pop n bytes from the stack and store them to the segment address in DT[-2*n]
	1		n	offset			Pop n bytes from the stack and store them to the segment address in SB[offset]
	2		n	offset			Pop n bytes from the stack and store them to the segment address in ST[offset]
	3		n	offset			Pop n bytes from the stack and store them to the segment address in DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Pop n bytes from the stack and store them to the segment address in LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Pop n bytes from the stack and store them to the segment address in LT[offset]
	6		n	offset			Pop n bytes from the stack and store them to the segment address in PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Pop n bytes from the stack and store them to the segment address in PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x0B	0	CMPBRA	o				Reserved for prototype new instruction.
	1	LOADA	offset				Load the segment address of SB[offset] onto the stack
	2		offset				Load the segment address of ST[offset] onto the stack
	3		offset				Load the segment address of DB[offset] onto the stack
	3		offset				Compact version where 0 <= offset <= 255
	4		offset				Load the segment address of LB[offset] onto the stack
	4		offset				Compact version where -128 <= offset <= 128

OpCode	Tag	Instruction	b1 w1	b2 w2	b3 w3	b4	Notes
	5		offset				Load the segment address of DT[offset] onto the stack
	6		offset				Load the segment address of PB[offset] onto the stack
	6		offset				Compact version where 0 <= offset <= 255
	7		offset				Load the segment address of PT[offset] onto the stack
	7		offset				Compact version where -256 <= offset <= -1
0x0C	0	INDEX					illegal instruction
	1		b	offset			Multiplies the byte at the top of the stack with b, adds the segment address of a record of SB[offset] to the product and loads the result onto the stack
	2		b	offset			Multiplies the byte at the top of the stack with b, adds the segment address of a record of ST[offset] to the product and loads the result onto the stack
	3		b	offset			Multiplies the byte at the top of the stack with b, adds the segment address of a record of DB[offset] to the product and loads the result onto the stack
	3		b	offset			Compact version where 0 <= offset <= 255
	4		b	offset			Multiplies the byte at the top of the stack with b, adds the segment address of a record of LB[offset] to the product and loads the result onto the stack
	4		b	offset			Compact version where -128 <= offset <= 127
	5		b	offset			Multiplies the byte at the top of the stack with b, adds the segment address of a record of DT[offset] to the product and loads the result onto the stack
	6		b	offset			Multiplies the byte at the top of the stack with b, adds the segment address of a record of PB[offset] to the product and loads the result onto the stack
	6		b	offset			Compact version where 0 <= offset <= 255
	7		b	offset			Multiplies the byte at the top of the stack with b, adds the segment address of a record of PT[offset] to the product and loads the result onto the stack
	7		b	offset			Compact version where -256 <= offset <= -1
0x0D	0	SETB	b				Sets the byte at the top of the stack to b
	1		b	offset			Sets the byte at SB[offset] to b
	2		b	offset			Sets the byte at ST[offset] to b
	3		b	offset			Sets the byte at DB[offset] to b
	3		b	offset			Compact version where 0 <= offset <= 255
	4		b	offset			Sets the byte at LB[offset] to b
	4		b	offset			Compact version where -128 <= offset <= 127
	5		b	offset			Sets the byte at DT[offset] to b
	6		b	offset			Sets the byte at PB[offset] to b
	6		b	offset			Compact version where 0 <= offset <= 255
	7		b	offset			Sets the byte at PT[offset] to b
	7		b	offset			Compact version where -256 <= offset <= -1
0x0E	0	CMPB	b				Compares byte at the top of the stack with b
	1		b	offset			Compares byte at SB[offset] with b
	2		b	offset			Compares byte at ST[offset] with b
	3		b	offset			Compares byte at DB[offset] with b
	3		b	offset			Compact version where 0 <= offset <= 255
	4		b	offset			Compares byte at LB[offset] with b
	4		b	offset			Compact version where -128 <= offset <= 127
	5		b	offset			Compares byte at DT[offset] with b
	6		b	offset			Compares byte at PB[offset] with b
	6		b	offset			Compact version where 0 <= offset <= 255
	7		b	offset			Compares byte at PT[offset] with b
	7		b	offset			Compact version where -256 <= offset <= -1
0x0F	0	ADDB	b				Adds b to the byte at the top of the stack
	1		b	offset			Adds b to the byte at the byte stored at SB[offset]
	2		b	offset			Adds b to the byte at the byte stored at ST[offset]
	3		b	offset			Adds b to the byte at the byte stored at DB[offset]

