# Trabajo Práctico Número 3

## Sistemas con Microprocesadores y Microcontroladores

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http://www.microprocesadores.unt.edu.ar/procesadores

# Temas a tratar

- **Arquitectura de Set de Instrucciones ISA**
- **Camino de datos**
- **RTN concreto**
- **Unidad de Control**

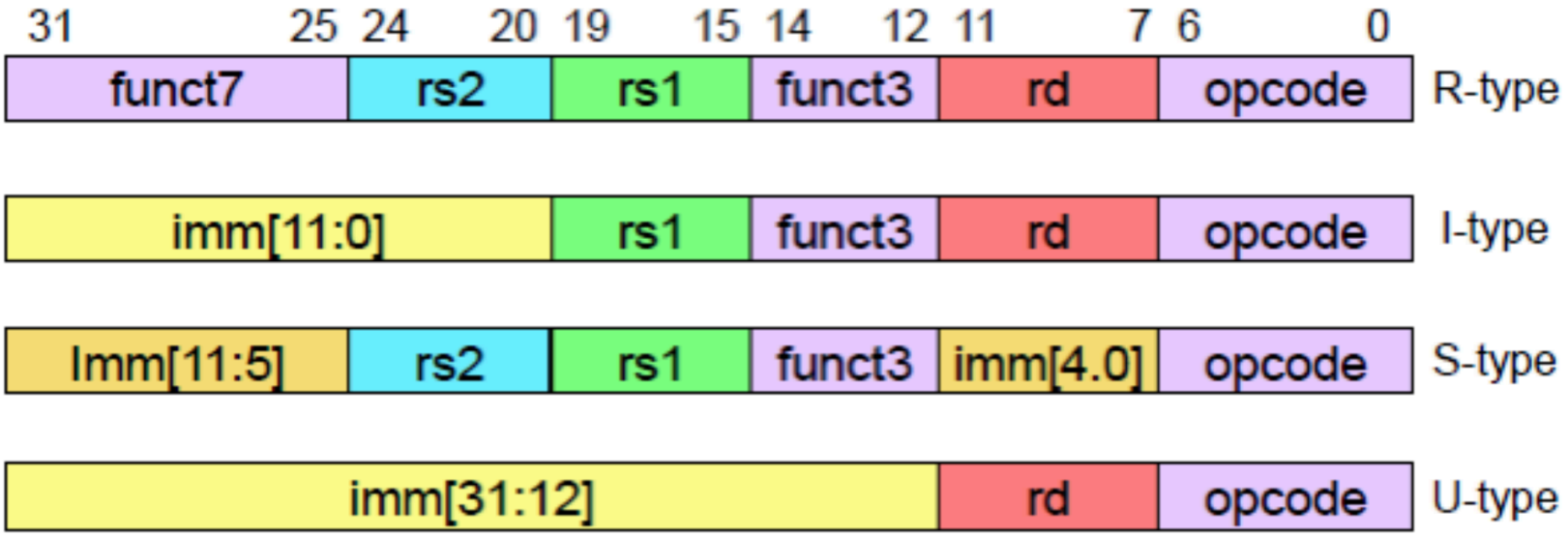
# Consigna

- **Dada una computadora de 8 bits que dispone de una única instrucción `rs`, reste y salta, la cual tiene tres operandos y realiza las siguientes operaciones.**

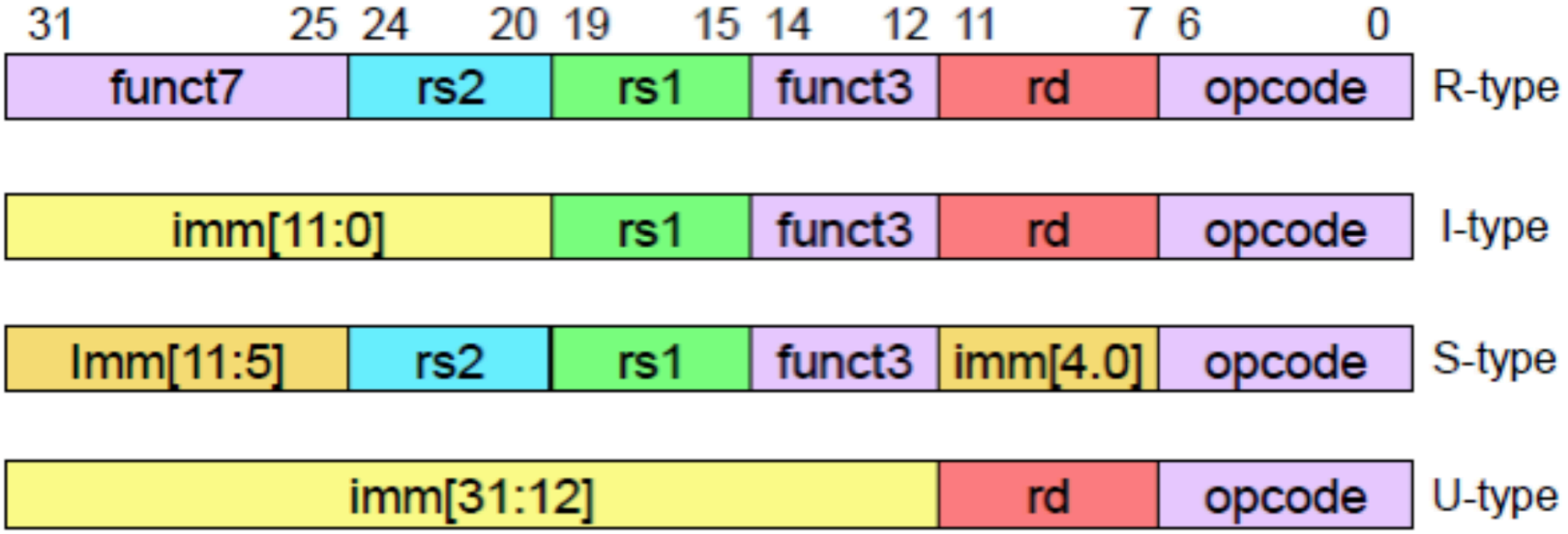
  `rs a, b, c: Mem[a] ← Mem[a] – Mem [b]; PC ← C`

