**ΑΣΚΗΣΗ 5**

PC    Program Counter: 0010

AC Accumulator: 0000

X    :0110

TEMP1: 0001

TEMP2: 0011

**LOAD R,$K**

**PC+1->PC,MAR**

**MDR+0->ACC**

**PC+1->PC,MAR**

**MDR+0->NOP,MAR**

**MDR+0->X**

**ACC+0->NOP,FBR**

**X+0->R,SHELB=0)**

**PC+1->PC,MAR**

**NEXT(PC)**

**STORE R,$K**

**PC+1->PC,MAR**

**MDR+0->ACC**

**PC+1->PC,MAR**

**MDR+0->NOP,MAR**

**ACC+0->NOP,FBR**

**R+0->NOP,MWE,(SHELB=0)**

**PC+1->PC,MAR**

**NEXT(PC)**

**ADD R,$K**

**PC+1->PC,MAR**

**MDR+0->ACC**

**PC+1->PC,MAR**

**MDR+0->NOP,MAR**

**MDR+0->X**

**ACC+0->NOP,FBR**

**X+R->R,(SHELB=0)**

**PC+1->PC,MAR**

**NEXT(PC)**

**ADD R1,R2**

**PC+2->PC,MAR**

**MDR+0->NOP,FBR**

**R2+0->Q,(SHELB=0)**

**Q+0->X**

**PC-1->PC,MAR**

**MDR+0->NOP,FBR**

**R1+X->R1,(SHELB=0)**

**PC+2->PC,MAR**

**NEXT(PC)**

**SHL R**

**PC+1->PC,MAR**

**MDR+0->NOP,FBR**

**LSL(R)->R,(SHELB=0)**

**PC+1->PC,MAR**

**NEXT(PC)**

**DEC R**

**PC+1->PC,MAR**

**MDR+0->NOP,FBR**

**R+0->Q,(SHELB=0)**

**MDR+0->NOP,FBR**

**Q-1->R,(SHELB=0)**

**PC+1->PC,MAR**

**NEXT(PC)**

**SUB R1 $K**

**PC+1->PC,MAR**

**MDR+0->TEMP1**

**PC+1->PC,MAR**

**MDR+0->NOP,MAR**

**MDR+0->TEMP2**

**TEMP1+0->FB**

**R(FB)-TEMP2->R(FB)**

**PC+1->PC,MAR**

**NEXT(PC)**

**HALT**

**PC+0->PC,MAR**

**NEXT(PC)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **BOOTSTRAP** | BRA | BIN | CON | I | I | I | APORT | BPORT | DDATA | SH~ | SELB | MWE~ | MARCLK | MSTATUS | LDS~ | PCE~ | CARRYE~ | MDE~ | DDATAE~ | **ADDRESS** |
|  | (4:0) | (2:0) | (2:0) | (2:0) | (5:3) | (8:6) | (3:0) | (3:0) | (1:0) |  |  |  |  |  |  |  |  |  |  |  |
| SW+0->PC,MAR | xxxxx | 000 | xxx | 111 | 000 | 011 | xxxx | 0010 | xx | X | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | M00 |
| NEXT(PC) | xxxxx | 000 | xxx | xxx | xxx | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M01 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **LOAD R,$K** | BRA | BIN | CON | I | I | I | APORT | BPORT | DDATA | SH~ | SELB | MWE~ | MARCLK | MSTATUS | LDS~ | PCE~ | CARRYE~ | MDE~ | DDATAE~ | **ADDRESS** |
|  | (4:0) | (2:0) | (2:0) | (2:0) | (5:3) | (8:6) | (3:0) | (3:0) | (1:0) |  |  |  |  |  |  |  |  |  |  |  |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M02 |
| MDR+0->ACC | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXΧ | 0000 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M03 |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M04 |
| MDR+0->NOP,MAR | XXXXX | 000 | XXX | 111 | XXX | 001 | XXXΧ | XXXΧ | XX | X | X | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | M05 |
| MDR+0->X | xxxxx | 000 | xxx | 111 | 000 | 011 | XXXX | 0110 | xx | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M06 |
| ACC+0->NOP,FBR | xxxxx | 000 | xxx | 100 | 000 | 001 | 0000 | xxxx | xx | X | X | 1 | 0 | 0 | 1 | X | 1 | X | X | M07 |
| X+0->R,SHELB=0) | xxxxx | 000 | xxx | 100 | 000 | 011 | 0110 | XXXX | 01 | X | 0 | 1 | 0 | 0 | 1 | X | 1 | X | X | M08 |
| PC+1->PC,MAR | xxxxx | 000 | xxx | 101 | xxx | 011 | 0010 | 0010 | xx | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M09 |
| NEXT(PC) | xxxxx | 000 | xxx | xxx | 000 | 001 | XXXX | XXXX | xx | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M0a |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **STORE R,$K** | BRA | BIN | CON | I | I | I | APORT | BPORT | DDATA | SH~ | SELB | MWE~ | MARCLK | MSTATUS | LDS~ | PCE~ | CARRYE~ | MDE~ | DDATAE~ | **ADDRESS** |
