MC404

ORGANIZAÇÃO BÁSICA DE COMPUTADORES E LINGUAGEM DE MONTAGEM

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MC404

ORGANIZAÇÃO BÁSICA DE COMPUTADORES E LINGUAGEM DE MONTAGEM

"Subrotinas

e

Pilha"

Subrotinas
Sumário

- Instruções
- Uso da Pilha
- Regras Básicas

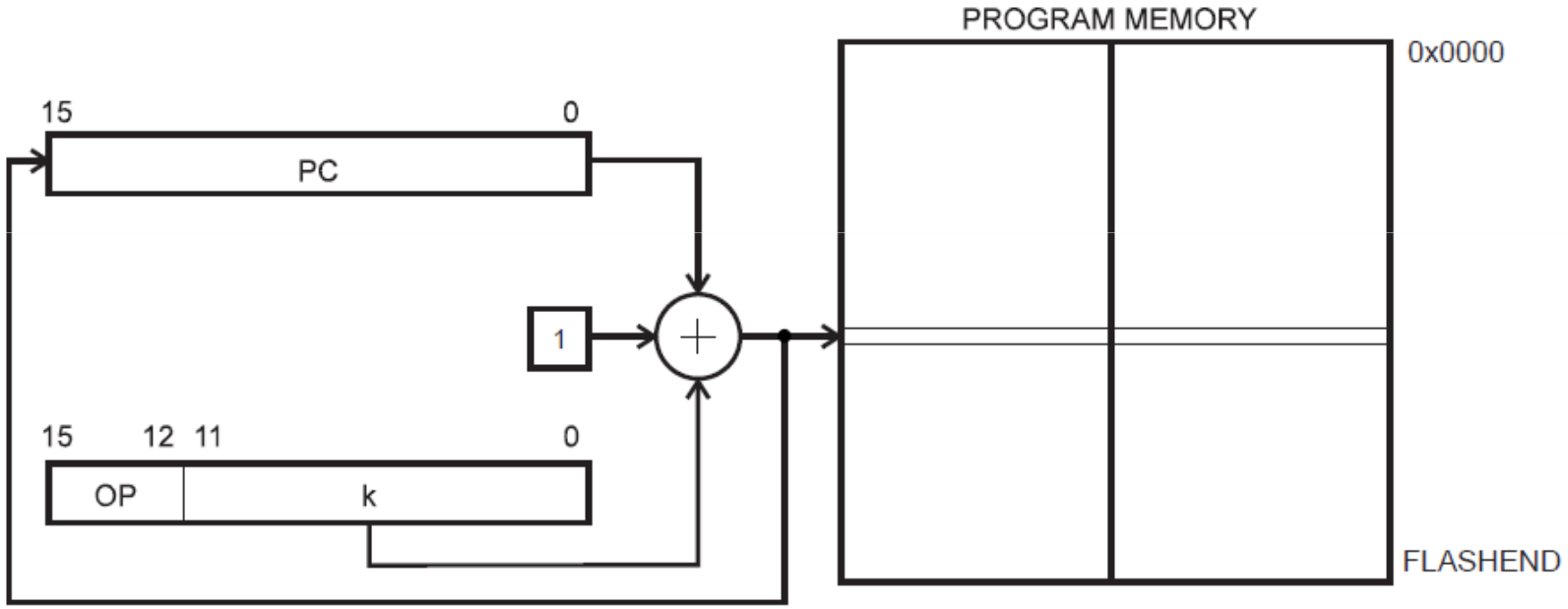
Instruções

- **Rcall**
- **Icall**
- **Call**
- **Ret**
- **Reti**
- **Push**
- **Pop**

RCALL

Relative Program Addressing, RJMP and RCALL

Figure 13. Relative Program Memory Addressing



Program execution continues at address PC + k + 1. The relative address k is from -2048 to 2047.

RCALL

Description:

Relative call to an address within PC - 2K + 1 and PC + 2K (words). The return address (the instruction after the RCALL) is stored onto the Stack. See also CALL. For AVR microcontrollers with Program memory not exceeding 4K words (8K bytes) this instruction can address the entire memory from every address location. The Stack Pointer uses a post-decrement scheme during RCALL.