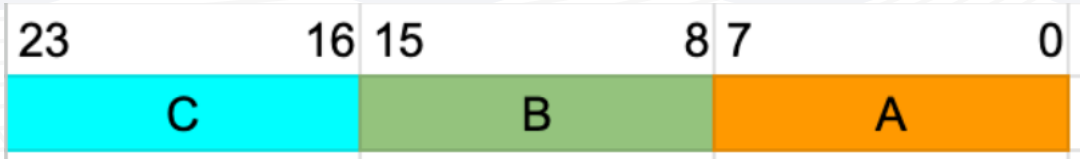
a) **Defina un formato de instrucción**
b) **Reste 2 valores y almacene el resultado en la dirección siguiente**
c) **Dibuje el mapa de memoria y el contenido según el apartado anterior**
d) **Diseñe un camino de datos posible para este ISA**
e) **Escriba el RTN concreto según el apartado anterior**
f) **Indique las señales de control del registro C**
g) **Diseñe la unidad del control.**

# Formato de instrucción



# Formato de instrucción



# Consigna

- **Dada una computadora de 8 bits que dispone de una única instrucción `rs`, reste y salta, la cual tiene tres operandos y realiza las siguientes operaciones.**

  `rs a, b, c: Mem[a] ← Mem[a] – Mem [b]; PC ← C`

a) **Defina un formato de instrucción**
b) **Reste 2 valores y almacene el resultado en la dirección siguiente**
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f) **Indique las señales de control del registro C**
g) **Diseñe la unidad del control.**

# Programa

```
.data
    numA:  .byte 5
    numB:  .byte 3
    res:   .byte 0
```

# Programa

```
.data
    numA:  .byte 5
    numB:  .byte 3
    res:   .byte 0
```

| | |
|---|---|
| 0x00 | 0x05 |
| 0x01 | 0x03 |
| 0x02 | 0x00 |
| 0x03 | ? |
| ... | |
| 0x7F | ? |
| 0x80 | ? |
| 0x81 | ? |
| 0x82 | ? |
| 0x83 | ? |
| 0x84 | ? |
| 0x85 | ? |
| ... | |
| 0xFF | ? |

# Programa

```
.data
    numA:  .byte 5
    numB:  .byte 3
    res:   .byte 0

.text
main:
    rs numA, numB, main+3
```

| | |
|---|---|
| 0x00 | 0x05 |
| 0x01 | 0x03 |
| 0x02 | 0x00 |
| 0x03 | ? |
| ... | |
| 0x7F | ? |
| 0x80 | ? |
| 0x81 | ? |
| 0x82 | ? |
| 0x83 | ? |
| 0x84 | ? |
| 0x85 | ? |
| ... | |
| 0xFF | ? |

# Programa

```
.data
    numA:  .byte 5
    numB:  .byte 3
    res:   .byte 0

.text
main:
    rs numA, numB, main+3
```

| | |
|---|---|
| 0x00 | 0x05 |
| 0x01 | 0x03 |
| 0x02 | 0x00 |
| 0x03 | ? |
| ... | |
| 0x7F | ? |
| 0x80 | 0x00 |
| 0x81 | 0x01 |
| 0x82 | 0x83 |
| 0x83 | ? |
| 0x84 | ? |
| 0x85 | ? |
| ... | |
| 0xFF | ? |

# Programa

```
.data
    numA:  .byte 5
    numB:  .byte 3
    res:   .byte 0

.text
main:
    rs numA, numB, main+3
```

| | |
|---|---|
| 0x00 | **0x02** |
| 0x01 | 0x03 |
| 0x02 | 0x00 |
| 0x03 | ? |
| ... | |
| 0x7F | ? |
| 0x80 | 0x00 |
| 0x81 | 0x01 |
| 0x82 | 0x83 |
| 0x83 | ? |
| 0x84 | ? |
| 0x85 | ? |
| ... | |
| 0xFF | ? |

# Programa

```
.data
    numA:  .byte 5
    numB:  .byte 3
    res:   .byte 0

.text
main:
    rs numA, numB, main+3
    rs res, numA, main+6
```

| | |
|---|---|
| 0x00 | **0x02** |
| 0x01 | 0x03 |
| 0x02 | 0x00 |
| 0x03 | ? |
| ... | |
| 0x7F | ? |
| 0x80 | 0x00 |
| 0x81 | 0x01 |
| 0x82 | 0x83 |
| 0x83 | ? |
| 0x84 | ? |
| 0x85 | ? |
| ... | |
| 0xFF | ? |

# Programa

```
.data
    numA:  .byte 5
    numB:  .byte 3
    res:   .byte 0

.text
main:
    rs numA, numB, main+3
    rs res, numA, main+6
```

| | |
|---|---|
| 0x00 | **0x02** |
| 0x01 | 0x03 |
| 0x02 | 0x00 |
| 0x03 | ? |
| ... | |
| 0x7F | ? |
| 0x80 | 0x00 |
| 0x81 | 0x01 |
| 0x82 | 0x83 |
| 0x83 | 0x02 |
| 0x84 | 0x00 |
| 0x85 | 0x86 |
| ... | |
| 0xFF | ? |

# Programa

```
.data
    numA:  .byte 5
    numB:  .byte 3
    res:   .byte 0

.text
main:
    rs numA, numB, main+3
    rs res, numA, main+6
```

| | |
|---|---|
| 0x00 | **0x02** |
| 0x01 | 0x03 |
| 0x02 | **0xFE** |
| 0x03 | ? |
| ... | |
| 0x7F | ? |
| 0x80 | 0x00 |
| 0x81 | 0x01 |
| 0x82 | 0x83 |
| 0x83 | 0x02 |
| 0x84 | 0x00 |
| 0x85 | 0x86 |
| ... | |
| 0xFF | ? |