|  | (4:0) | (2:0) | (2:0) | (2:0) | (5:3) | (8:6) | (3:0) | (3:0) | (1:0) |  |  |  |  |  |  |  |  |  |  |  |
| PC+1->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M0b |
| MDR+0->ACC | xxxxx | 000 | xxx | 111 | 000 | 011 | xxxx | 0000 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M0c |
| PC+1->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M0d |
| MDR+0->NOP,MAR | xxxxx | 000 | xxx | 111 | 000 | 001 | xxxx | xxxx | XX | X | X | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | M0e |
| ACC+0->NOP,FBR | xxxxx | 000 | xxx | 100 | 000 | 001 | 0000 | xxxx | xx | X | X | 1 | 0 | 0 | 1 | X | 1 | X | X | M0f |
| R+0>NOP,MWE | xxxxx | 000 | xxx | 011 | 000 | 001 | xxxx | xxxx | xx | X | 0 | 0 | 0 | 0 | 1 | X | 1 | X | X | M10 |
| PC+1->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M11 |
| NEXT(PC) | xxxxx | 000 | xxx | xxx | xxx | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M12 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ADD R,$K** | BRA | BIN | CON | I | I | I | APORT | BPORT | DDATA | SH~ | SELB | MWE~ | MARCLK | MSTATUS | LDS~ | PCE~ | CARRYE~ | MDE~ | DDATAE~ | **ADDRESS** |
|  | (4:0) | (2:0) | (2:0) | (2:0) | (5:3) | (8:6) | (3:0) | (3:0) | (1:0) |  |  |  |  |  |  |  |  |  |  |  |
| PC+2->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M13 |
| MDR+0->NOP,FBR | xxxxx | 000 | xxx | 111 | 000 | 011 | xxxx | 0000 | xx | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M14 |
| R2+0->Q,(SHELB=0) | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 0 | 1 | 0 | 0 | 1 | X | 1 | X | X | M15 |
| Q+0->X | xxxxx | 000 | xxx | 111 | 000 | 001 | xxxx | xxxx | xx | X | 1 | 1 | 0 | 0 | 1 | X | 1 | X | X | M16 |
| PC-1->PC,MAR | xxxxx | 000 | xxx | 111 | 000 | 011 | xxxx | 0110 | xx | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M17 |
| MDR+0->NOP,FBR | xxxxx | 000 | xxx | 100 | 000 | 001 | 0000 | xxxx | xx | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M18 |
| R1+X->R1,(SHELB=0) | xxxxx | 000 | xxx | 001 | 000 | 011 | 0110 | xxxx | xx | X | 0 | 1 | 0 | 0 | 1 | X | 1 | X | X | M19 |
| PC+2->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M1a |
| NEXT(PC) | xxxxx | 000 | xxx | xxx | xxx | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M1b |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ADD R1,R2** | BRA | BIN | CON | I | I | I | APORT | BPORT | DDATA | SH~ | SELB | MWE~ | MARCLK | MSTATUS | LDS~ | PCE~ | CARRYE~ | MDE~ | DDATAE~ | **ADDRESS** |
|  | (4:0) | (2:0) | (2:0) | (2:0) | (5:3) | (8:6) | (3:0) | (3:0) | (1:0) |  |  |  |  |  |  |  |  |  |  |  |
| PC+2->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 10 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M1c |
| MDR+0->NOP,FBR | xxxxx | 000 | xxx | 111 | 000 | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M1d |
| R2+0->Q,(SHELB=0) | xxxxx | 000 | xxx | 011 | 000 | 000 | xxxx | xxxx | xx | X | 0 | 1 | 0 | 0 | 1 | X | 1 | X | X | M1e |
| Q+0->X | xxxxx | 000 | xxx | 010 | 000 | 011 | xxxx | 0110 | xx | X | 1 | 1 | 0 | 0 | 1 | X | 1 | X | X | M1f |
| PC-1->PC,MAR | xxxxx | 000 | xxx | 101 | 001 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M20 |
| MDR+0->NOP,FBR | xxxxx | 000 | xxx | 111 | 000 | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M21 |
| R1+X->R1,(SHELB=0) | xxxxx | 000 | xxx | 001 | 000 | 011 | 0110 | xxxx | xx | X | 0 | 1 | 0 | 0 | 1 | X | 1 | X | X | M22 |
