

USP - ICMC - SSC
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Disciplina de Arquitetura de Computadores

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Material on-line: COTEIA - <http://coteia.icmc.usp.br>

Aula 04 - Tópicos Abordados

Conteúdos Abordados:

1. Neander: Breve Revisão

2. Neander: Linguagem de Máquina (*Assembly*)

Características do Conjunto de Instruções (*Instruction Set*)

Programando no Neander

3. Conceitos de Programação em *Assembly*

Modos de Endereçamento: *Direto, Indireto, Imediato, Indexado*

Tipos de Endereço: *Absoluto, Relativo*

4. Microprocessador 6502

Arquitetura

Programação

Neander - Computador Hipotético [Weber 2001*]

Arquitetura: características gerais

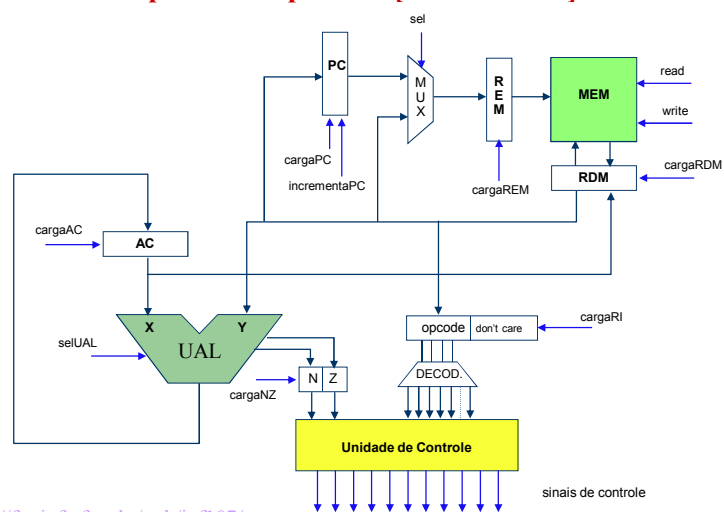
- Largura de dados e endereços de 8 bits (bus)
- Dados representados em complemento de 2
- Acumulador de 8 bits (AC - Accumulator)
- Apontador de programa de 8 bits (PC - Program Counter)
- Registrador de Instruções de 8 bits (IR - Instruction Reg.)
- Registrador de estado (flags) com 2 códigos de condição: Negativo (N) e Zero (Z)
- Endereçamento de memória total de 256 bytes

3

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* <ftp://ftp.inf.ufrgs.br/pub/inf107/>

Neander - Computador Hipotético [Weber 2001*]



4

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* <ftp://ftp.inf.ufrgs.br/pub/inf107/>

Neander: Simulação

Neander => Simulador WNeander

Neander Versão 2.1
Autor: Paul Fernando Vilela
Tayá Silva Ribeiro
Versão: Paulo Augusto Dal Castel
WNeader

Programa

P	End.	Dado	Mnemônico
0	0	0	NOP
1	0	0	NOP
2	0	0	NOP
3	0	0	NOP
4	0	0	NOP
5	0	0	NOP
6	0	0	NOP
7	0	0	NOP
8	0	0	NOP
9	0	0	NOP
10	0	0	NOP
11	0	0	NOP
12	0	0	NOP
13	0	0	NOP
14	0	0	NOP
15	0	0	NOP
16	0	0	NOP

Neander

Arquivo Editar Visualizar Executar ?

AC: 0000 PC: 0000

Execução: 000000

Acessos: 000000

Instruções: 000000

Instrução: 0

Reg.Instrução: 0

Mnemônico: NOP

Ok.

Mnemônicos

NOP 00	ADD 48 end	JMP 128 end
STA 16 end	OR 64 end	JN 144 end
LDA 32 end	AND 80 end	JZ 160 end
	NOT 96	HLT 240

Dados

End.	Dado
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0

BP: 255 [0]: 0

[128]: 0

Simuladores Didáticos
ftp://ftp.inf.ufrgs.br/pub/inf107/
ftp://ftp.inf.ufrgs.br/pub/inf108/