OpCode	Tag	Instruction	b1 w1	b2 w2	b3 w3	b4	Notes
	3		b	offset			Compact version where 0 <= offset <= 255
	4		b	offset			Adds b to the byte at the byte stored at LB[offset]
	4		b	offset			Compact version where -128 <= offset <= 127
	5		b	offset			Adds b to the byte at the byte stored at DT[offset]
	6		b	offset			Adds b to the byte at the byte stored at PB[offset]
	6		b	offset			Compact version where 0 <= offset <= 255
	7		b	offset			Adds b to the byte at the byte stored at PT[offset]
	7		b	offset			Compact version where -256 <= offset <= -1
0x10	0	SUBB	b				Subtracts b from the byte at the top of the stack
	1		b	offset			Subtracts b from the byte stored at SB[offset]
	2		b	offset			Subtracts b from the byte stored at ST[offset]
	3		b	offset			Subtracts b from the byte stored at DB[offset]
	3		b	offset			Compact version where 0 <= offset <= 255
	4		b	offset			Subtracts b from the byte stored at LB[offset]
	4		b	offset			Compact version where -128 <= offset <= 127
	5		b	offset			Subtracts b from the byte stored at DT[offset]
	6		b	offset			Subtracts b from the byte stored at PB[offset]
	6		b	offset			Compact version where 0 <= offset <= 255
	7		b	offset			Subtracts b from the byte stored at PT[offset]
	7		b	offset			Compact version where -256 <= offset <= -1
0x11	0	SETW	w				Sets the word stored at the top of the stack to w
	1		w		offset		Sets the word at SB[offset] to w
	2		w		offset		Sets the word at ST[offset] to w
	3		w		offset		Sets the word at DB[offset] to w
	3		w		offset		Compact version where 0 <= offset <= 255
	4		w		offset		Sets the word at LB[offset] to w
	4		w		offset		Compact version where -128 <= offset <= 127
	5		w		offset		Sets the word at DT[offset] to w
	6		w		offset		Sets the word at PB[offset] to w
	6		w		offset		Compact version where 0 <= offset <= 255
	7		w		offset		Sets the word at PT[offset] to w
	7		w		offset		Compact version where -256 <= offset <= -1
0x12	0	CMPW	w				Compares the word at the top of the stack with w
	1		w		offset		Compares w with the word stored at SB[offset]
	2		w		offset		Compares w with the word stored at ST[offset]
	3		w		offset		Compares w with the word stored at DB[offset]
	3		w		offset		Compact version where 0 <= offset <= 255
	4		w		offset		Compares w with the word stored at LB[offset]
	4		w		offset		Compact version where -128 <= offset <= 127
	5		w		offset		Compares w with the word stored at DT[offset]
	6		w		offset		Compares w with the word stored at PB[offset]
	6		w		offset		Compact version where 0 <= offset <= 255
	7		w		offset		Compares w with the word stored at PT[offset]
	7		w		offset		Compact version where -256 <= offset <= -1
0x13	0	ADDW	w				Adds w to the word at the top of the stack
	1		w		offset		Adds w to the word at SB[offset]
	2		w		offset		Adds w to the word at ST[offset]
	3		w		offset		Adds w to the word at DB[offset]
	3		w		offset		Compact version where 0 <= offset <= 255
	4		w		offset		Adds w to the word at LB[offset]
	4		w		offset		Compact version where -128 <= offset <= 127
	5		w		offset		Adds w to the word at DT[offset]
	6		w		offset		Adds w to the word at PB[offset]
	6		w		offset		Compact version where 0 <= offset <= 255
	7		w		offset		Adds w to the word at PT[offset]
	7		w		offset		Compact version where -256 <= offset <= -1
0x14	0	SUBW	w				Subtracts w from the word at the top of the stack.
	1		w		offset		Subtracts w from the word at SB[offset]

