

MC404

ORGANIZAÇÃO BÁSICA DE COMPUTADORES E LINGUAGEM DE MONTAGEM

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Prof. Paulo Cesar Centoducatte
ducatte@ic.unicamp.br
www.ic.unicamp.br/~ducatte

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ORGANIZAÇÃO BÁSICA DE COMPUTADORES E LINGUAGEM DE MONTAGEM

“Subrotinas
e
Pilha”

Subrotinas Sumário

- Instruções
- Uso da Pilha
- Regras Básicas

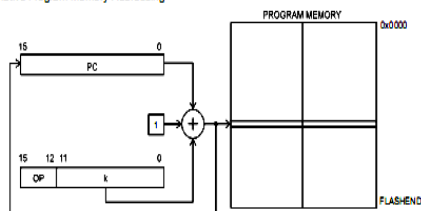
Instruções

- 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

RCALL – Relative Call to Subroutine

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). In the assembler, labels are used instead of relative operands. 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) $PC \leftarrow PC + k + 1$ Devices with 16 bits PC, 128K bytes Program memory maximum.
- (ii) $PC \leftarrow PC + k + 1$ Devices with 22 bits PC, 8M bytes Program memory maximum.

Syntax:

- | | Operands: | Program Counter: | Stack: |
|------|-----------|-------------------|---|
| (i) | RCALL k | $-2K \leq k < 2K$ | $PC \leftarrow PC + k + 1$ $SP \leftarrow SP - 2$ (2 bytes, 16 bits) |
| (ii) | RCALL k | $-2K \leq k < 2K$ | $PC \leftarrow PC + k + 1$ $SP \leftarrow SP - 3$ (3 bytes, 22 bits) |

ICALL

Indirect Program Addressing, JMP 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).

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ICALL

ICALL – Indirect Call to Subroutine

Description:
Indirect call of a subroutine pointed to by the Z (16 bits) Pointer Register in the Register File. The Z-pointer Register is 16 bits wide and allows call to a subroutine within the lowest 64K words (128K bytes) section in the Program memory space. The Stack Pointer uses a post-decrement scheme during ICALL.
This instruction is not available in all devices. Refer to the device specific instruction set summary.

Operation:

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

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

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CALL

Direct Program Addressing, JMP and CALL

Figure 11. Direct Program Memory Addressing

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

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CALL

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) $PC \leftarrow k$ Devices with 16 bits PC, 128K bytes Program memory maximum.
- (ii) $PC \leftarrow k$ Devices with 22 bits PC, 8M bytes Program memory maximum.

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

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RET

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

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

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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 \leftarrow Rr

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

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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) $Rd \leftarrow \text{STACK}$

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

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 |
| Read/Write | 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 |

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) $Rd \leftarrow I/O(A)$

Syntax: Operands: Program Counter:
 (i) IN Rd,A $0 \leq d \leq 31, 0 \leq A \leq 83$ $PC \leftarrow PC + 1$

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) $I/O(A) \leftarrow Rr$

Syntax: Operands: Program Counter:
 (i) OUT A,Rr $0 \leq r \leq 31, 0 \leq A \leq 83$ $PC \leftarrow PC + 1$

Pilha

- Inicialização do Apontador de Pilha

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

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