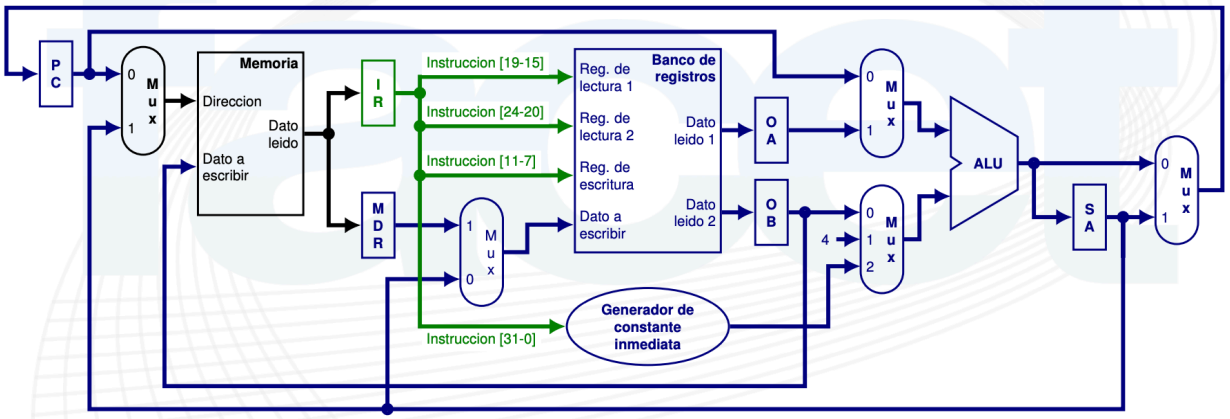
# Consigna

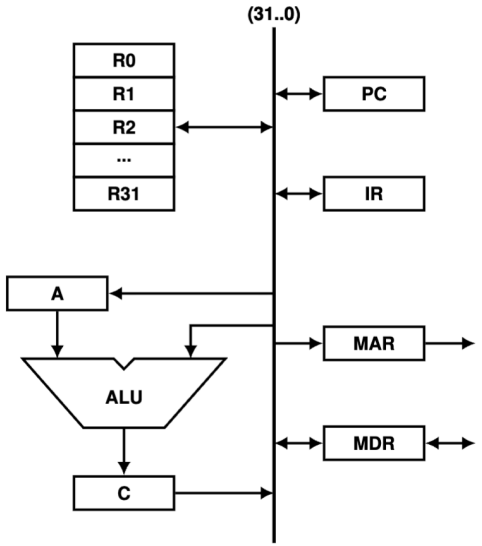
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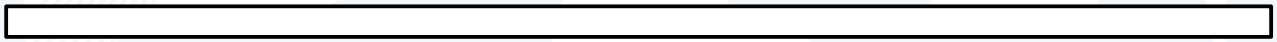
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# Diseño del Camino de Datos

