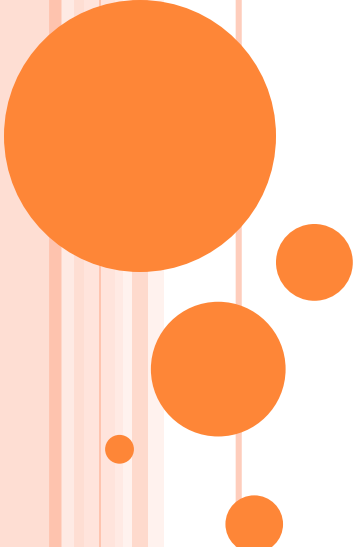




# LÓGICA SECUENCIAL

## UNIDAD V

### Diseño Digital



# FUNDAMENTOS

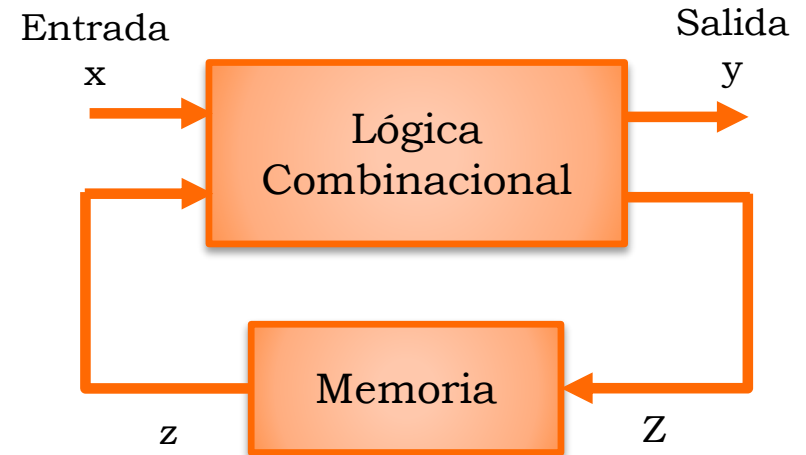
## ○ Combinacional



$$y = f(x)$$

- Entradas
- Salidas

## ○ Secuencial



$$y = f(x, z)$$

$$Z = f(x, z)$$

- Entradas
- Salidas
- Edo. Presente
- Edo. Siguiente
- Edo de transición





# DISPOSITIVOS DE MEMORIA

## ○ Características:

- Biestables:
  - Tienen dos posibles estados estables, 0 y 1.
- Entradas de excitación:
  - Llevan al circuito al nivel deseado.
  - **Set:** Obliga a la salida a ser 1.
  - **Reset:** Obliga a la salida a ser 0.
  - **Set-Reset:** Combina ambos casos

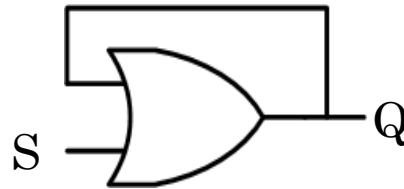




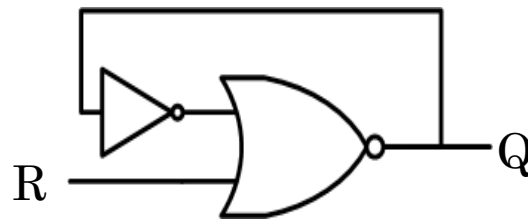
# LATCH

- Elemento de memoria cuyas señales de entrada de excitación controlan el estado del dispositivo.