5

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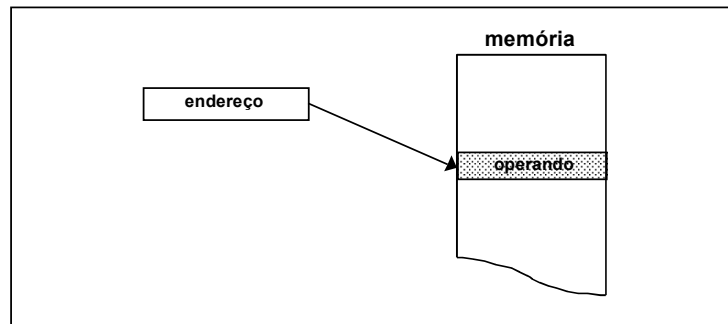
Neander: Programação

Neander - Modos de Endereçamento

NEANDER - Somente UM modo de endereçamento:

Modo Direto

Mnemônicos		
NOP	0	ADD 30 end
STA	10 end	OR 40 end
LDA	20 end	AND 50 end
		NOT 60
		JMP 80 end
		JN 90 end
		JZ A0 end
		HLT F0



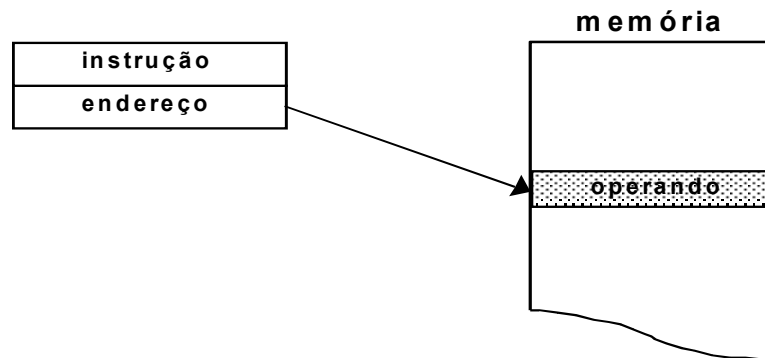
6

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Neander: Programação

Neander - Modos de Endereçamento

Endereçamento direto (absoluto)



7

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Neander: Programação

Neander - Gerando o código...

Mnemônicos			
NOP	0	ADD	30 end
STA	10 end	OR	40 end
LDA	20 end	AND	50 end
		NOT	60
		JMP	80 end
		JN	90 end
		JZ	A0 end
		HLT	F0

Linguagem de Montagem (Assembly Language)

```
LDA Valor1 ; Valor1 <=> End. $50
ADD Valor2 ; Valor2 <=> End. $51
STA Valor3 ; Valor3 <=> End. $52
```

Código de Execução / Código de Máquina

Montador (Assembler) →

\$20	\$50
\$30	\$51
\$10	\$52

Linguagem de Montagem (Assembly): Mnemônicos, Labels e Diretivas

```
[NomeVariavel:]  ORG      [PosicaoMemoria]
                  DB       [Valor_Inicial]      [; comentario]
[Rotulo:]        Mnemonico  [Operandos]        [; comentario]
```

- > Existe um montador que foi desenvolvido para as arquiteturas dos processadores didáticos: Deadalus (Montador do Ahmes, Ramses e Cesar)
- > Estamos adotando uma linguagem similar mas não idêntica

8

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Neander: Programação - Exemplo

Neander - Somar 2 números

Mnemônicos

NOP	0	ADD	30 end	JMP	80 end
STA	10 end	OR	40 end	JN	90 end
LDA	20 end	AND	50 end	JZ	A0 end
		NOT	60	HLT	F0

```

                ORG      $00      ; Início da área de programa

Início:        LDA      Valor1 ; Lê o valor contido no end. Valor1
                ADD      Valor2 ; Soma com o dado do end. Valor2
                STA      Valor3 ; Armazena no end. Valor3
                HLT

                ORG      $50      ; Início da área de dados
Valor1         DB      $10      ; Armazena o valor $10 neste end.
Valor2         DB      $23      ; Armazena o valor $23 neste end.
Valor3         DB      $00      ; Cria uma posição vazia neste end.

                END.
  