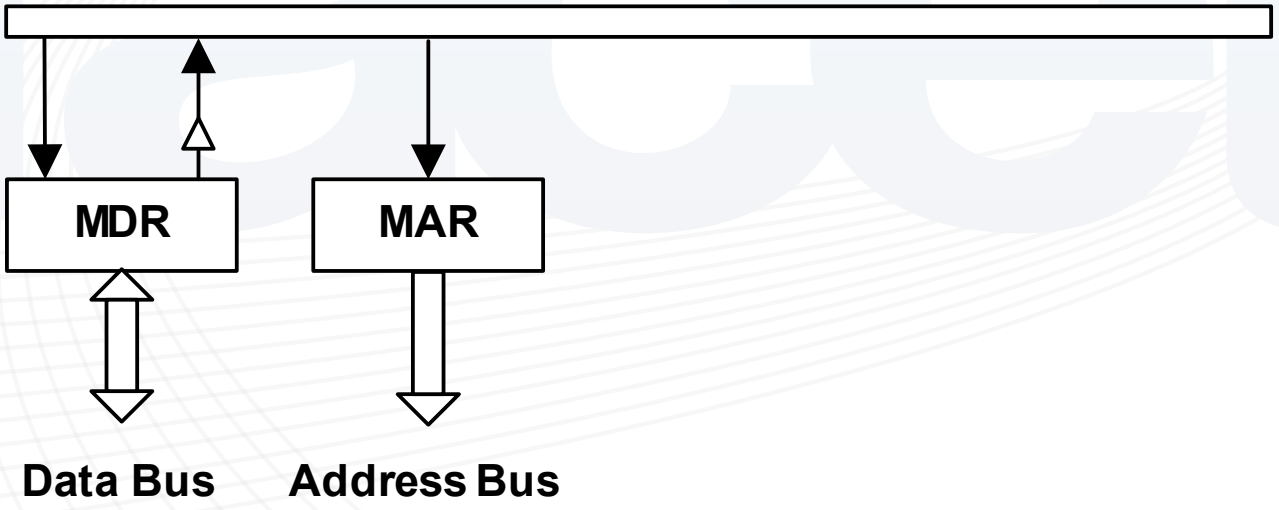


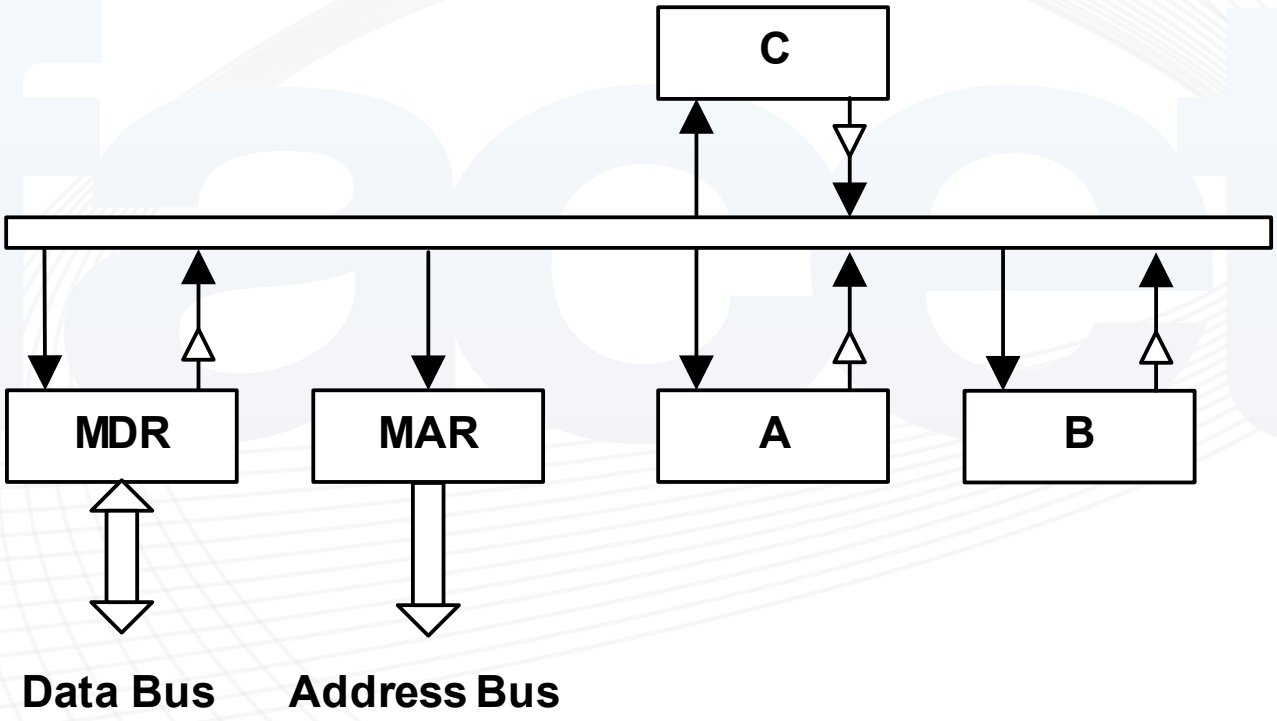
# Diseño del Camino de Datos



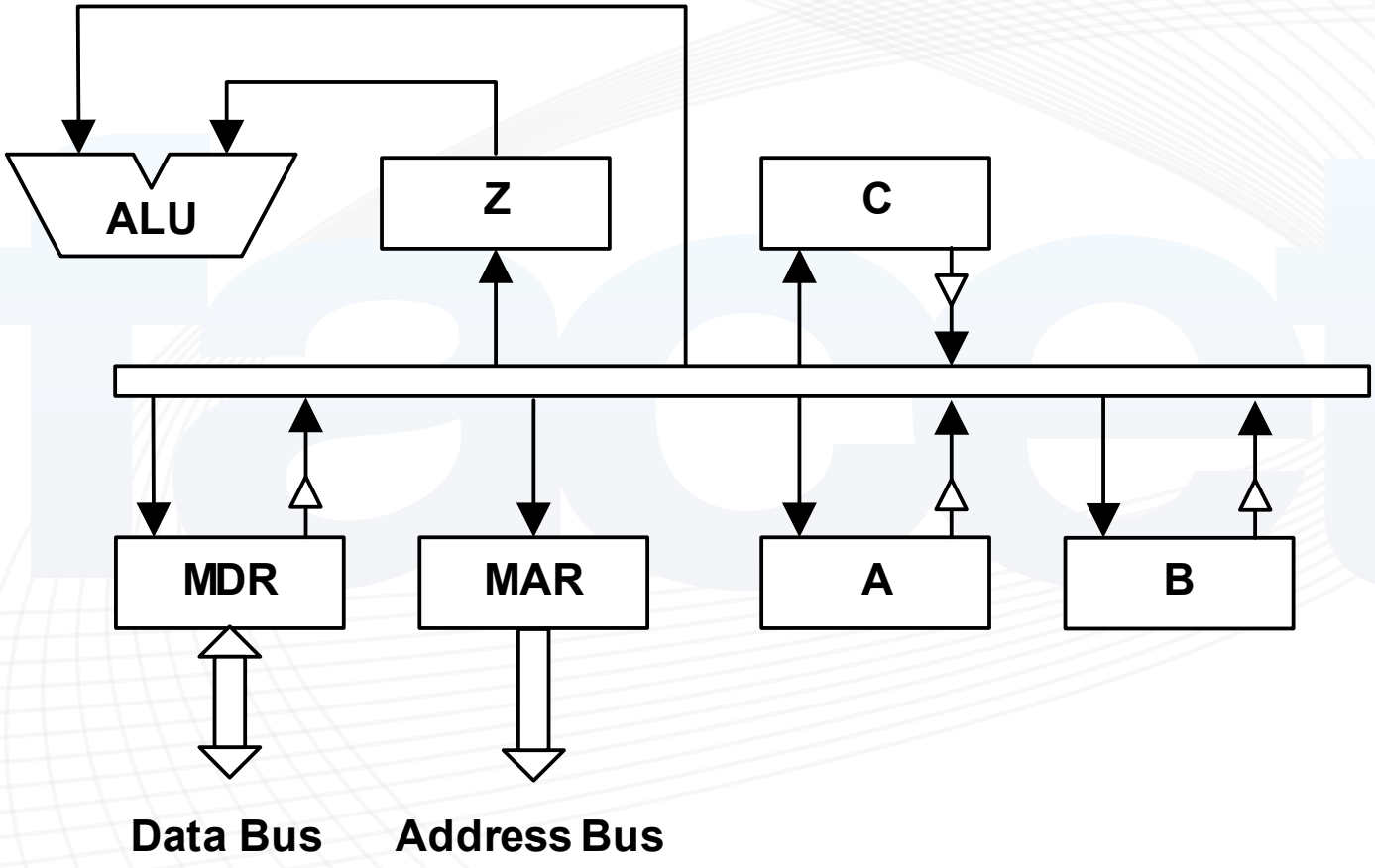
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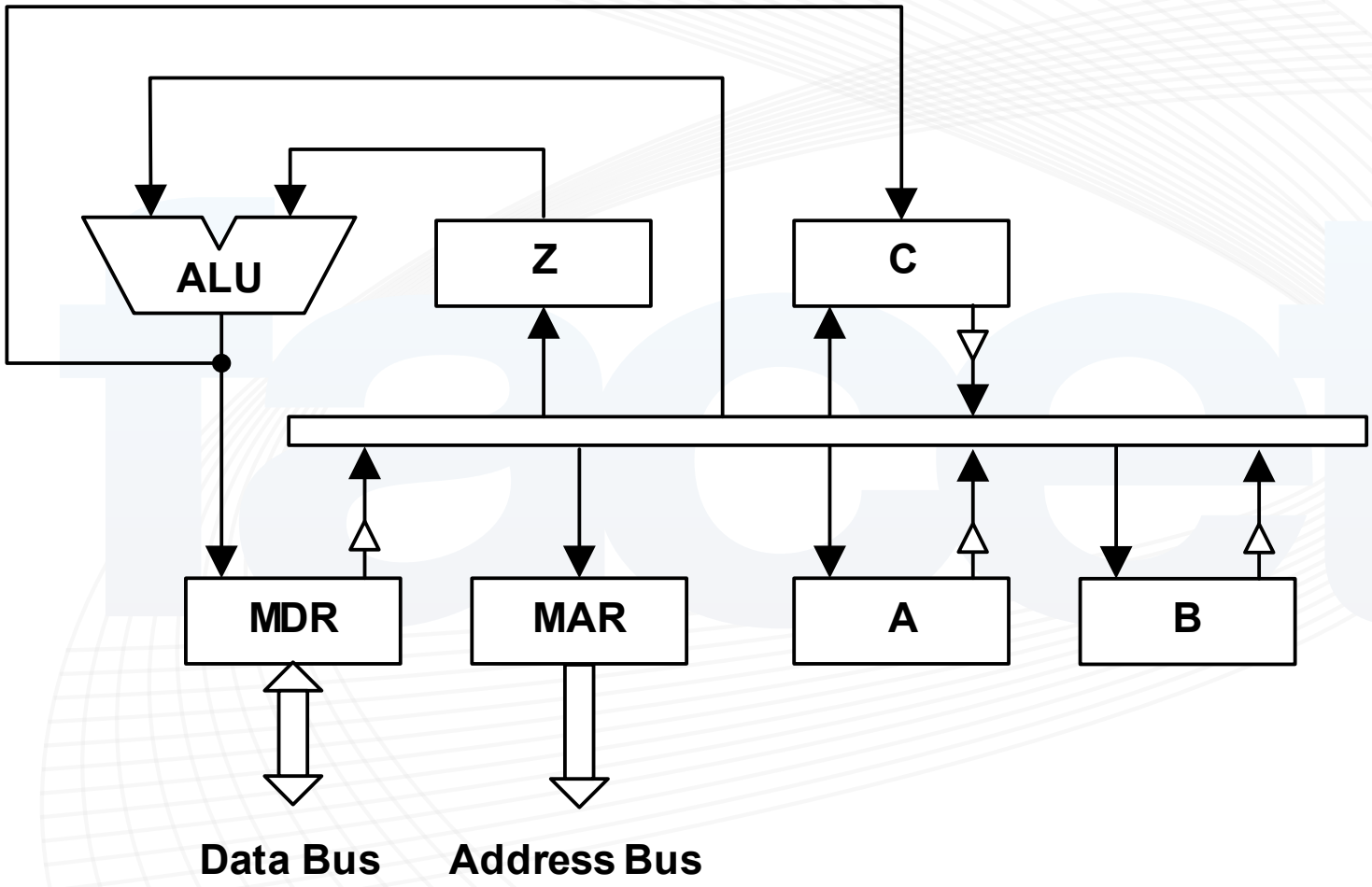
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# Diseño del Camino de Datos



