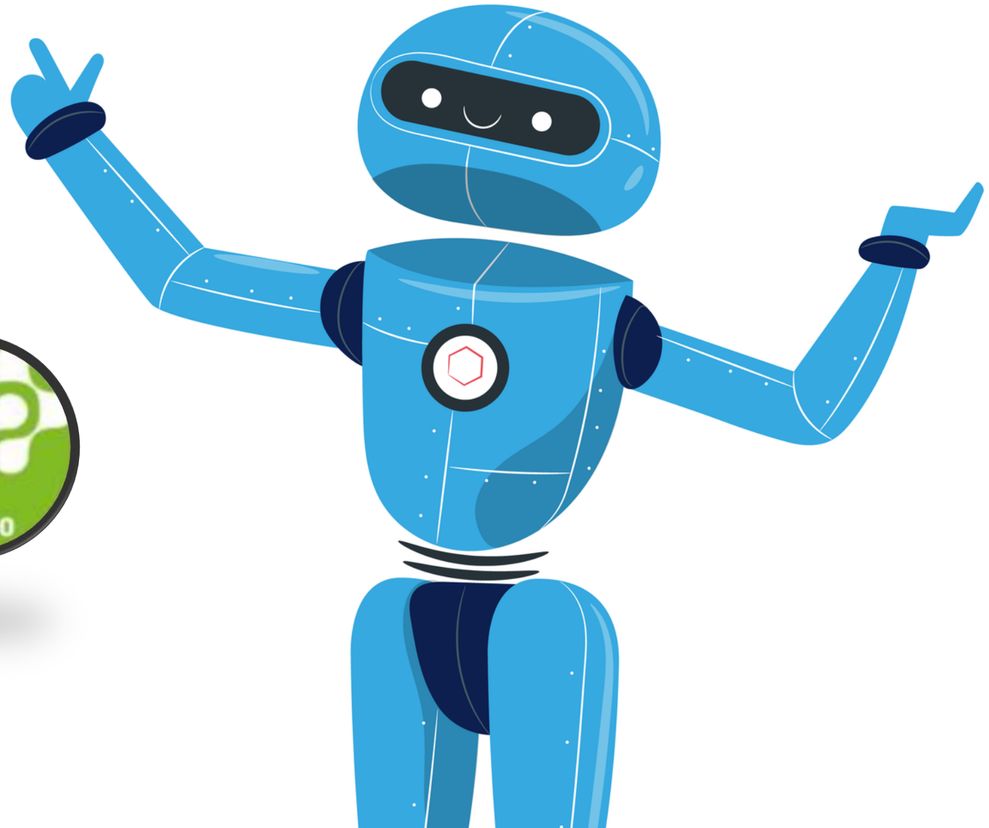
CLASE 4: SYSTICK

MICROCONTROLADORES

ARM



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PERIFERICOS CORTEX-M4

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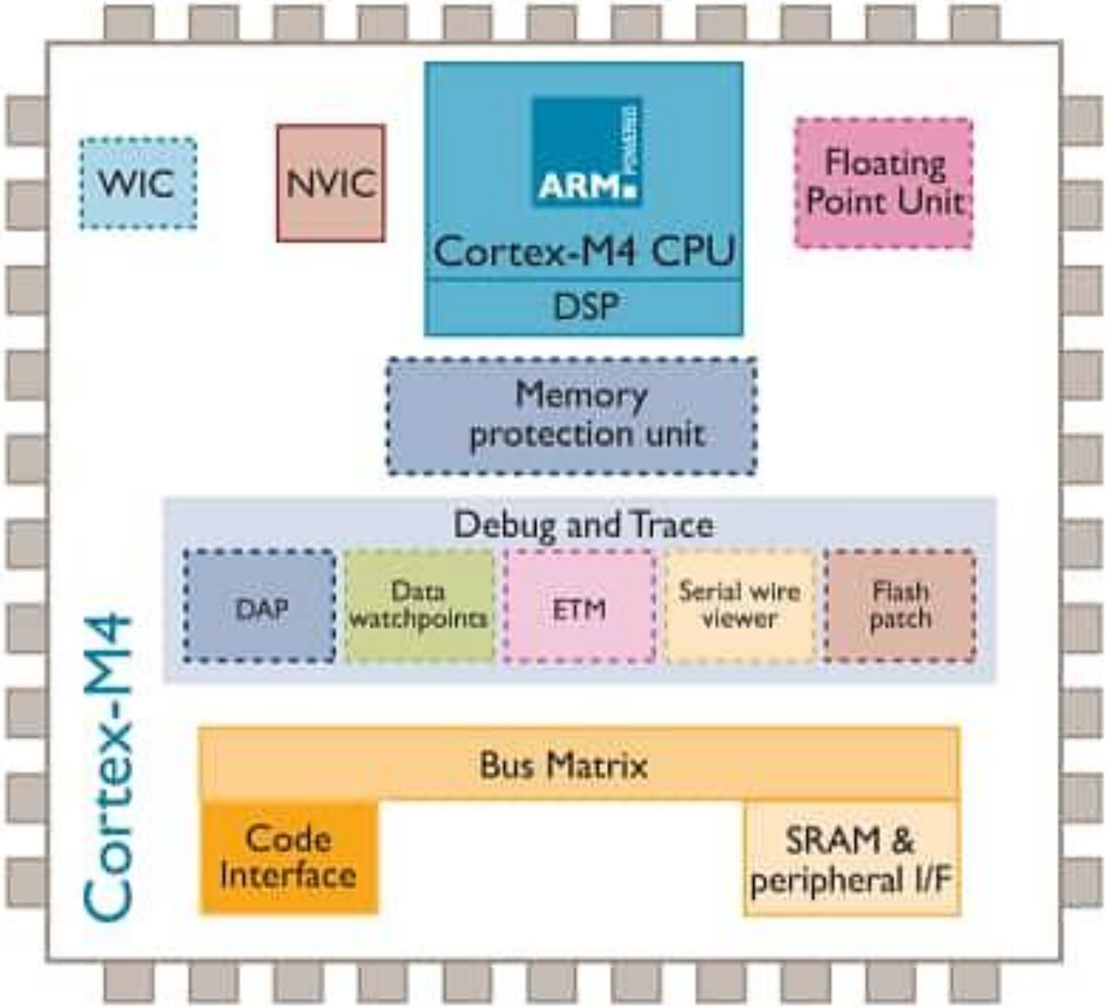
PERIFERICOS DEL PROCESOR CORTEX M4

- SysTick
- NVIC
- SCB
- MPU
- FPU



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SYSTICK TIMER

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SYSTICK

- El procesador CORTEX M4 incluye un temporizador del sistema integrado conocido como SysTick de 24 bits de longitud de palabra. El contador es de 24 bits y de decremento .

- El contador del **SysTick** se ejecuta en sincronización del reloj del sistema (system clock) o del oscilador interno (SYSCLK) divido por 8.

- Está integrado como parte del NVIC y puede generar la excepción SysTick (tipo de excepción n. ° 15).

- Si no necesita un sistema operativo integrado en su aplicación(RTOS), el temporizador SysTick se puede utilizar como un simple periférico temporizador para la generación periódica de interrupciones, la generación de retardos o la medición de tiempos.