Operation:

(i)	PC ← PC + k + 1	Devices with 16 bits PC, 128K bytes Program memory maximum.
(ii)	PC ← PC + k + 1	Devices with 22 bits PC, 8M bytes Program memory maximum.

	Syntax:	Operands:	Program Counter:	Stack:
(i)	RCALL k	-2K ≤ k < 2K	PC ← PC + k + 1	STACK ← PC + 1 SP ← SP - 2 (2 bytes, 16 bits)
(ii)	RCALL k	-2K ≤ k < 2K	PC ← PC + k + 1	STACK ← PC + 1 SP ← SP - 3 (3 bytes, 22 bits)

16-bit Opcode:

1101	kkkk	kkkk	kkkk

Status Register (SREG) and Boolean Formula:

I	T	H	S	V	N	Z	C
–	–	–	–	–	–	–	–

RCALL - exemplo

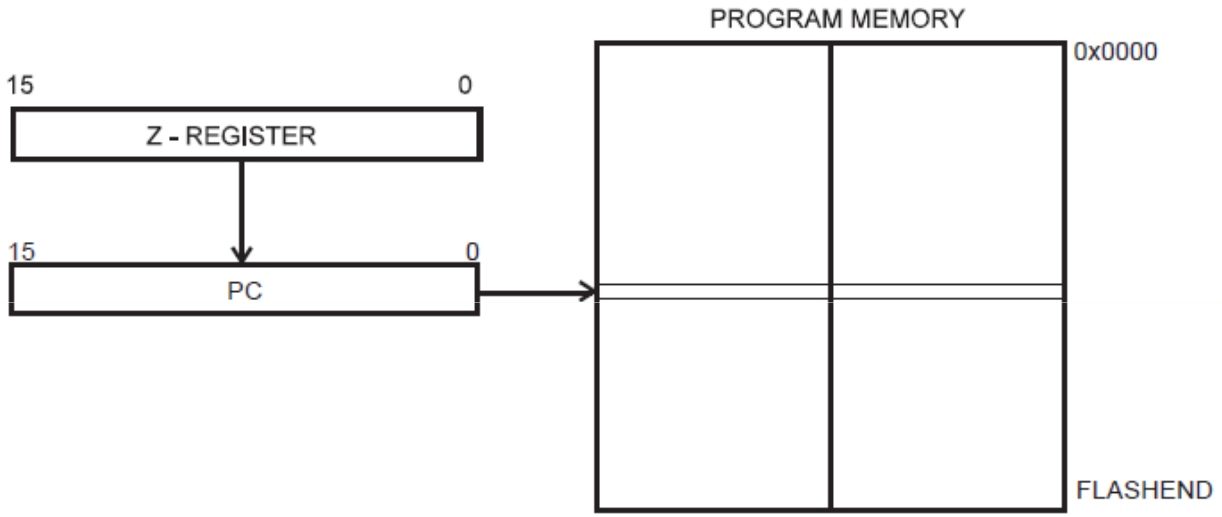
```
        rcall routine       ; Call subroutine
...
routine:
        push r14            ; Save r14 on the Stack
...
        pop r14             ; Restore r14

        ret ; Return from subroutine
```

Words : 1 (2 bytes)
Cycles : 3, devices with 16 bit PC
4, devices with 22 bit PC

ICALL

Indirect Program Addressing, IJMP and ICALL

Figure 12. Indirect Program Memory Addressing



Program execution continues at address contained by the Z-register (i.e., the PC is loaded with the contents of the Z-register).

ICALL

ICALL – Indirect Call to Subroutine

Description:

Calls to a subroutine within the entire 4M (words) Program memory. The return address (to the instruction after the CALL will be stored onto the Stack. See also RCALL. The Stack Pointer uses a post-decrement scheme during CALL.

This instruction is not available in all devices. Refer to the device specific instruction set summary.