| PC+2->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 10 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M23 |
| NEXT(PC) | xxxxx | 000 | xxx | xxx | xxx | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M24 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SHL R** | BRA | BIN | CON | I | I | I | APORT | BPORT | DDATA | SH~ | SELB | MWE~ | MARCLK | MSTATUS | LDS~ | PCE~ | CARRYE~ | MDE~ | DDATAE~ | **ADDRESS** |
|  | (4:0) | (2:0) | (2:0) | (2:0) | (5:3) | (8:6) | (3:0) | (3:0) | (1:0) |  |  |  |  |  |  |  |  |  |  |  |
| PC+1->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M25 |
| MDR+0->NOP,FBR | xxxxx | 000 | xxx | 111 | 000 | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M26 |
| LSL(R)->R,(SHELB=0) | xxxxx | 000 | xxx | 011 | 000 | 111 | xxxx | xxxx | xx | X | 0 | 1 | 0 | 0 | 1 | X | 1 | X | X | M27 |
| PC+1->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M28 |
| NEXT(PC) | xxxxx | 000 | xxx | xxx | xxx | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M29 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **DEC R** | BRA | BIN | CON | I | I | I | APORT | BPORT | DDATA | SH~ | SELB | MWE~ | MARCLK | MSTATUS | LDS~ | PCE~ | CARRYE~ | MDE~ | DDATAE~ | **ADDRESS** |
|  | (4:0) | (2:0) | (2:0) | (2:0) | (5:3) | (8:6) | (3:0) | (3:0) | (1:0) |  |  |  |  |  |  |  |  |  |  |  |
| PC+1->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M2a |
| MDR+0->NOP,FBR | xxxxx | 000 | xxx | 111 | 000 | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M2b |
| R+0->Q,(SHELB=0) | xxxxx | 000 | xxx | 011 | 000 | 000 | xxxx | xxxx | xx | X | 0 | 1 | 0 | 0 | 1 | X | 1 | X | X | M2c |
| MDR+0->NOP,FBR | xxxxx | 000 | xxx | 111 | 000 | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M2d |
| Q-1->R,(SHELB=0) | xxxxx | 000 | xxx | 110 | 001 | 011 | xxxx | xxxx | 01 | X | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | M2e |
| PC+1->PC,MAR | xxxxx | 000 | xxx | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M2f |
| NEXT(PC) | xxxxx | 000 | xxx | xxx | xxx | 001 | xxxx | xxxx | xx | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M30 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SUB R1,$K** | BRA | BIN | CON | I | I | I | APORT | BPORT | DDATA | SH~ | SELB | MWE~ | MARCLK | MSTATUS | LDS~ | PCE~ | CARRYE~ | MDE~ | DDATAE~ | **ADDRESS** |
|  | (4:0) | (2:0) | (2:0) | (2:0) | (5:3) | (8:6) | (3:0) | (3:0) | (1:0) |  |  |  |  |  |  |  |  |  |  |  |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M31 |
| MDR+0->TEMP1 | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXX | 0001 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M32 |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M33 |
| MDR+0->NOP,MAR | XXXXX | 000 | XXX | 111 | 000 | 001 | XXXX | XXXX | XX | X | X | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | M34 |
| MDR+0->TEMP2 | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXX | 0011 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M35 |
| TEMP1+0->FB | XXXXX | 000 | XXX | 100 | 000 | 001 | 0001 | XXXX | XX | X | X | 1 | 0 | 0 | 1 | X | 1 | X | X | M36 |
| R(FB)-TEMP2->R(FB) | XXXXX | 000 | XXX | 001 | 001 | 011 | 0011 | XXXX | XX | X | 0 | 1 | 0 | 0 | 1 | X | 1 | X | X | M37 |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M38 |
| NEXT(PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M39 |