# Diseño del Camino de Datos



# Consigna

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# RTN Concreto

```
MAR ← C: C ← C + 1;
MDR ← M[MAR];
A ← MDR;
```

```
MAR ← C: C ← C + 1;
MDR ← M[MAR];
B ← MDR;
```

```
MAR ← C;
MDR ← M[MAR];
C ← MDR;
```

```
MAR ← B;
MDR ← M[MAR];
Z ← MDR;
```

```
MAR ← A;
MDR ← M[MAR];
```

```
MDR ← MDR - Z;
M[MAR] ← MDR;
```

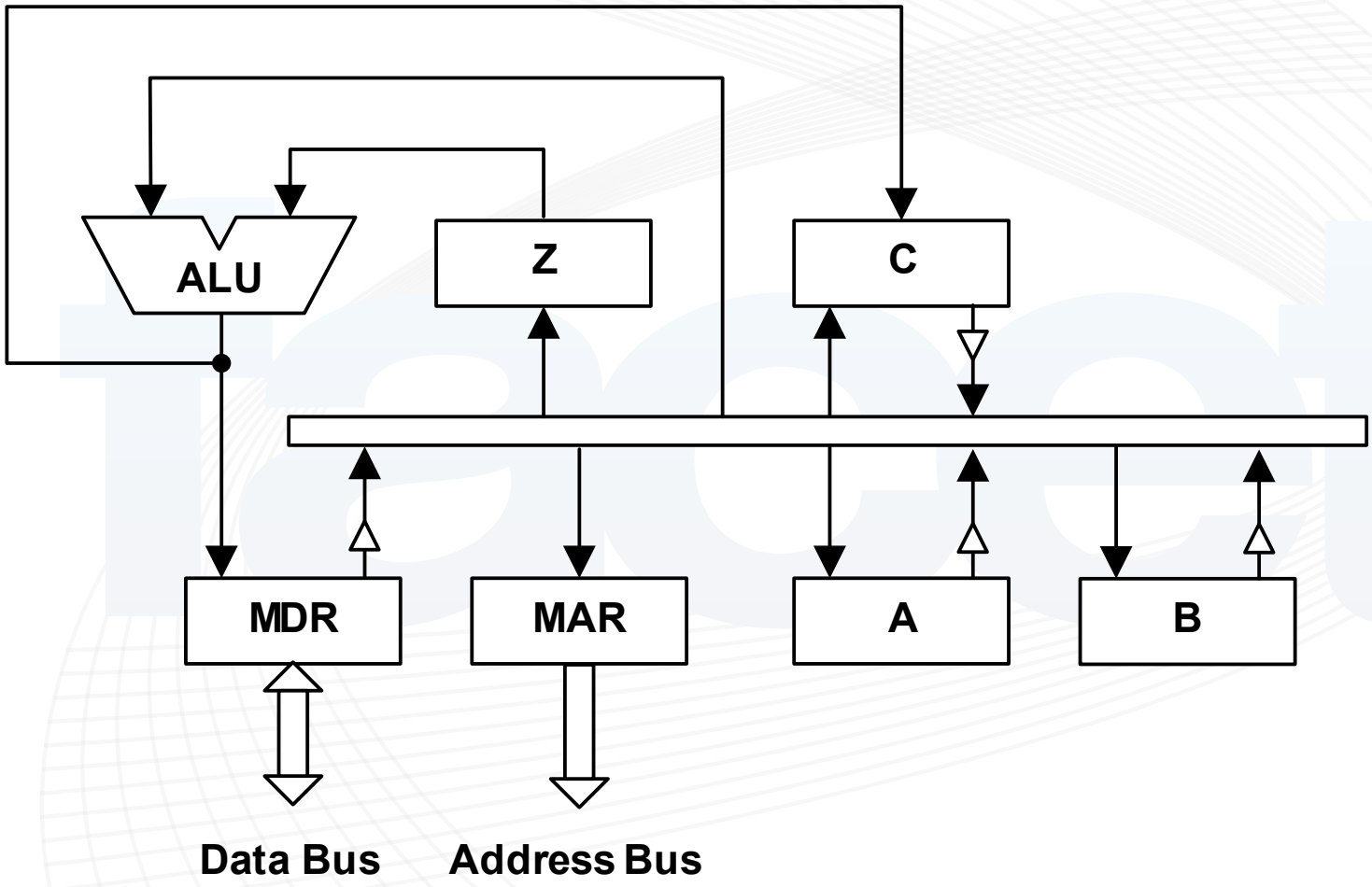
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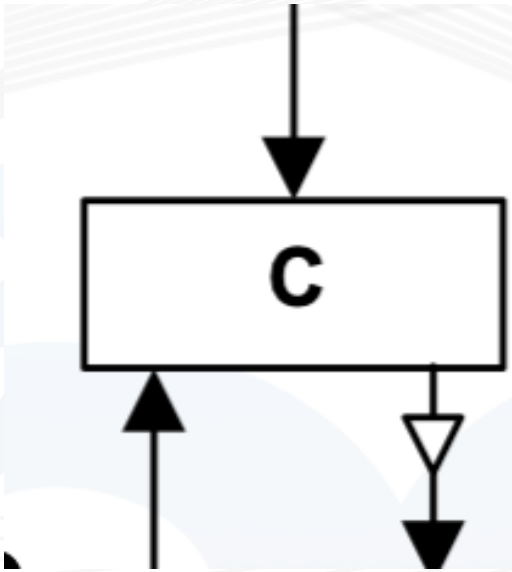
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a) **Defina un formato de instrucción**
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# Camino de Datos