Operation:

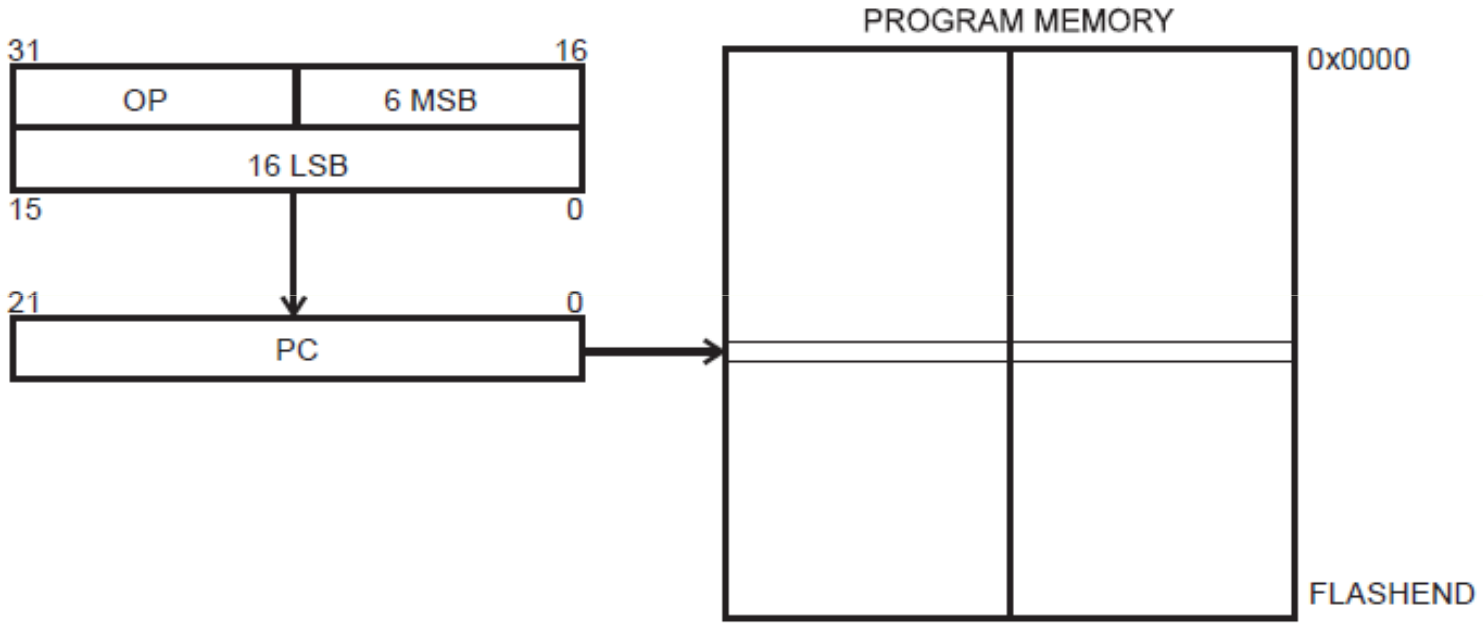
(i) PC(15:0) ← Z(15:0) Devices with 16 bits PC, 128K bytes Program memory maximum.
(ii) PC(15:0) ← Z(15:0) Devices with 22 bits PC, 8M bytes Program memory maximum.
PC(21:16) ← 0

	Syntax:	Operands:	Program Counter:	Stack:
(i)	ICALL	None	See Operation	STACK ← PC + 1 SP ← SP - 2 (2 bytes, 16 bits)
(ii)	ICALL	None	See Operation	STACK ← PC + 1 SP ← SP - 3 (3 bytes, 22 bits)

CALL

Direct Program Addressing, JMP and CALL

Figure 11. Direct Program Memory Addressing



Program execution continues at the address immediate in the instruction word.

CALL (não implementada no ATmega88)

CALL – Long Call to a Subroutine

Description:

Calls to a subroutine within the entire Program memory. The return address (to the instruction after the CALL) will be stored onto the Stack. (See also RCALL). The Stack Pointer uses a post-decrement scheme during CALL.

This instruction is not available in all devices. Refer to the device specific instruction set summary.

	Operation:	
(i)	PC ← k	Devices with 16 bits PC, 128K bytes Program memory maximum.
(ii)	PC ← k	Devices with 22 bits PC, 8M bytes Program memory maximum.

