**ΑΣΚΗΣΗ 4**

PC    Program Counter: 0001

BR    Base Register: 0010

SP    Stack Pointer: 1000

LR    Limit Register: 1000

Temp Temporary Register: 0011

**LΟΑDSP #Υ**

PC + 1 -> PC, MAR

MDR + 0 -> SP

PC + 1 -> PC, MAR

NEXT(PC)

//δημιουργούμε δύο έξτρα εντολές για να φορτώσουμε τον base και τον limit register

**LOADBR #K**

PC+1->PC,MAR

MDR+0->BR

PC+1->PC,MAR

NEXT(PC)

**LOADLR #K**

PC+1->PC,MAR

MDR+0->LR

PC+1->PC,MAR

NEXT(PC)

**PUSH $K**

SP-LR->OP,MSTATUSCLK

BRNZ[5],PC+1->PC, MAR

MDR+0->MAR

MDR+0-> TEMP

SP-1->SP,MAR

TEMP +0->NOP,MWE

PC+1->PC,MAR

NEXT(PC)

**POP$K**

BR-SP->NOP,MSTATUSCLK

BRNN[7],0+0->NOP

SP+0->NOP,MAR

MDR+0->TEMP

PC+1->PC,MAR

MDR+0->MAR

TEMP +0->MWE~

SP+1->SP

PC+1->PC,MAR

NEXT(PC)

**ADD**

BR-SP->NOP,MSTATUSCLK

BRNZ[6],0+0->NOP

SP+0->NOP,MAR

MDR+0-> TEMP

SP+1->SP,MAR

MDR+ TEMP -> TEMP

TEMP +0->NOP,MWE

PC+1->PC,MAR

NEXT(PC)

**SUB**

BR-SP->NOP,MSTATUSCLK

BRNZ[6],0+0->NOP

SP+0->NOP,MAR

MDR+0-> TEMP

SP+1->SP,MAR

TEMP -MDR-> TEMP

TEMP +0->NOP,MWE

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 | 1100 | 00 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | M00 |
| NEXT(PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | M01 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **LΟΑDSP #Υ** | 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 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M02 |
| MDR + 0 -> SP | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXΧ | 0100 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M03 |
| PC + 1 -> PC, MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M04 |
| NEXT(PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXΧ | XXXΧ | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M05 |

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| **LOADBR #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 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M06 |
| MDR+0->BR | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXX | 0010 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M07 |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M08 |
| NEXT(PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M09 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **LOADLR #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 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M0a |
| MDR+0->LR | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXX | 1000 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M0b |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M0c |
| NEXT(PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M0d |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **PUSH $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) |  |  |  |  |  |  |  |  |  |  |  |
| SP-LR->OP,MSTATUSCLK | XXXXX | 000 | XXX | 001 | 010 | 001 | 0100 | 1000 | XX | X | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | M0e |
| BRNZ[5],PC+1->PC, MAR | 00101 | 011 | 011 | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M0f |
| MDR+0->MAR | XXXXX | 000 | XXX | 111 | 000 | 001 | XXXX | XXXX | XX | X | X | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | M10 |
| MDR+0-> TEMP | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXX | 0011 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M11 |
| SP-1->SP,MAR | XXXXX | 000 | XXX | 101 | 001 | 011 | 0100 | 0100 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M12 |
| TEMP +0->NOP,MWE | XXXXX | 000 | XXX | 100 | 000 | 001 | 0011 | XXXX | XX | X | X | 0 | 0 | 0 | 1 | X | 1 | X | X | M13 |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M14 |
| NEXT(PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M15 |

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| **POP$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) |  |  |  |  |  |  |  |  |  |  |  |
| BR-SP->NOP,MSTATUSCLK | XXXXX | 000 | XXX | 001 | 010 | 001 | 0010 | 0100 | XX | X | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | M16 |
| BRNN[7],0+0->NOP | 0011 | 011 | 010 | 111 | 000 | 001 | XXXX | XXXX | 00 | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | M17 |
| SP+0->NOP,MAR | XXXXX | 000 | XXX | 100 | 000 | 001 | 0100 | XXXX | XX | X | X | 1 | 1 | 0 | 1 | X | 1 | X | X | M18 |
| MDR+0->TEMP | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXX | 0011 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M19 |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M1a |
| MDR+0->MAR | XXXXX | 000 | XXX | 111 | 000 | 001 | XXXX | XXXX | XX | X | X | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | M1b |
| TEMP +0->MWE~ | XXXXX | 000 | XXX | 100 | 000 | 001 | 0011 | XXXX | XX | X | X | 0 | 0 | 0 | 1 | X | 1 | X | X | M1c |
| SP+1->SP | XXXXX | 000 | XXX | 101 | 000 | 011 | 0100 | 0100 | 01 | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | M1d |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M1e |
| NEXT(PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M1f |