# Señales de control



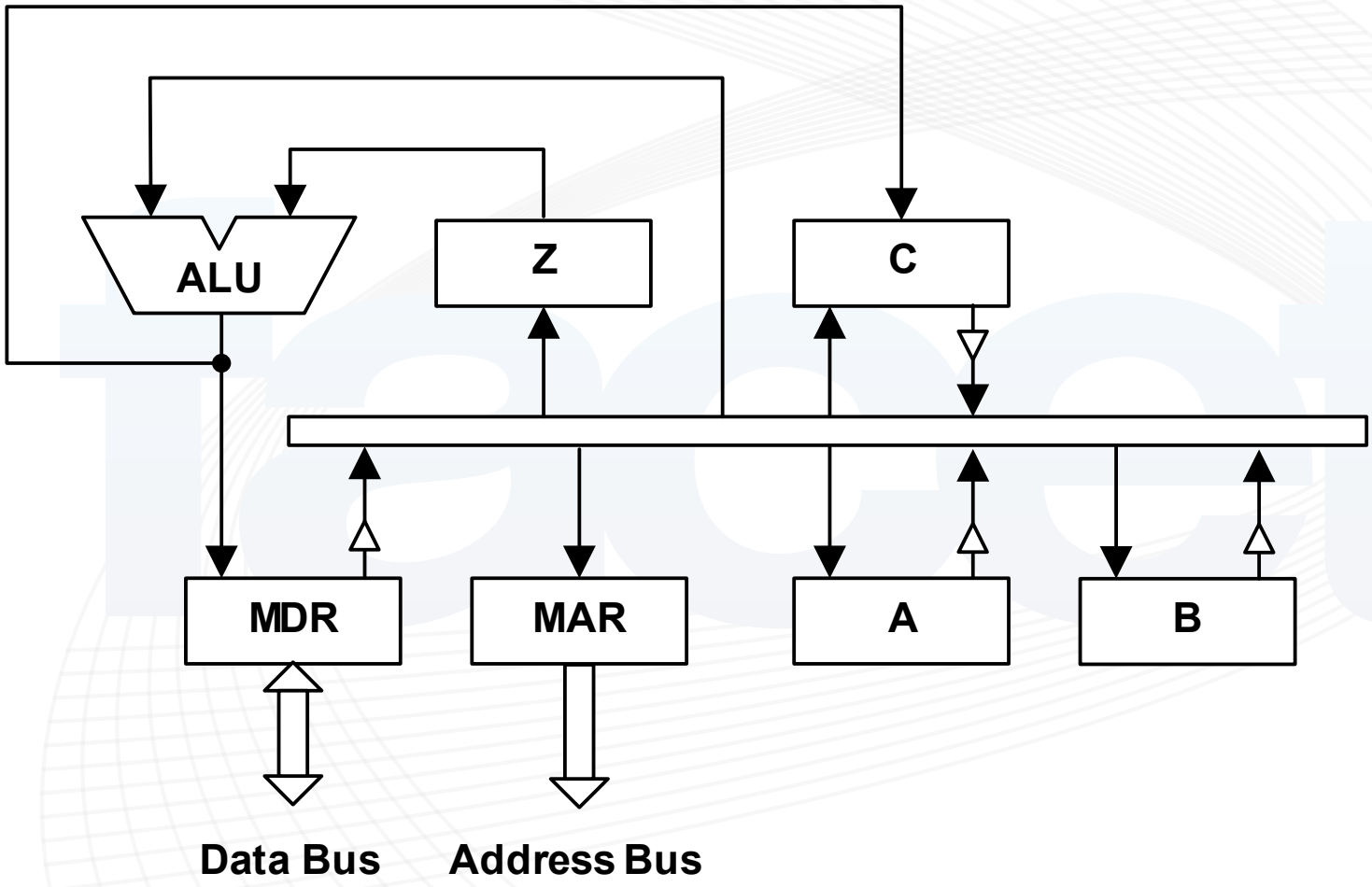
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g) **Diseñe la unidad del control.**

# Diseño del Camino de Datos



# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
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# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
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# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| | | | | | | | | | | | |

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | |

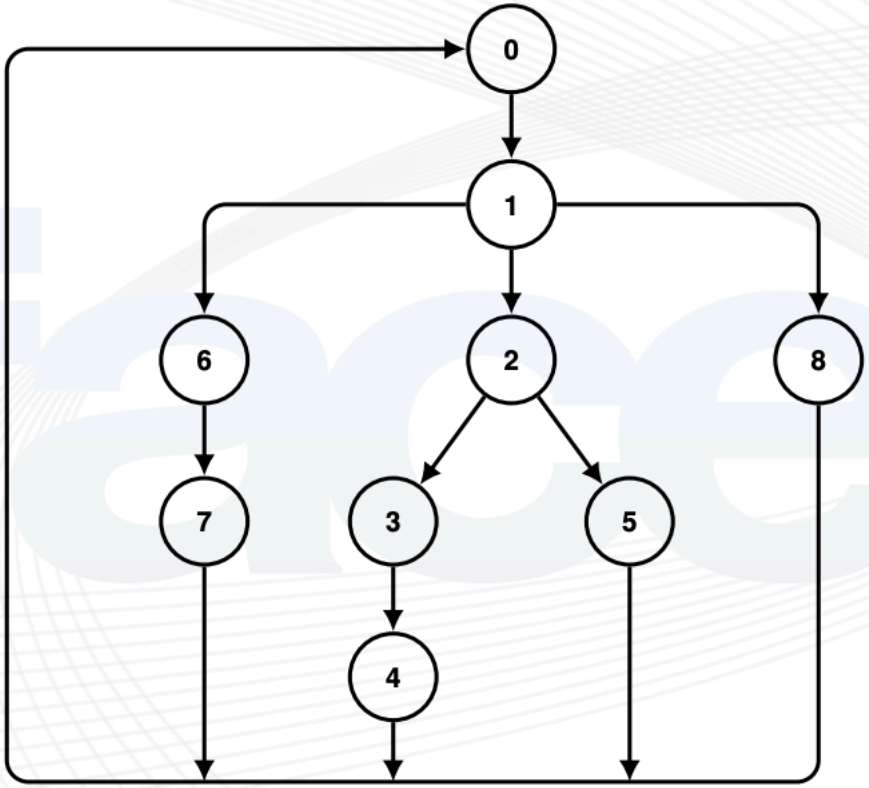
# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