OpCode	Tag	Instruction	b1 w1	b2 w2	b3 w3	b4	Notes
	2		w		offset		Subtracts w from the word at ST[offset]
	3		w		offset		Subtracts w from the word at BB[offset]
	3		w		offset		Compact version where 0 <= offset <= 255
	4		w		offset		Subtracts w from the word at LB[offset]
	4		w		offset		Compact version where -128 <= offset <= 127
	5		w		offset		Subtracts w from the word at DT[offset]
	6		w		offset		Subtracts w from the word at PB[offset]
	6		w		offset		Compact version where 0 <= offset <= 255
	7		w		offset		Subtracts w from the word at PT[offset]
	7		w		offset		Compact version where -256 <= offset <= -1
0x15	0	CLEARN	n				Clears the top n bytes of the stack
	1		n	offset			Clears n bytes starting at SB[offset]
	2		n	offset			Clears n bytes starting at ST[offset]
	3		n	offset			Clears n bytes starting at DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Clears n bytes starting at LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Clears n bytes starting at DT[offset]
	6		n	offset			Clears n bytes starting at PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Clears n bytes starting at PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x16	0	TESTN	n				Compares the top n bytes of the stack with 0
	1		n	offset			Compares the top n bytes at SB[offset] with 0
	2		n	offset			Compares the top n bytes at ST[offset] with 0
	3		n	offset			Compares the top n bytes at DB[offset] with 0
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Compares the top n bytes at LB[offset] with 0
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Compares the top n bytes at DT[offset] with 0
	6		n	offset			Compares the top n bytes at PB[offset] with 0
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Compares the top n bytes at PT[offset] with 0
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x17	0	INCN	n				Increments the number at DT[-n] of length n bytes
	1		n	offset			Increments the number at SB[offset] of length n bytes.
	2		n	offset			Increments the number at ST[offset] of length n bytes.
	3		n	offset			Increments the number at DB[offset] of length n bytes.
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Increments the number at LB[offset] of length n bytes.
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Increments the number at DT[offset] of length n bytes.
	6		n	offset			Increments the number at PB[offset] of length n bytes.
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Increments the number at PT[offset] of length n bytes.
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x18	0	DECN	n				Decrements the number at DT[-n] of length n bytes

OpCode	Tag	Instruction	b1 w1	b2 w2	b3 w3	b4	Notes
	1		n	offset			Decrements the number at SB[offset] of length n bytes.
	2		n	offset			Decrements the number at ST[offset] of length n bytes.
	3		n	offset			Decrements the number at DB[offset] of length n bytes.
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Decrements the number at LB[offset] of length n bytes.
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Decrements the number at DT[offset] of length n bytes.
	6		n	offset			Decrements the number at PB[offset] of length n bytes.
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Decrements the number at PT[offset] of length n bytes.
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x19	0	NOTN	n				Inverts the top n bytes of the stack.
	1		n	offset			Inverts n bytes stored at SB[offset]
	2		n	offset			Inverts n bytes stored at ST[offset]
	3		n	offset			Inverts n bytes stored at DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Inverts n bytes stored at LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Inverts n bytes stored at DT[offset]
	6		n	offset			Inverts n bytes stored at PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Inverts n bytes stored at PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x1A	0	CMPN	n				Compares top n bytes of stack with the bytes stored at DT[-2*n]
	1		n	offset			Compares top n bytes of stack with the bytes stored at SB[offset]
	2		n	offset			Compares top n bytes of stack with the bytes stored at ST[offset]
	3		n	offset			Compares top n bytes of stack with the bytes stored at DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Compares top n bytes of stack with the bytes stored at LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Compares top n bytes of stack with the bytes stored at DT[offset]
	6		n	offset			Compares top n bytes of stack with the bytes stored at PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Compares top n bytes of stack with the bytes stored at PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x1B	0	ADDN	n				Adds top n bytes of stack with bytes stored at DT[-2*n]
	1		n	offset			Adds top n bytes of stack to bytes stored at SB[offset]
	2		n	offset			Adds top n bytes of stack to bytes stored at ST[offset]
	3		n	offset			Adds top n bytes of stack to bytes stored at DB[offset]