	Syntax:	**Operands:**	**Program Counter**	**Stack:**
(i)	CALL k	$0 \le k < 64K$	PC ← k	STACK ← PC+2 SP ← SP-2, (2 bytes, 16 bits)
(ii)	CALL k	$0 \le k < 4M$	PC ← k	STACK ← PC+2 SP ← SP-3 (3 bytes, 22 bits)

RETCALL (não implementada no ATmega88)

RET – Return from Subroutine

Description:

Returns from subroutine. The return address is loaded from the STACK. The Stack Pointer uses a pre-increment scheme during RET.

Operation:

(i) PC(15:0) ← STACK Devices with 16 bits PC, 128K bytes Program memory maximum.
(ii) PC(21:0) ← STACK Devices with 22 bits PC, 8M bytes Program memory maximum.

	Syntax:	Operands:	Program Counter:	Stack:
(i)	RET	None	See Operation	SP←SP + 2, (2bytes,16 bits)
(ii)	RET	None	See Operation	SP←SP + 3, (3bytes,22 bits)

PUSH

PUSH – Push Register on Stack

Description:

This instruction stores the contents of register Rr on the STACK. The Stack Pointer is post-decremented by 1 after the PUSH.

This instruction is not available in all devices. Refer to the device specific instruction set summary.

Operation:

(i) STACK ← Rr

	Syntax:	Operands:	Program Counter:	Stack:
(i)	PUSH Rr	$0 \leq r \leq 31$	PC ← PC + 1	SP ← SP - 1

POP

POP – Pop Register from Stack

Description:

This instruction loads register Rd with a byte from the STACK. The Stack Pointer is pre-incremented by 1 before the POP.

This instruction is not available in all devices. Refer to the device specific instruction set summary.

	Operation:
(i)	Rd ← STACK

	Syntax:	**Operands:**	**Program Counter:**	**Stack:**
(i)	POP Rd	$0 \leq d \leq 31$	PC ← PC + 1	SP ← SP + 1

Pilha

The AVR Stack Pointer is implemented as two 8-bit registers in the I/O space. The number of bits actually used is implementation dependent. Note that the data space in some implementations of the AVR architecture is so small that only SPL is needed. In this case, the SPH Register will not be present.

Bit	15	14	13	12	11	10	9	8	
	SP15	SP14	SP13	SP12	SP11	SP10	SP9	SP8	SPH
	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	SPL
	7	6	5	4	3	2	1	0	
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	RAMEND	RAMEND	RAMEND	RAMEND	RAMEND	RAMEND	RAMEND	RAMEND	
	RAMEND	RAMEND	RAMEND	RAMEND	RAMEND	RAMEND	RAMEND	RAMEND	

Endereço: 0x3E (SPH) e 0x 3D (SPL)

Espaço de I/O

IN - Load an I/O Location to Register

Description:

Loads data from the I/O Space (Ports, Timers, Configuration Registers etc.) into register Rd in the Register File.

Operation:

(i) Rd ← I/O(A)

	Syntax:	Operands:	Program Counter:
(i)	IN Rd,A	$0 \le d \le 31, 0 \le A \le 63$	PC ← PC + 1

Espaço de I/O

OUT – Store Register to I/O Location

Description:

Stores data from register Rr in the Register File to I/O Space (Ports, Timers, Configuration Registers etc.).

	Operation:
(i)	I/O(A) ← Rr

	Syntax:	Operands:	Program Counter:
(i)	OUT A,Rr	$0 \leq r \leq 31$, $0 \leq A \leq 63$	PC ← PC + 1

Pilha

- **Inicialização do Apontador de Pilha**

```
.def    r =r16   ; usado na inicialização dos apontadores
                 ; da pilha e iinicio da RAM

    ldi   r,low(RAMEND) ; fim da RAM: definido em m88def.inc
    out   SPL,r         ; inicializa Stack Pointer
    ldi   r,high(RAMEND)
    out   SPH, r
```

OBS: ver valor inicializado pelo HW no SP nesta família de proc.

Regras Básicas para Programação de Subrotinas

- **NomeRotina:**

- **Salvar contexto (em geral na pilha)**
  - **Registradores utilizados na subrotina**
  - **Flags (se necessário) – Registrador SREG**

- **Corpo da Subrotina**

- **Restaurar registradores salvos**

- **RET**

OBS: para salvar/recuperar SREG

```
IN r16, SREG
OUT SREG, r17
```