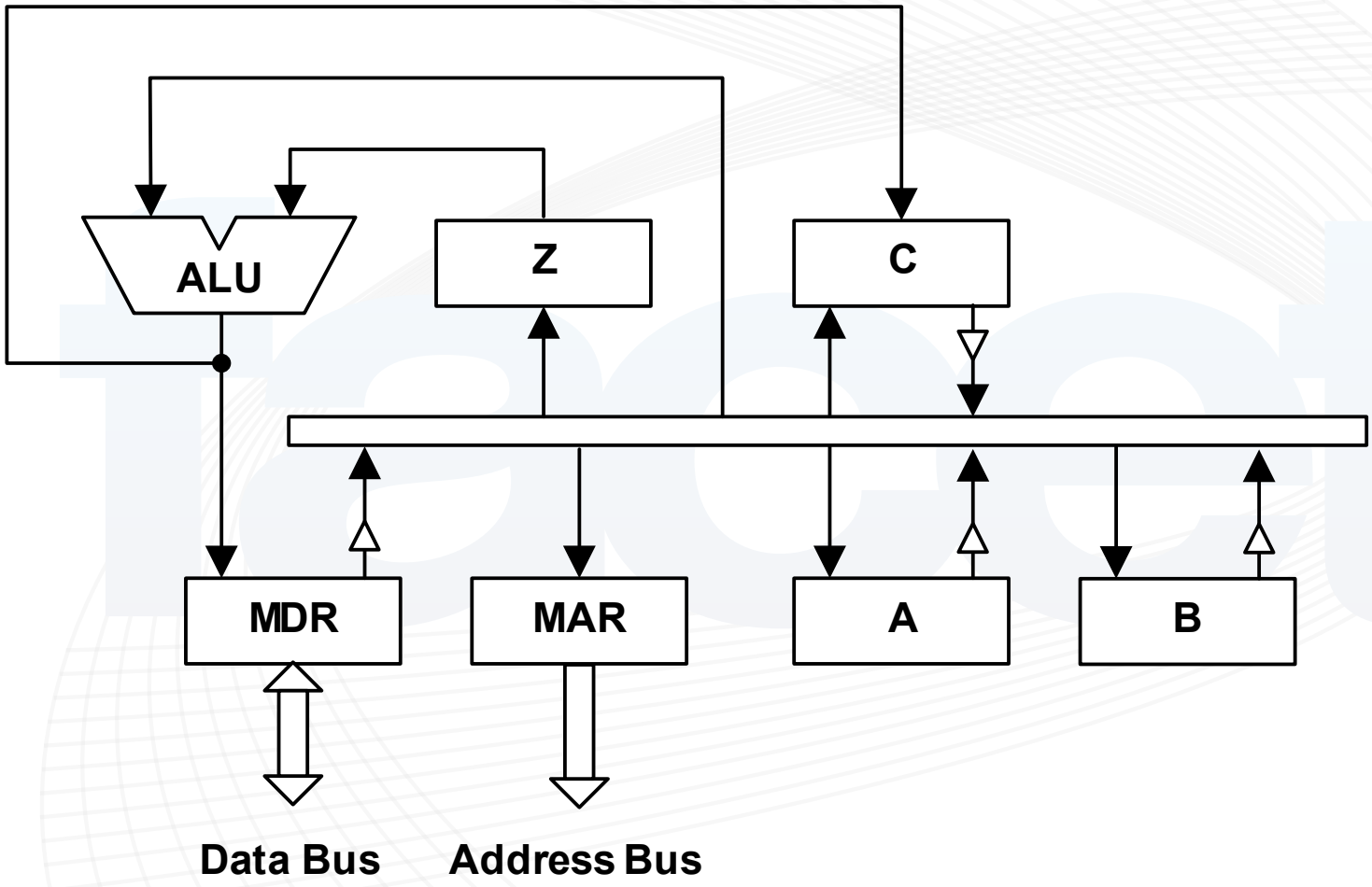
# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |

# Unidad de Control



# Diseño del Camino de Datos



# RTN Concreto

```
MAR ← C: C ← C + 1;
MDR ← M[MAR];
A ← MDR;
```

```
MAR ← C: C ← C + 1;
MDR ← M[MAR];
B ← MDR;
```

```
MAR ← C;
MDR ← M[MAR];
C ← MDR;
```

```
MAR ← B;
MDR ← M[MAR];
Z ← MDR;
```

```
MAR ← A;
MDR ← M[MAR];
```

```
MDR ← MDR - Z;
M[MAR] ← MDR;
```

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | | | | | | | | 1 | | | | | | |

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 2 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 2 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 3 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 2 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 3 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 4 | | 1 | | | | | | | | | | | | 1 | | | | | |