- Set



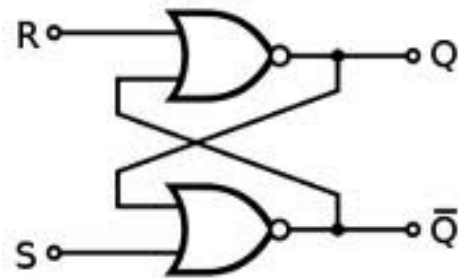
- Reset



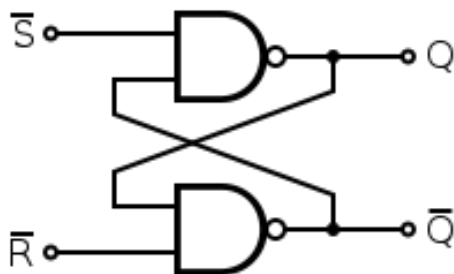


# LATCH SET-RESET (S-R)

- NOR



- NAND

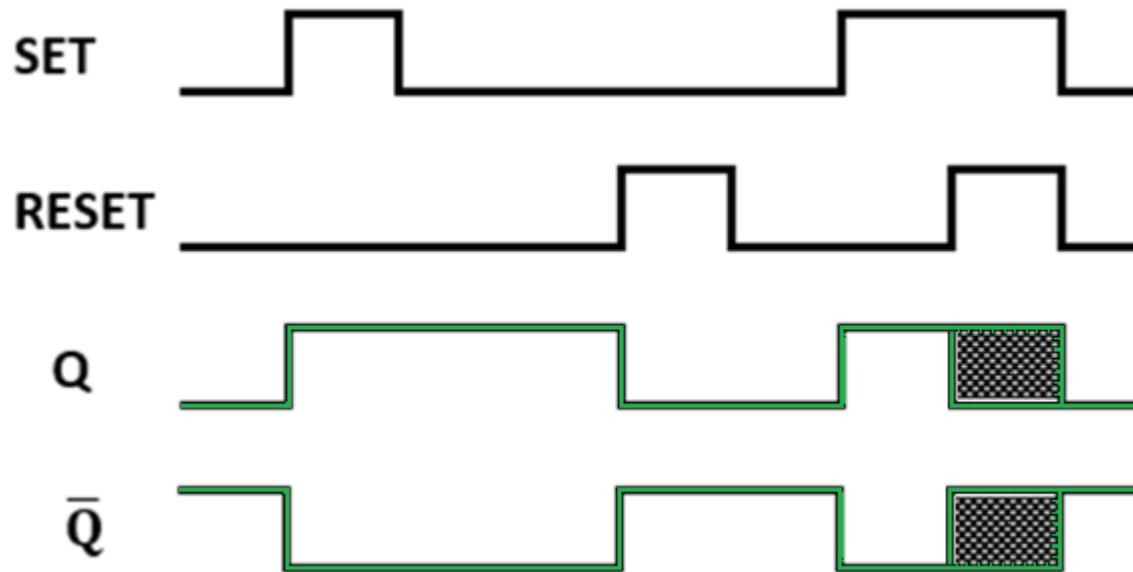


| Entradas de excitación |   | Edo. Pres. | Edo. Sig. |                  |
|------------------------|---|------------|-----------|------------------|
| S                      | R | $Q_t$      | $Q_{t+1}$ |                  |
| 0                      | 0 | 0          | 0         | Sin cambio       |
| 0                      | 0 | 1          | 1         |                  |
| 0                      | 1 | 0          | 0         | Reset            |
| 0                      | 1 | 1          | 0         |                  |
| 1                      | 0 | 0          | 1         | Set              |
| 1                      | 0 | 1          | 1         |                  |
| 1                      | 1 | 0          | X         | Estado prohibido |
| 1                      | 1 | 1          | X         |                  |



# LATCH S-R

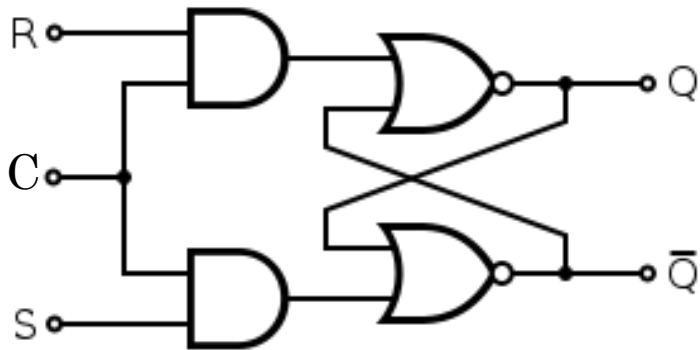
- Diagrama de tiempo





# LATCH S-R

## Con compuertas

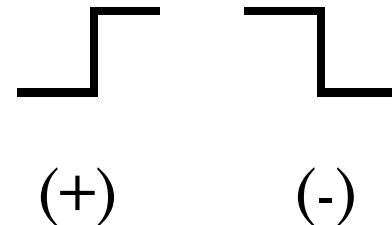


| Ent. | Entradas de excitación |   | Edo. Pres. | Edo. Sig. |              |
|------|------------------------|---|------------|-----------|--------------|
| C    | S                      | R | $Q_t$      | $Q_{t+1}$ |              |
| 0    | X                      | X | 0          | 0         | Retención    |
| 0    | X                      | X | 1          | 1         |              |
| 1    | 0                      | 0 | 0          | 0         | Sin cambio   |
| 1    | 0                      | 0 | 1          | 1         |              |
| 1    | 0                      | 1 | 0          | 0         | Reset        |
| 1    | 0                      | 1 | 1          | 0         |              |
| 1    | 1                      | 0 | 0          | 1         | Set          |
| 1    | 1                      | 0 | 1          | 1         |              |
| 1    | 1                      | 1 | 0          | X         | No permitido |
| 1    | 1                      | 1 | 1          | X         |              |