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| **HALT** | BRA | BIN | CON | I | I | I | APORT | BPORT | DDATA | SH~ | SELB | MWE~ | MARCLK | MSTATUS | LDS~ | PCE~ | CARRYE~ | MDE~ | DDATAE~ | **ADDRESS** |
|  | (4:0) | (2:0) | (2:0) | (2:0) | (5:3) | (8:6) | (3:0) | (3:0) | (1:0) |  |  |  |  |  |  |  |  |  |  |  |
| PC + 0 -> PC, MARX | XXXXX | 000 | XXX | 101 | 000 | 011 | 0010 | 0010 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M3A |
| NEXT (PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M3B |

|  |  |  |
| --- | --- | --- |
| **MAIN** | | |
| m00 | **00** | LOAD R,$K |
| m01 | **01** | R1 |
| m02 | **05** | X |
| m03 | **02** | ADD R,$K |
| m04 | **01** | R1 |
| m05 | **03** | Y |
| m06 | **06** | SUB R1,$K |
| m07 | **01** | R1 |
| m08 | **02** | Z |
| m09 | **05** | DEC R |
| m0a | **01** | R1 |
| m0b | **04** | SHLR |
| m0c | **01** | R1 |
| m0d | **04** | SHLR |
| m0e | **01** | R1 |
| m0f | **00** | LOAD R,$K |
| m10 | **02** | R2 |
| m11 | **05** | X |
| m12 | **02** | ADD R,$K |
| m13 | **05** | R2 |
| m14 | **03** | Y |
| m15 | **05** | DEC R |
| m16 | **02** | R2 |
| m17 | **04** | SHLR |
| m18 | **02** | R2 |
| m19 | **03** | ADD R1,R2 |
| m1a | **01** | R1 |
| m1b | **02** | R2 |
| m1c | **01** | STORE R,$K |
| m1d | **07** | R1 |
| m1e | **46** | W |
| m1f | **07** | HALT |
| m20 | **05** | X |
| m21 | **03** | Y |
| m22 | **02** | Z |
| m23 | **00** | W |

|  |  |  |
| --- | --- | --- |
| **Mapper** | | |
| Κώδικας εντολής | Opcode | Περιεχόμενα |
| LOAD R,$K | **M00** | 02 |
| STORE R,$K | **M01** | 0b |
| ADD R,$K | **M02** | 13 |
| ADD R1,R2 | **M03** | 1c |
| SHLR | **M04** | 25 |
| DECR | **M05** | 2a |
| SUB R1,$K | **M06** | 31 |
| HALT | **M07** | 3a |