OpCode	Tag	Instruction	b1 w1	b2 w2	b3 w3	b4	Notes
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Adds top n bytes of stack to bytes stored at LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Adds top n bytes of stack to bytes stored at DT[offset]
	6		n	offset			Adds top n bytes of stack to bytes stored at PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Adds top n bytes of stack to bytes stored at PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x1C	0	SUBN	n				Subtracts top n bytes of stack with bytes stored at DT[-2*n]
	1		n	offset			Subtracts top n bytes of stack from bytes stored at SB[offset]
	2		n	offset			Subtracts top n bytes of stack from bytes stored at ST[offset]
	3		n	offset			Subtracts top n bytes of stack from bytes stored at DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Subtracts top n bytes of stack from bytes stored at LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Subtracts top n bytes of stack from bytes stored at DT[offset]
	6		n	offset			Subtracts top n bytes of stack from bytes stored at PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Subtracts top n bytes of stack from bytes stored at PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x1D	0	ANDN	n				Logically ANDs top n bytes of stack with bytes stored at DT[-2*n]
	1		n	offset			Logically ANDs top n bytes of stack with bytes stored at SB[offset]
	2		n	offset			Logically ANDs top n bytes of stack with bytes stored at ST[offset]
	3		n	offset			Logically ANDs top n bytes of stack with bytes stored at DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Logically ANDs top n bytes of stack with bytes stored at LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Logically ANDs top n bytes of stack with bytes stored at DT[offset]
	6		n	offset			Logically ANDs top n bytes of stack with bytes stored at PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Logically ANDs top n bytes of stack with bytes stored at PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.

OpCode	Tag	Instruction	b1 w1	b2 w2	b3 w3	b4	Notes
0x1E	0	ORN	n				Logically Ors top n bytes of stack with bytes stored at DT[-2*n]
	1		n	offset			Logically Ors top n bytes of stack with bytes stored at SB[offset]
	2		n	offset			Logically Ors top n bytes of stack with bytes stored at ST[offset]
	3		n	offset			Logically Ors top n bytes of stack with bytes stored at DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Logically Ors top n bytes of stack with bytes stored at LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Logically Ors top n bytes of stack with bytes stored at DT[offset]
	6		n	offset			Logically Ors top n bytes of stack with bytes stored at PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Logically Ors top n bytes of stack with bytes stored at PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.
0x1F	0	XORN	n				Logically XORs top n bytes of stack with bytes stored at DT[-2*n]
	1		n	offset			Logically XORs top n bytes of stack with bytes stored at SB[offset]
	2		n	offset			Logically XORs top n bytes of stack with bytes stored at ST[offset]
	3		n	offset			Logically XORs top n bytes of stack with bytes stored at DB[offset]
	3		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	4		n	offset			Logically XORs top n bytes of stack with bytes stored at LB[offset]
	4		b				Compact version where n = 1, 2, 4 or 8 and -32 <= offset <= 31.
	5		n	offset			Logically XORs top n bytes of stack with bytes stored at DT[offset]
	6		n	offset			Logically XORs top n bytes of stack with bytes stored at PB[offset]
	6		b				Compact version where n = 1, 2, 4 or 8 and 0 <= offset <= 63.
	7		n	offset			Logically XORs top n bytes of stack with bytes stored at PT[offset]
	7		b				Compact version where n = 1, 2, 4 or 8 and -64 <= offset <= -1.

Primtive Set Listing

MULTOS Primitives are divided into four sets: 0, 1, 2 and 3. These are based on the number of non-stack argument bytes that are passed to a primitive. Please note that any number of values may be placed on the stack for the primitive without it impacting on the Primitive Set designation. Within each set a hex value is assigned to the primitive. This is used to uniquely identify that primitive within the set.