```

Após a montagem... (valores com \$ estão em hexadecimal)

00: \$20	\$50	50: \$10	Após a execução...	50: \$10
02: \$30	\$51	51: \$23		51: \$23
04: \$10	\$52	52: \$00		52: \$33

Neander: Programação - Exemplo

Neander - Somar 2 números

SOMAR 2 NÚMEROS

```

LDA $50
ADD $51
STA $52
HLT
  
```

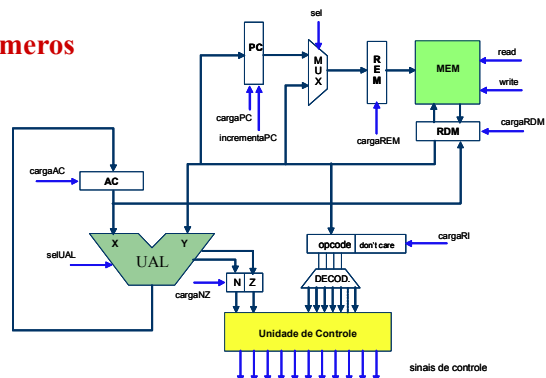
Acessos a memória:

LDA \$50
1) Lê OP Code "LDA"
2) Lê Operando: End. \$50
3) Lê Conteúdo do End. \$50

ADD \$51
1) Lê Op Code "ADD"
2) Lê Operando: End. \$51
3) Lê Conteúdo do End. \$51

STA \$52
1) Lê Op Code "STA"
2) Lê Operando: End. \$52
3) Armazena dado no End. \$52

Total de Acessos a memória: 3x3 = 9 acessos



Neander: Programação - Exemplo

Neander - Somar 2 números

SOMAR 2 NÚMEROS

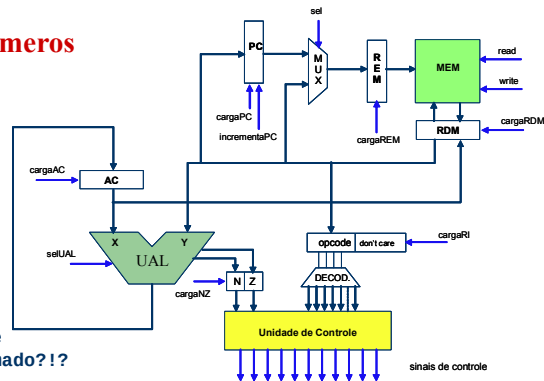
```
LDA $50
ADD $51
STA $52
HLT
```

Acessos a memória:

E se o operando já fosse
o próprio dado a ser somado?!

```
LDA #$10
ADD #$23
STA $51
```

Total de Acessos a memória:
2 x 2 + 3 = 7 acessos



Modo Imediato

- LDA #\$10
- 1) Lê OP Code "LDA"
 - 2) Lê Operando: Valor \$10
 - 3) -

11

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Arquiteturas Didáticas: Ramses

Neander x Ramses

Programa

P	End.	Dado	Mnemônico
0	0	0	NOP
1	0	0	NOP
2	0	0	NOP
3	0	0	NOP
4	0	0	NOP
5	0	0	NOP
6	0	0	NOP
7	0	0	NOP
8	0	0	NOP
9	0	0	NOP
10	0	0	NOP
11	0	0	NOP
12	0	0	NOP
13	0	0	NOP
14	0	0	NOP
15	0	0	NOP

BP: 255 IO: 0

Ramses v1.2

Arquivo Editar Visualizar Executar ?