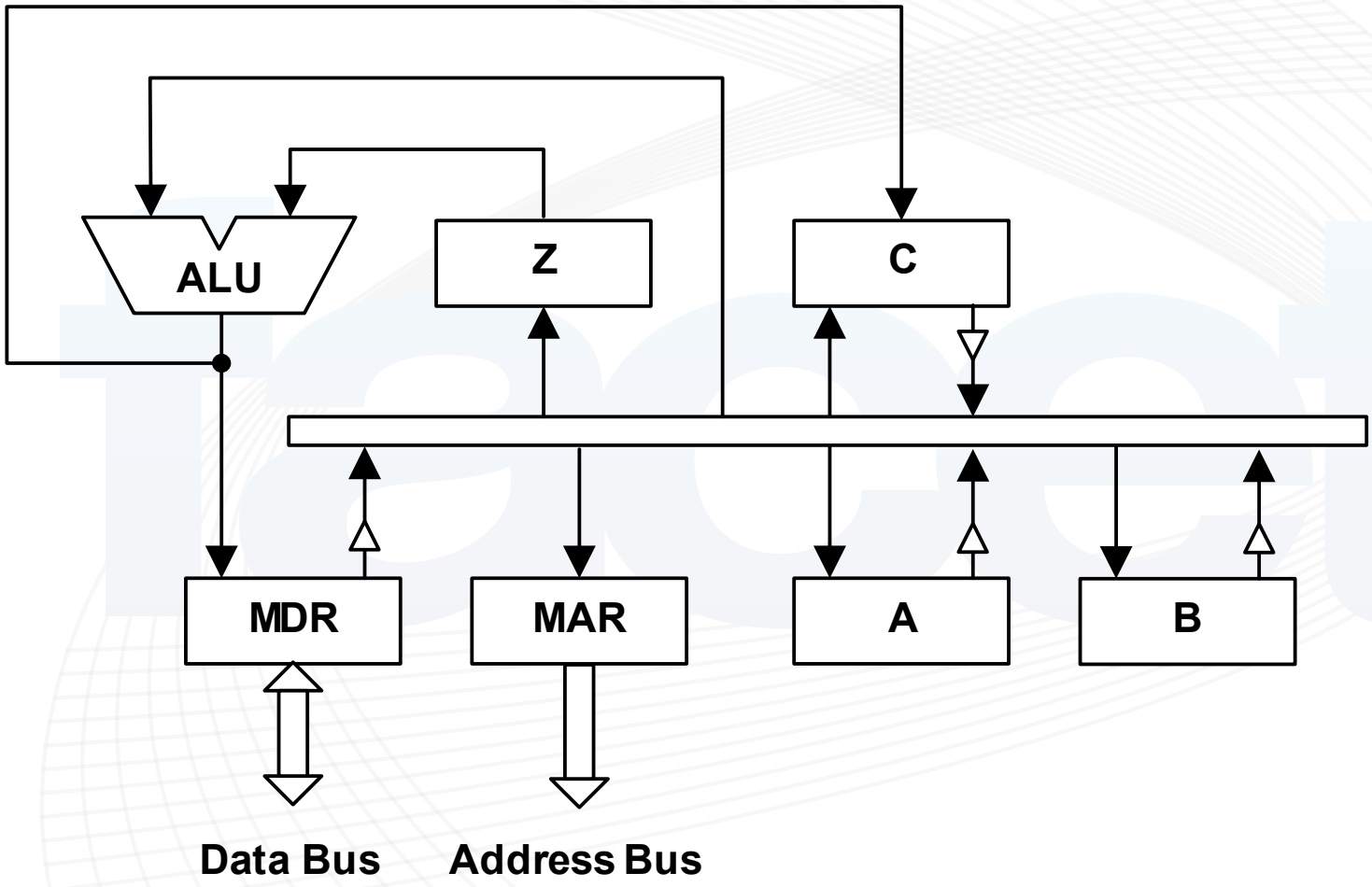
# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 2 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 3 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 4 | | 1 | | | | | | | | | | | | 1 | | | | | |
| 5 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 6 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 7 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 8 | | | | 1 | | | | | | | | | | 1 | | | | | |

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 2 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 3 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 4 | | 1 | | | | | | | | | | | | 1 | | | | | |
| 5 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 6 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 7 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 8 | | | | 1 | | | | | | | | | | 1 | | | | | |
| 9 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 10 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 11 | | | | | | | 1 | | | | | | | 1 | | | | | |

# Diseño del Camino de Datos



# RTN Concreto

```
MAR ← C: C ← C + 1;
MDR ← M[MAR];
A ← MDR;
```

```
MAR ← C: C ← C + 1;
MDR ← M[MAR];
B ← MDR;
```

```
MAR ← C;
MDR ← M[MAR];
C ← MDR;
```

```
MAR ← B;
MDR ← M[MAR];
Z ← MDR;
```

```
MAR ← A;
MDR ← M[MAR];
```

```
MDR ← MDR - Z;
M[MAR] ← MDR;
```

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 2 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 3 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 4 | | 1 | | | | | | | | | | | | 1 | | | | | |
| 5 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 6 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 7 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 8 | | | | 1 | | | | | | | | | | 1 | | | | | |
| 9 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 10 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 11 | | | | | | | 1 | | | | | | | 1 | | | | | |
| 12 | | | 1 | | | | | | | | | | 1 | | | | | | |
| 13 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 14 | | | | | | | | | 1 | | | | | 1 | | | | | |

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 2 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 3 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 4 | | 1 | | | | | | | | | | | | 1 | | | | | |
| 5 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 6 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 7 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 8 | | | | 1 | | | | | | | | | | 1 | | | | | |
| 9 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 10 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 11 | | | | | | | 1 | | | | | | | 1 | | | | | |
| 12 | | | 1 | | | | | | | | | | 1 | | | | | | |
| 13 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 14 | | | | | | | | | 1 | | | | | 1 | | | | | |
| 15 | 1 | | | | | | | | | | | | 1 | | | | | | |
| 16 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |

# Unidad de Control

| ESTADO | READ A | WRITE A | READ B | WRITE B | READ C | WRITE C ALU | WRITE C BUS | READ Z | WRITE Z | OP ALU +1 | OP ALU -Z | READ MAR | WRITE MAR | READ MDR BUS | WRITE MRD BUS | READ MDR MEM | WRITE MDR MEM | READ MEM | WRITE MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 2 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 3 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 4 | | 1 | | | | | | | | | | | | 1 | | | | | |
| 5 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 6 | | | | | 1 | 1 | | | | 1 | | | | | | | | | |
| 7 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 8 | | | | 1 | | | | | | | | | | 1 | | | | | |
| 9 | | | | | 1 | | | | | | | | 1 | | | | | | |
| 10 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 11 | | | | | | | 1 | | | | | | | 1 | | | | | |
| 12 | | | 1 | | | | | | | | | | 1 | | | | | | |
| 13 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 14 | | | | | | | | | 1 | | | | | 1 | | | | | |
| 15 | 1 | | | | | | | | | | | | 1 | | | | | | |
| 16 | | | | | | | | | | | | 1 | | | | | 1 | 1 | |
| 17 | | | | | | | | 1 | | | 1 | | | 1 | 1 | | | | |
| 18 | | | | | | | | | | | | 1 | | | | 1 | | | 1 |