# FLIP-FLOP

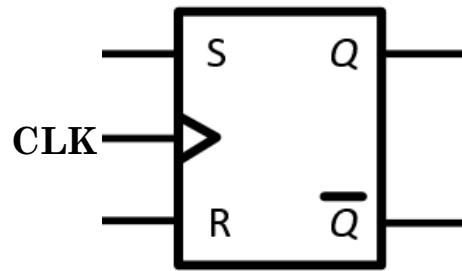
- Elemento de memoria que, además de las señales de excitación, cuenta con una señal de control que le permite cambiar de estado dependiendo de dichas entradas de excitación.
  - Permite sincronizar
- C (**CLK**) = Reloj
  - Control por transición:
    - Positiva: Flanco de subida
    - Negativa: Flanco de bajada





# FLIP-FLOP S-R

## ○ Símbolo



| Q\SR | 00 | 01 | 11 | 10 |
|------|----|----|----|----|
| 0    | 0  | 0  | X  | 1  |
| 1    | 1  | 0  | X  | 1  |

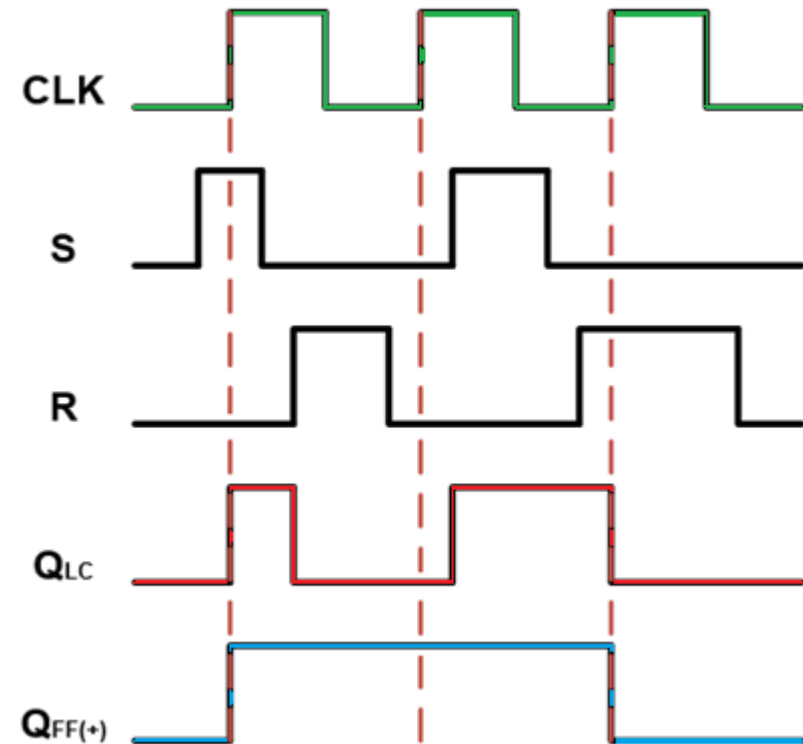
$$Q_{t+1} = S + \bar{R}Q_t$$

|     | Entradas de excitación |   | Edo. Pres. | Edo. Sig. |
|-----|------------------------|---|------------|-----------|
| CLK | S                      | R | $Q_t$      | $Q_{t+1}$ |
|     | 0                      | 0 | 0          | 0         |
|     | 0                      | 0 | 1          | 1         |
|     | 0                      | 1 | 0          | 0         |
|     | 0                      | 1 | 1          | 0         |
|     | 1                      | 0 | 0          | 1         |
|     | 1                      | 0 | 1          | 1         |
|     | 1                      | 1 | 0          | X         |
|     | 1                      | 1 | 1          | X         |