RA: 0000 RB: 0000 RX: 0000 PC: 0000

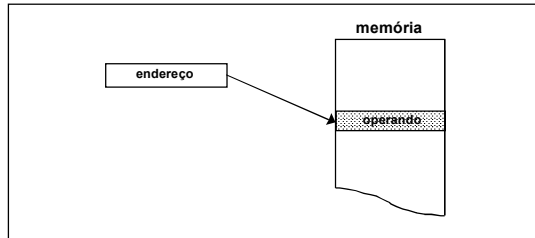
N Z C

Execução: 00000000 Instrução: 00000000

Acessos: 00000000 RI: 0 Mnem: NOP

0..9 0..F [OK] [F5] [F6] [F7] [F8] [F9] [F10] [F11] [F12] [F13] [F14] [F15] [F16] [F17] [F18] [F19] [F20] [F21] [F22] [F23] [F24] [F25] [F26] [F27] [F28] [F29] [F30] [F31] [F32] [F33] [F34] [F35] [F36] [F37] [F38] [F39] [F40] [F41] [F42] [F43] [F44] [F45] [F46] [F47] [F48] [F49] [F50] [F51] [F52] [F53] [F54] [F55] [F56] [F57] [F58] [F59] [F60] [F61] [F62] [F63] [F64] [F65] [F66] [F67] [F68] [F69] [F70] [F71] [F72] [F73] [F74] [F75] [F76] [F77] [F78] [F79] [F80] [F81] [F82] [F83] [F84] [F85] [F86] [F87] [F88] [F89] [F90] [F91] [F92] [F93] [F94] [F95] [F96] [F97] [F98] [F99] [F100] [F101] [F102] [F103] [F104] [F105] [F106] [F107] [F108] [F109] [F110] [F111] [F112] [F113] [F114] [F115] [F116] [F117] [F118] [F119] [F120] [F121] [F122] [F123] [F124] [F125] [F126] [F127] [F128] [F129] [F130] [F131] [F132] [F133] [F134] [F135] [F136] [F137] [F138] [F139] [F140] [F141] [F142] [F143] [F144] [F145] [F146] [F147] [F148] [F149] [F150] [F151] [F152] [F153] [F154] [F155] [F156] [F157] [F158] [F159] [F160] [F161] [F162] [F163] [F164] [F165] [F166] [F167] [F168] [F169] [F170] [F171] [F172] [F173] [F174] [F175] [F176] [F177] [F178] [F179] [F180] [F181] [F182] [F183] [F184] [F185] [F186] [F187] [F188] [F189] [F190] [F191] [F192] [F193] [F194] [F195] [F196] [F197] [F198] [F199] [F200] [F201] [F202] [F203] [F204] [F205] [F206] [F207] [F208] [F209] [F210] [F211] [F212] [F213] [F214] [F215] [F216] [F217] [F218] [F219] [F220] [F221] [F222] [F223] [F224] [F225] [F226] [F227] [F228] [F229] [F230] [F231] [F232] [F233] [F234] [F235] [F236] [F237] [F238] [F239] [F240] [F241] [F242] [F243] [F244] [F245] [F246] [F247] [F248] [F249] [F250] [F251] [F252] [F253] [F254] [F255] [F256] [F257] [F258] [F259] [F260] [F261] [F262] [F263] [F264] [F265] [F266] [F267] [F268] [F269] [F270] [F271] [F272] [F273] [F274] [F275] [F276] [F277] [F278] [F279] [F280] [F281] [F282] [F283] [F284] [F285] [F286] [F287] [F288] [F289] [F290] [F291] [F292] [F293] [F294] [F295] [F296] [F297] [F298] [F299] [F300] [F301] [F302] [F303] [F304] [F305] [F306] [F307] [F308] [F309] [F310] [F311] [F312] [F313] [F314] [F315] [F316] [F317] [F318] [F319] [F320] [F321] [F322] [F323] [F324] [F325] [F326] [F327] [F328] [F329] [F330] [F331] [F332] [F333] [F334] [F335] [F336] [F337] [F338] [F339] [F340] [F341] [F342] [F343] [F344] [F345] [F346] [F347] [F348] [F349] [F350] [F351] [F352] [F353] [F354] [F355] [F356] [F357] [F358] [F359] [F360] [F361] [F362] [F363] [F364] [F365] [F366] [F367] [F368] [F369] [F370] [F371] [F372] [F373] [F374] [F375] [F376] [F377] [F378] [F379] [F380] [F381] [F382] [F383] [F384] [F385] [F386] [F387] [F388] [F389] [F390] [F391] [F392] [F393] [F394] [F395] [F396] [F397] [F398] [F399] [F400] [F401] [F402] [F403] [F404] [F405] [F406] [F407] [F408] [F409] [F410] [F411] [F412] [F413] [F414] [F415] [F416] [F417] [F418] [F419] [F420] [F421] [F422] [F423] [F424] [F425] [F426] [F427] [F428] [F429] [F430] [F431] [F432] [F433] [F434] [F435] [F436] [F437] [F438] [F439] [F