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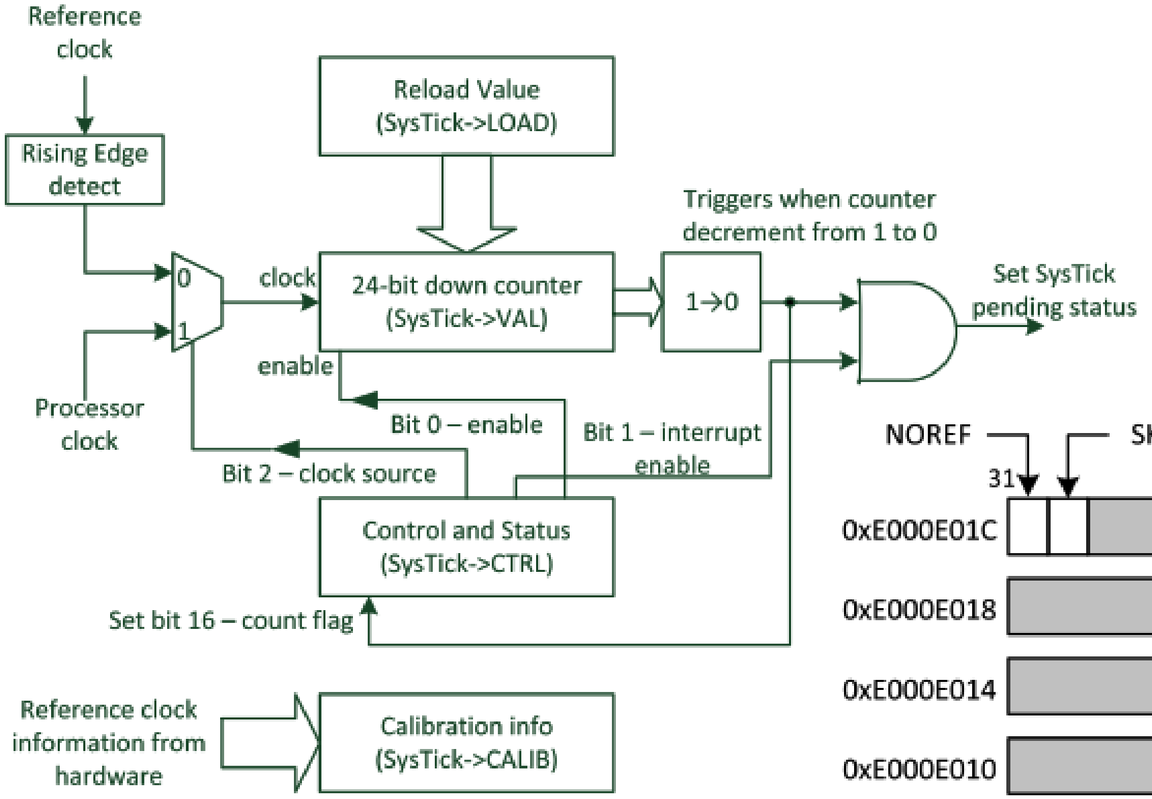
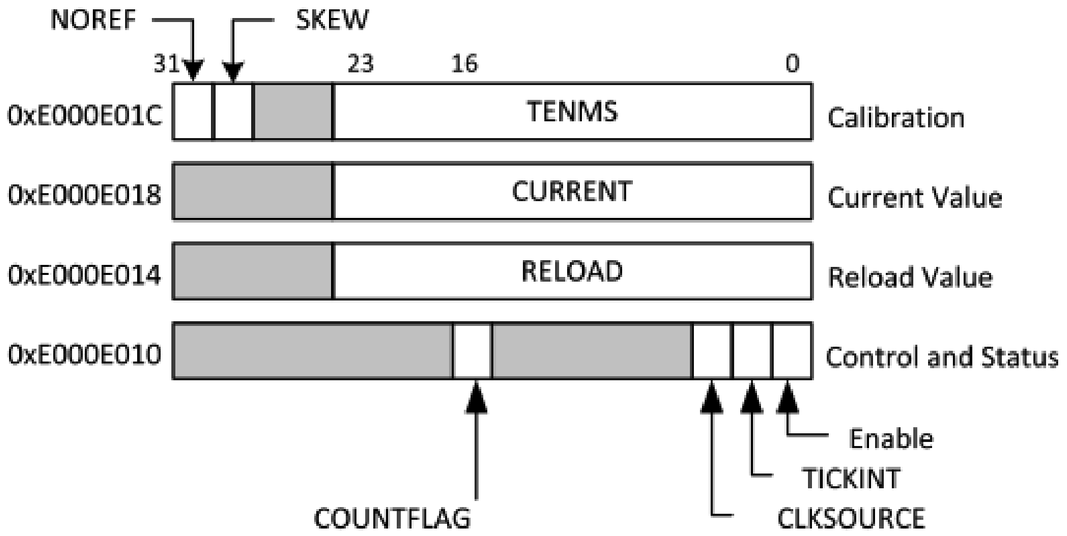
SYSTICK

FUNCIONAMIENTO





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CONFIGURACION DEL SYSTICK TIMER

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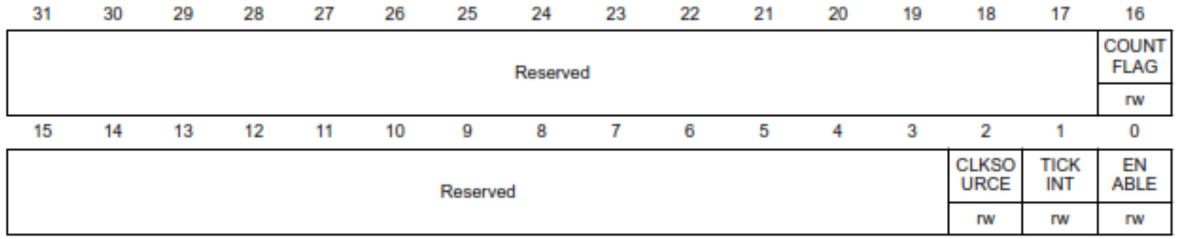
SYSTICK
REGISTROS

Address	CMSIS-Core Symbol	Register
0xE000E010	SysTick->CTRL	SysTick Control and Status Register
0xE000E014	SysTick->LOAD	SysTick Reload Value Register
0xE000E018	SysTick->VAL	SysTick Current Value Register
0xE000E01C	SysTick->CALIB	SysTick Calibration Register

SYSTICK
REGISTROS

SysTick control and status register (STK_CTRL)

Address offset: 0x00
Reset value: 0x0000 0000
Required privilege: Privileged
The SysTick CTRL register enables the SysTick features.