Set 0

Primitive Name	Hex Value
Check Case	0x01
Reset WWT	0x02
Get Session Size	0x03
Update Session Size	0x04
Load CCR	0x05
Store CCR	0x06
Set ATR File Record	0x07
Set ATR Historical Characters	0x08
Get Memory Reliability	0x09
Lookup	0x0A
Memory Compare	0x0B
Memory Copy	0x0C
Query Interface Type	0x0D
Set ATS Historical Characters	0x0E
Memory Copy Non-Atomic	0x0F
Control Auto Reset WWT	0x10
Set FCI File Record	0x11
Set AFI	0x12
Card Unblock	0x13
Lookup Word	0x14
Get Configuration Data	0x15
Get Transaction State	0x16
Exit to MULTOS and Restart	0x17
Update Process Events	0x18
Memory Fill	0x19
Delegate	0x80
Reset Session Data	0x81
Checksum	0x82
Call Codelet	0x83
Query Codelet	0x84
Exchange Data	0x85
Query Channel	0x86
Get FCI State	0x87
Query Algorithm	0x8A
Platform Optimised Checksum	0x89
DES ECB Encipher	0xC1
Modular Multiplication	0xC2
Modular Reduction	0xC3
Get Random Number	0xC4
DES ECB Decipher	0xC5
Generate DES CBC Signature	0xC6
Generate Triple DES CBC Signature	0xC7
Modular Exponentiation / RSA Sign	0xC8
Modular Exponentiation CRT / RSA Sign CRT	0xC9
SHA-1	0xCA
GSM Authenticate	0xCB
Generate Random Prime	0xCC
SEED ECB Decipher	0xCD
SEED ECB Encipher	0xCE
Secure Hash	0xCF
ECC Addition	0xD0
ECC Convert Representation	0xD1
ECC Equality Test	0xD2
ECC Inverse	0xD3
ECC Scalar Multiplication	0xD4

AES Decipher	0xD6
AES Encipher	0xD7
Triple DES ECB Decipher	0xD8
Triple DES ECB Encipher	0xD9
Check BCD	0xDA
Get Replaced Application State	0xDB
Modular Exponentiation CRT Protected / RSA Sign CRT Protected	0xDC
Get AID	0xDD
Secure Hash IV	0xE4
Initialise PIN	0xE5
Read PIN	0xE6
Verify PIN	0xE7
Get Process Event	0xE8
Reject Process Event	0xE9
RSA Verify	0xEB
Flush Public	0xEC

Set 1

Primitive Name	Hex Value
Query0	0x00
Query1	0x01
Query2	0x02
Query3	0x03
Update Static Size	0x04
Memory Compared Enhanced	0x05
Memory Copy From Replaced Application	0x06
Manage Stack	0x07
DivideN	0x08
Get DIR File Record	0x09
Get File Control Information	0x0A
Get Manufacturer Data	0x0B
Get MULTOS Data	0x0C
Get Purse Type	0x0D
Memory Copy Fixed Length	0x0E
Memory Compare Fixed Length	0x0F
MultiplyN	0x10
Add BCDN	0x11
Subtract BCDN	0x12
Memory Copy Non-Atomic Fixed Length	0x13
Convert BCD	0x14
Pad	0x15
Unpad	0x16
Get Available Interface Types	0x17
Control Atomic Writes	0x18
Set Transaction Protection	0x80
Get Delegator AID	0x81
Set PIN Data	0x85
Get PIN Data	0x86
Get Data	0x87
Generate Asymmetric Hash General	0xC4
Generate MAC	0xC6
Modular Inverse	0xD0
ECC Verify	0xD1
Configure Read Binary	0xDC
Memory Copy Additional Static	0xDD
Memory Fill Additional Static	0xDE
Get Static Size	0xDF
Generate Asymmetric Signature General	0xE1
Verify Asymmetric and Retrieve General	0xE2
Set Silent Mode	0xE3
Initialise PIN Extended	0xE4
ECC Generate Signature	0xE5
ECC Verify Signature	0xE6
ECC Generate Key Pair	0xE7
ECC Elliptic Curve Diffie Hellman	0xE8
ECC ECIES Decipher	0xE9

ECC ECIES Encipher	0xEA

Set 2

Primitive Name	Hex Value
Bit Manipulate Byte	0x01
Shift Left	0x02
Shift Right	0x03
SetSelectSW	0x04
CardBlock	0x05
SetContactlessSelectSW	0x06
Shift Rotate	0x07
Return From Codelet	0x80
Block Decipher	0xDA
Block Encipher	0xDB
Generate RSA Key Pair	0xE0

Set 3

Primitive Name	Hex Value
Bit Manipulate Word	0x01
Call Extension 0, 1, 2, 3, 4, 5, 6	0x8*x*, where *x* = extension value [0, 6] 0x86: The compiler uses a printf library and this library uses this primitive to perform the actual printf operation. The printf library calls the primitive with the three primitive parameters set to zero and it also pushes a value of zero onto the stack before calling the primitive. The simulator executes this primitive, printing the printf message onto the output window.

----- End of Document -----