440] [F441] [F442] [F443] [F444] [F445] [F446] [F447] [F448] [F449] [F450] [F451] [F452] [F453] [F454] [F455] [F456] [F457] [F458] [F459] [F460] [F461] [F462] [F463] [F464] [F465] [F466] [F467] [F468] [F469] [F470] [F471] [F472] [F473] [F474] [F475] [F476] [F477] [F478] [F479] [F480] [F481] [F482] [F483] [F484] [F485] [F486] [F487] [F488] [F489] [F490] [F491] [F492] [F493] [F494] [F495] [F496] [F497] [F498] [F499] [F500] [F501] [F502] [F503] [F504] [F505] [F506] [F507] [F508] [F509] [F510] [F511] [F512] [F513] [F514] [F515] [F516] [F517] [F518] [F519] [F520] [F521] [F522] [F523] [F524] [F525] [F526] [F527] [F528] [F529] [F530] [F531] [F532] [F533] [F534] [F535] [F536] [F537] [F538] [F539] [F540] [F541] [F542] [F543] [F544] [F545] [F546] [F547] [F548] [F549] [F550] [F551] [F552] [F553] [F554] [F555] [F556] [F557] [F558] [F559] [F560] [F561] [F562] [F563] [F564] [F565] [F566] [F567] [F568] [F569] [F570] [F571] [F572] [F573] [F574] [F575] [F576] [F577] [F578] [F579] [F580] [F581] [F582] [F583] [F584] [F585] [F586] [F587] [F588] [F589] [F590] [F591] [F592] [F593] [F594] [F595] [F596] [F597] [F598] [F599] [F600] [F601] [F602] [F603] [F604] [F605] [F606] [F607] [F608] [F609] [F610] [F611] [F612] [F613] [F614] [F615] [F616] [F617] [F618] [F619] [F620] [F621] [F622] [F623] [F624] [F625] [F626] [F627] [F628] [F629] [F630] [F631] [F632] [F633] [F634] [F635] [F636] [F637] [F638] [F639] [F640] [F641] [F642] [F643] [F644] [F645] [F646] [F647] [F648] [F649] [F650] [F651] [F652] [F653] [F654] [F655] [F656] [F657] [F658] [F659] [F660] [F661] [F662] [F663] [F664] [F665] [F666] [F667] [F668] [F669] [F670] [F671] [F672] [F673] [F674] [F675] [F676] [F677] [F678] [F679] [F680] [F681] [F682] [F683] [F684] [F685] [F686] [F687] [F688] [F689] [F690] [F691] [F692] [F693] [F694] [F695] [F696] [F697] [F698] [F699] [F700] [F701] [F702] [F703] [F704] [F705] [F706] [F707] [F708] [F709] [F710] [F711] [F712] [F713] [F714] [F715] [F716] [F717] [F718] [F719] [F720] [F721] [F722] [F723] [F724] [F725] [F726] [F727] [F728] [F729] [F730] [F731] [F732] [F733] [F734] [F735] [F736] [F737] [F738] [F739] [F740] [F741] [F742] [F743] [F744] [F745] [F746] [F747] [F748] [F749] [F750] [F751] [F752] [F753] [F754] [F755] [F756] [F757] [F758] [F759] [F760] [F761] [F762] [F763] [F764] [F765] [F766] [F767] [F768] [F769] [F770] [F771] [F772] [F773] [F774] [F775] [F776] [F777] [F778] [F779] [F780] [F781] [F782] [F783] [F784] [F785] [F786] [F787] [F788] [F789] [F790] [F791] [F792] [F793] [F794] [F795] [F796] [F797] [F798] [F799] [F800] [F801] [F802] [F803] [F804] [F805] [F806] [F807] [F808] [F809] [F810] [F811] [F812] [F813] [F814] [F815] [F816] [F817] [F818] [F819] [F820] [F821] [F822] [F823] [F824] [F825] [F826] [F827] [F828] [F829] [F830] [F831] [F832] [F833] [F834] [F835] [F836] [F837] [F838] [F839] [F840] [F841] [F842] [F843] [F844] [F845] [F846] [F847] [F848] [F849] [F850] [F851] [F852] [F853] [F854] [F855] [F856] [F857] [F858] [F859] [F860] [F861] [F862] [F863] [F864] [F865] [F866] [F867] [F868] [F869] [F870] [F871] [F872] [F873] [F874] 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Modos de Endereçamento