# FLIP-FLOP S-R

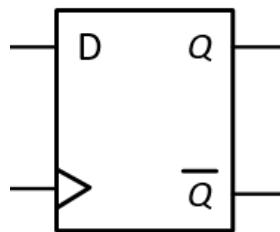
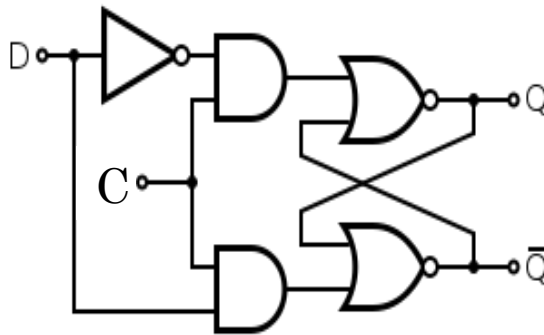
- Latch con compuertas (**LC**)
  - C = Control por nivel
- Flip-Flop (**FF**)
  - CLK = Control por transición
    - Positiva (+)





# FLIP-FLOP D

- S-R con entradas complementadas



$$Q_{t+1} = D$$

|     | Ent.<br>Exc. | Edo.<br>Pres. | Edo.<br>Sig. |
|-----|--------------|---------------|--------------|
| CLK | D            | $Q_t$         | $Q_{t+1}$    |
|     | 0            | 0             | 0            |
|     | 0            | 1             | 0            |
|     | 1            | 0             | 1            |
|     | 1            | 1             | 1            |

**D** = Delay = Retardo

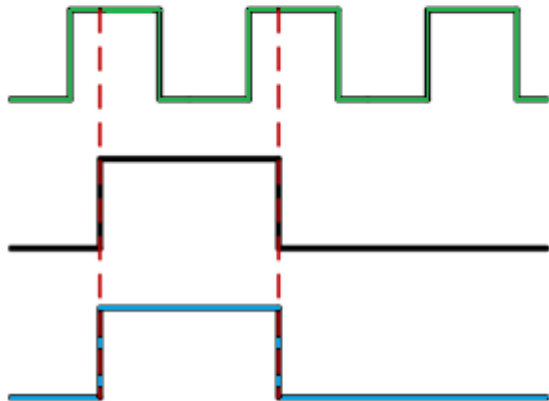
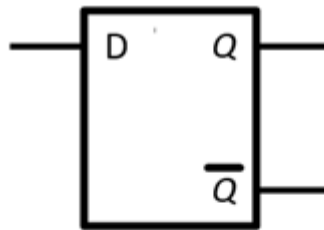




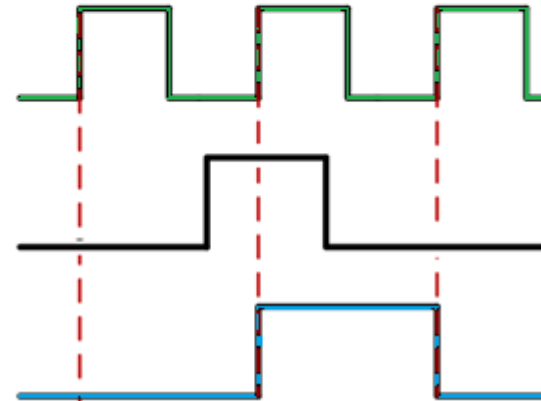
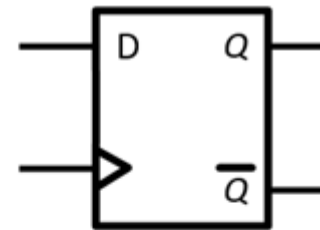
# LATCH VS. FLIP-FLOP D