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| **ADD** | 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) |  |  |  |  |  |  |  |  |  |  |  |
| BR-SP->NOP,MSTATUSCLK | XXXXX | 000 | XXX | 001 | 010 | 001 | 0010 | 0100 | XX | X | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | M20 |
| BRNZ[6],0+0->NOP | 00110 | 011 | 010 | 111 | 000 | 001 | XXXX | XXXX | 00 | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | M21 |
| SP+0->NOP,MAR | XXXXX | 000 | XXX | 100 | 000 | 001 | 0100 | XXXX | XX | X | X | 1 | 1 | 0 | 1 | X | 1 | X | X | M22 |
| MDR+0-> TEMP | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXX | XXXX | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M23 |
| SP+1->SP,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0100 | 0100 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M24 |
| MDR+ TEMP -> TEMP | XXXXX | 000 | XXX | 101 | 000 | 011 | 0011 | 0011 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M25 |
| TEMP +0->NOP,MWE | XXXXX | 000 | XXX | 100 | 000 | 001 | 0011 | XXXX | XX | X | X | 0 | 0 | 0 | 1 | X | 1 | X | X | M26 |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M27 |
| NEXT(PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M28 |

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| **SUB** | 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) |  |  |  |  |  |  |  |  |  |  |  |
| BR-SP->NOP,MSTATUSCLK | XXXXX | 000 | XXX | 001 | 010 | 001 | 0010 | 0100 | XX | X | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | M29 |
| BRNZ[6],0+0->NOP | 00110 | 011 | 011 | 111 | 000 | 001 | XXXX | XXXX | 00 | X | X | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | M2a |
| SP+0->NOP,MAR | XXXXX | 000 | XXX | 100 | 000 | 001 | 0100 | XXXX | XX | X | X | 1 | 1 | 0 | 1 | X | 1 | X | X | M2b |
| MDR+0-> TEMP | XXXXX | 000 | XXX | 111 | 000 | 011 | XXXX | XXXX | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M2c |
| SP+1->SP,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0100 | 0100 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M2d |
| TEMP -MDR-> TEMP | XXXXX | 000 | XXX | 101 | 001 | 011 | 0011 | 0011 | XX | X | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | M2e |
| TEMP +0->NOP,MWE | XXXXX | 000 | XXX | 100 | 000 | 001 | 0011 | XXXX | XX | X | X | 0 | 0 | 0 | 1 | X | 1 | X | X | M2f |
| PC+1->PC,MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M30 |
| NEXT(PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M31 |

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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, MAR | XXXXX | 000 | XXX | 101 | 000 | 011 | 0001 | 0001 | 01 | X | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | M32 |
| NEXT (PC) | XXXXX | 000 | XXX | XXX | XXX | 001 | XXXX | XXXX | XX | X | X | 1 | 0 | 0 | 0 | X | X | X | X | M33 |

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| **MAIN** | | |
| m00 | 01 | //LOAD-BR #K |
| m01 | 27 |  |
| m02 | 00 | //LOAD-SP #K |
| m03 | 28 |  |
| m04 | 02 | //LOAD-LR #K |
| m05 | 20 |  |
| m06 | 03 | //PUSH $Z |
| m07 | 42 | //$Z |
| m08 | 03 | //PUSH $Y |
| m09 | 41 | //$Y |
| m0a | 03 | //PUSH $X |
| m0b | 40 | //$X |
| m0c | 06 | //SUB |
| m0d | 05 | //ADD |
| m0e | 04 | //POP $W |
| m0f | 43 | //$W |
| m20 | 00 | //LIMIT REGISTER |
| m21 | 00 |  |
| m22 | 00 |  |
| m23 | 00 |  |
| m24 | 00 |  |
| m25 | 00 |  |
| m26 | 00 |  |
| m27 | 00 | //BASE REGISTER |
| m28 | 01 | //X |
| m29 | 07 | //Y |
| m2a | 13 | //Z |
| m2b | 00 | //W |
| m2c | 01 | //X |
| m2d | 07 | //Y |

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| **Mapper** | | |
| Κώδικας εντολής | Opcode | Περιεχόμενα |
| LOADSP | **M00** | 02 |
| LOADBR | **M01** | 06 |
| LOADLR | **M02** | 0a |
| PUSH | **M03** | 0e |
| POP | **M04** | 16 |
| ADD | **M05** | 20 |
| SUB | **M06** | 29 |
| HALT | **M07** | 32 |