NEANDER:

Registradores: AC
Modos de endereçamento:
1 - Direto

OP Code: Código + Registrador + Operador

- 00 = A (registrador RA)
 - 01 = B (registrador RB)
 - 10 = X (registrador de índice)
 - 11 = nenhum registrador
-
- 00 = direto
 - 01 = indireto
 - 10 = imediato
 - 11 = indexado

RAMSES:

Registradores: RA, RB, RX
Modos de endereçamento:
1 - Direto
2 - Indireto
3 - Imediato
4 - Indexado

13

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Modos de Endereçamento

NOP	0	JMP	80	end	Modo: 0: Dir: n 1: Ind: n,l 2: Imd: #n 3: Idx: n,X
STR	10	JN	90	end	
LDR	20	JZ	A0	end	
ADD	30	JC	B0	end	
OR	40	JSR	C0	end	Registrador: 0: A 2: X 1: B 3: ?
AND	50	NEG	D0	r	
NOT	60	SHR	E0	r	
SUB	70	HLT	F0		

Instrução 2 bytes:

Byte 1: Instrução
xxxx rr ee

Byte 2: Operando
endereço/dado

OP Code: Código + Registrador + Operador

- 00 = A (registrador RA)
 - 01 = B (registrador RB)
 - 10 = X (registrador de índice)
 - 11 = nenhum registrador
-
- 00 = direto
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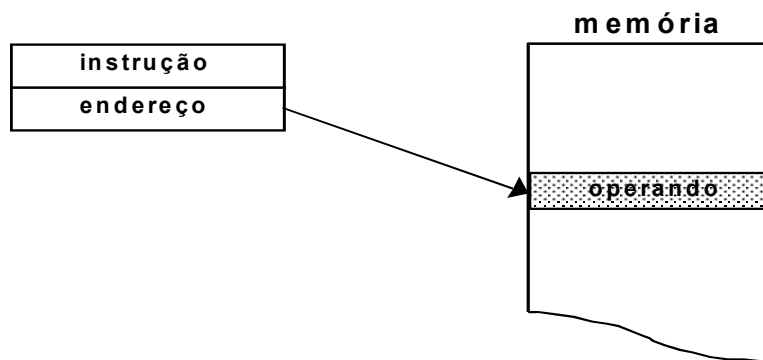
RAMSES:

Registradores: RA, RB, RX
Modos de endereçamento:
1 - Direto
2 - Indireto
3 - Imediato
4 - Indexado

14

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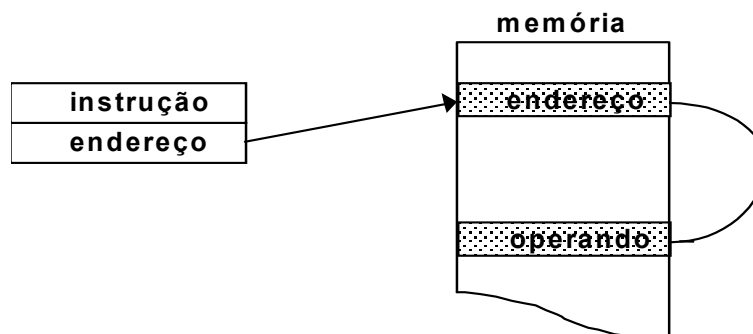
Endereçamento direto (absoluto)



15

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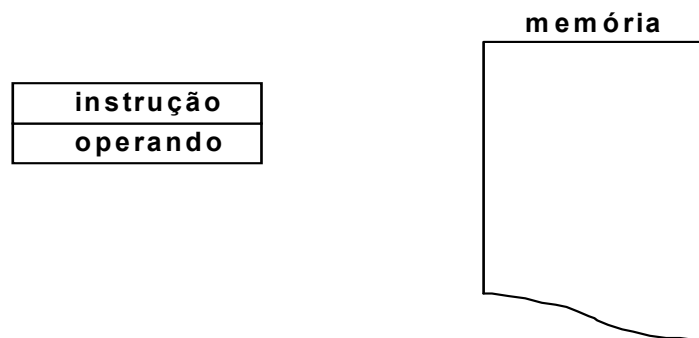
Endereçamento indireto



16

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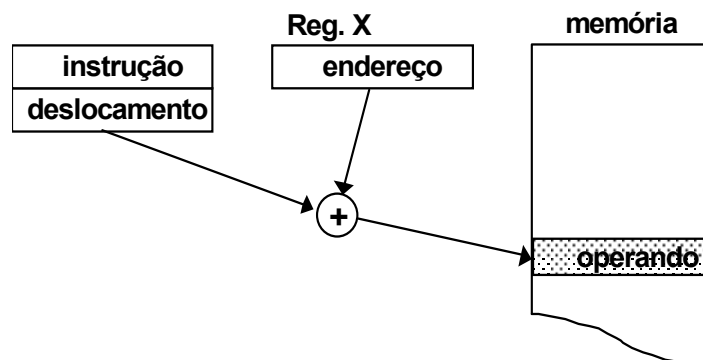
Endereçamento imediato