## ○ Diagramas de tiempo

*Latch D*



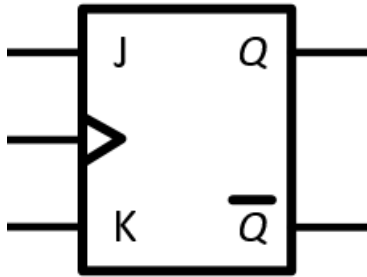
*Flip-Flop D*





# FLIP-FLOP J-K

- S-R sin estado prohibido



$$Q_{t+1} = J\bar{Q}_t + \bar{K}Q_t$$

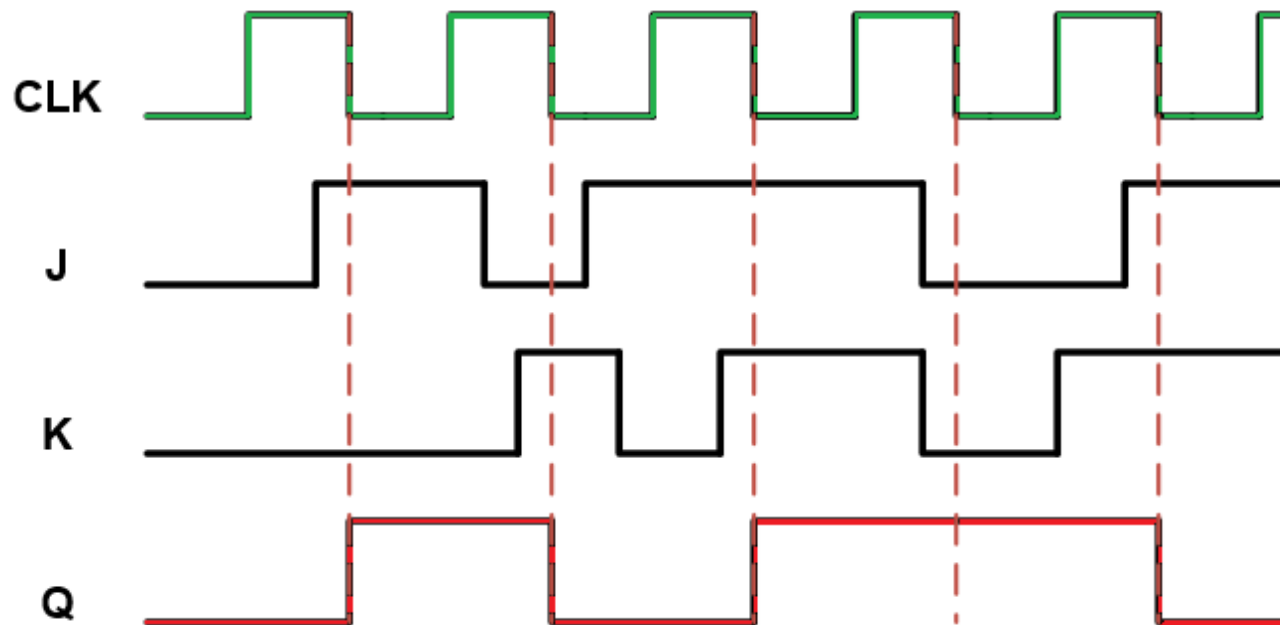
Inversión, complemento  
Volquete, negación, toggle

|     | Entradas de excitación |   | Edo. Pres. | Edo. Sig. |
|-----|------------------------|---|------------|-----------|
| CLK | J                      | K | $Q_t$      | $Q_{t+1}$ |
|     | 0                      | 0 | 0          | 0         |
|     | 0                      | 0 | 1          | 1         |
|     | 0                      | 1 | 0          | 0         |
|     | 0                      | 1 | 1          | 0         |
|     | 1                      | 0 | 0          | 1         |
|     | 1                      | 0 | 1          | 1         |
|     | 1                      | 1 | 0          | 1         |
|     | 1                      | 1 | 1          | 0         |



# FLIP-FLOP J-K

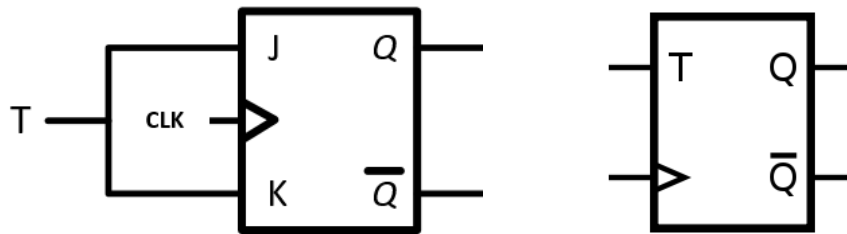
- Diagrama de tiempo





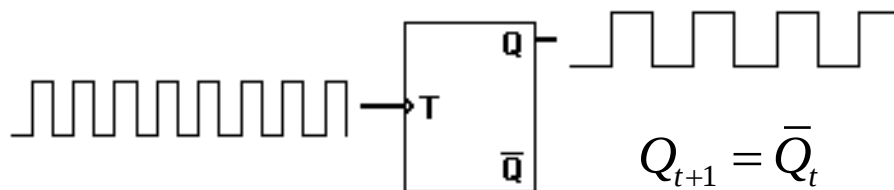
# FLIP-FLOP T (TOGGLE)