17

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Endereçamento indexado



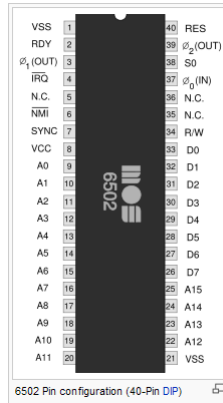
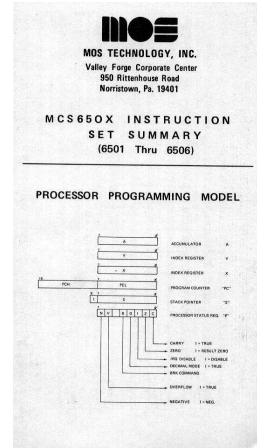
18

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3. Arquitetura de Microprocessador Comercial

MosTech 6502 - Adotado no Apple II

Microprocessador de 8 bits dados e 16 bits de endereço



19

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* http://en.wikipedia.org/wiki/MOS_Technology_6502

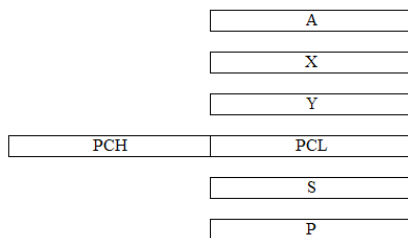
3. Arquitetura de Microprocessador Comercial

MosTech 6502 - Adotado no Apple II

Microprocessador de 8 bits dados e 16 bits de endereço

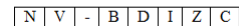
Registers

The 6502 only has 6 registers. Five are 8 bits wide, one is 16 bits wide.



Accumulator 8 bits A

Processor Status Register



N - Negative Flag
V - Overflow Flag
B - Break Command
D - Decimal Mode
I - Int. Disable
Z - Zero Flag
C - Carry Flag

Accumulator
Index Register X
Index Register Y
Program Counter
Stack Pointer
Processor Status (Flags)

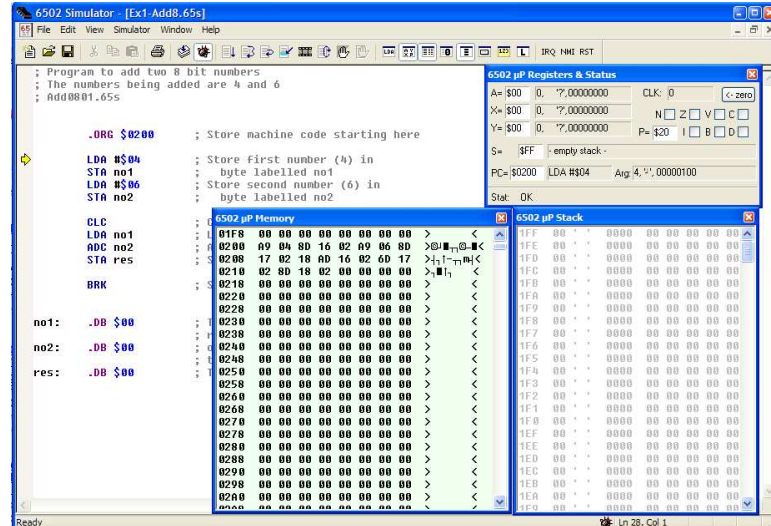
20

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* Simulador: 6502 Simulator / Site: http://home.pacbell.net/michal_k/ / By Michal Kowalski

3. Arquitetura de Microprocessador Comercial

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21

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INFORMAÇÕES SOBRE A DISCIPLINA

USP - Universidade de São Paulo - São Carlos, SP
ICMC - Instituto de Ciências Matemáticas e de Computação
SSC - Departamento de Sistemas de Computação

Prof. Fernando Santos OSÓRIO

Web institucional: <http://www.icmc.usp.br/ssc/>

Página pessoal: <http://www.icmc.usp.br/~fosorio/>

E-mail: [fosorio \[at\] icmc. usp. br](mailto:fosorio[at]icmc.usp.br) ou [fosorio \[at\] gmail. com](mailto:fosorio[at]gmail.com)

Disciplina de Arquitetura de Computadores / Informática

Estagiário PAE: Maurício A. Dias

Web disciplina: COTEIA - [Http://coteia.icmc.usp.br](http://coteia.icmc.usp.br)

> Programa, Material de Aulas, Critérios de Avaliação,

> Lista de Exercícios, Trabalhos Práticos, Datas das Provas

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22

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