- J-K con entradas cortocircuitadas



$$Q_{t+1} = T\bar{Q}_t + \bar{T}Q_t$$

- Una sola entrada



$$Q_{t+1} = \bar{Q}_t$$

|     | Ent.<br>Exc. | Edo.<br>Pres. | Edo.<br>Sig. |
|-----|--------------|---------------|--------------|
| CLK | T            | $Q_t$         | $Q_{t+1}$    |
|     | 0            | 0             | 0            |
|     | 0            | 1             | 1            |
|     | 1            | 0             | 1            |
|     | 1            | 1             | 0            |

| Ent.<br>Exc. | Edo.<br>Pres. | Edo.<br>Sig. |
|--------------|---------------|--------------|
| T            | $Q_t$         | $Q_{t+1}$    |
|              | 0             | 1            |
|              | 1             | 0            |



# TABLAS DE EXCITACIÓN

## ○ S-R

|                                                                                     | Entradas de excitación |   | Edo. Pres. | Edo. Sig. |
|-------------------------------------------------------------------------------------|------------------------|---|------------|-----------|
| CLK                                                                                 | S                      | R | $Q_t$      | $Q_{t+1}$ |
|    | 0                      | 0 | 0          | 0         |
|    | 0                      | 0 | 1          | 1         |
|    | 0                      | 1 | 0          | 0         |
|   | 0                      | 1 | 1          | 0         |
|  | 1                      | 0 | 0          | 1         |
|  | 1                      | 0 | 1          | 1         |
|  | 1                      | 1 | 0          | X         |
|  | 1                      | 1 | 1          | X         |

| $Q_t$ | $Q_{t+1}$ | S | R |
|-------|-----------|---|---|
| 0     | 0         | 0 | X |
| 0     | 1         | 1 | 0 |
| 1     | 0         | 0 | 1 |
| 1     | 1         | X | 0 |





# TABLAS DE EXCITACIÓN

## ○ D

|                                                                                     | Ent.<br>Exc. | Edo.<br>Pres. | Edo.<br>Sig. |
|-------------------------------------------------------------------------------------|--------------|---------------|--------------|
| CLK                                                                                 | D            | $Q_t$         | $Q_{t+1}$    |
|    | 0            | 0             | 0            |
|   | 0            | 1             | 0            |
|  | 1            | 0             | 1            |
|  | 1            | 1             | 1            |

| $Q_t$ | $Q_{t+1}$ | D |
|-------|-----------|---|
| 0     | 0         | 0 |
| 0     | 1         | 1 |
| 1     | 0         | 0 |
| 1     | 1         | 1 |





# TABLAS DE EXCITACIÓN

## ○ J-K

|                                                                                     | Entradas de excitación |   | Edo. Pres. | Edo. Sig. |
|-------------------------------------------------------------------------------------|------------------------|---|------------|-----------|
| CLK                                                                                 | J                      | K | $Q_t$      | $Q_{t+1}$ |
|    | 0                      | 0 | 0          | 0         |
|    | 0                      | 0 | 1          | 1         |
|    | 0                      | 1 | 0          | 0         |
|   | 0                      | 1 | 1          | 0         |
|  | 1                      | 0 | 0          | 1         |
|  | 1                      | 0 | 1          | 1         |
|  | 1                      | 1 | 0          | 1         |
|  | 1                      | 1 | 1          | 0         |

| $Q_t$ | $Q_{t+1}$ | J | K |
|-------|-----------|---|---|
| 0     | 0         | 0 | X |
| 0     | 1         | 1 | X |
| 1     | 0         | X | 1 |
| 1     | 1         | X | 0 |





# TABLAS DE EXCITACIÓN

## ○ T

|                                                                                     | Ent.<br>Exc. | Edo.<br>Pres. | Edo.<br>Sig. |
|-------------------------------------------------------------------------------------|--------------|---------------|--------------|
| CLK                                                                                 | T            | $Q_t$         | $Q_{t+1}$    |
|    | 0            | 0             | 0            |
|   | 0            | 1             | 1            |
|  | 1            | 0             | 1            |
|  | 1            | 1             | 0            |

| $Q_t$ | $Q_{t+1}$ | T |
|-------|-----------|---|
| 0     | 0         | 0 |
| 0     | 1         | 1 |
| 1     | 0         | 1 |
| 1     | 1         | 0 |