Bits 31:17 Reserved, must be kept cleared.

Bit 16 COUNTFLAG:
Returns 1 if timer counted to 0 since last time this was read.

Bits 15:3 Reserved, must be kept cleared.

Bit 2 **CLKSOURCE:** Clock source selection
Selects the clock source.
0: AHB/8
1: Processor clock (AHB)

Bit 1 **TICKINT**: SysTick exception request enable
0: Counting down to zero does not assert the SysTick exception request
1: Counting down to zero to asserts the SysTick exception request.
Note: Software can use COUNTFLAG to determine if SysTick has ever counted to zero.

Bit 0 **ENABLE**: Counter enable
Enables the counter. When ENABLE is set to 1, the counter loads the RELOAD value from the LOAD register and then counts down. On reaching 0, it sets the COUNTFLAG to 1 and optionally asserts the SysTick depending on the value of TICKINT. It then loads the RELOAD value again, and begins counting.
0: Counter disabled
1: Counter enabled

SYSTICK
REGISTROS

SysTick reload value register (STK_LOAD)

Address offset: 0x04
Reset value: 0x0000 0000
Required privilege: Privileged

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved								RELOAD[23:16]							
								rw	rw	rw	rw	rw	rw	rw	rw
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RELOAD[15:0]															
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

Bits 31:24 Reserved, must be kept cleared.

Bits 23:0 **RELOAD:** RELOAD value

The LOAD register specifies the start value to load into the STK_VAL register when the counter is enabled and when it reaches 0.

Calculating the RELOAD value

The RELOAD value can be any value in the range 0x00000001-0x00FFFFFF. A start value of 0 is possible, but has no effect because the SysTick exception request and COUNTFLAG are activated when counting from 1 to 0.

The RELOAD value is calculated according to its use:

- To generate a multi-shot timer with a period of N processor clock cycles, use a RELOAD value of N-1. For example, if the SysTick interrupt is required every 100 clock pulses, set RELOAD to 99.
- To deliver a single SysTick interrupt after a delay of N processor clock cycles, use a RELOAD of value N. For example, if a SysTick interrupt is required after 100 clock pulses, set RELOAD to 99.

SYSTICK
REGISTROS

SysTick current value register (STK_VAL)

Address offset: 0x08
Reset value: 0x0000 0000
Required privilege: Privileged

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved								CURRENT[23:16]							
								rw	rw	rw	rw	rw	rw	rw	rw
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CURRENT[15:0]															
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

Bits 31:24 Reserved, must be kept cleared.

Bits 23:0 **CURRENT:** Current counter value

The VAL register contains the current value of the SysTick counter.

Reads return the current value of the SysTick counter.

A write of any value clears the field to 0, and also clears the COUNTFLAG bit in the STK_CTRL register to 0.

SYSTICK
REGISTROS

SysTick calibration

value register (STK_CALIB)
Address offset: 0x0C
Reset value: 0x0000000
Required privilege: Privileged
The CALIB register indicates the SysTick calibration properties.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
NO REF	SKEW	Reserved						TENMS[23:16]							
r	r							r	r	r	r	r	r	r	r

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TENMS[15:0]															
r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r

Bit 31 **NOREF:** NOREF flag. Reads as zero. Indicates that a separate reference clock is provided. The frequency of this clock is HCLK/8.

Bit 30 **SKEW:** SKEW flag: Indicates whether the TENMS value is exact. Reads as one. Calibration value for the 1 ms inexact timing is not known because TENMS is not known. This can affect the suitability of SysTick as a software real time clock.

Bits 29:24 Reserved, must be kept cleared.

Bits 23:0 **TENMS[23:0]:** Calibration value. Indicates the calibration value when the SysTick counter runs on HCLK max/8 as external clock. The value is product dependent, please refer to the Product Reference Manual, SysTick Calibration Value section. When HCLK is programmed at the maximum frequency, the SysTick period is 1ms.

If calibration information is not known, calculate the calibration value required from the frequency of the processor clock or external clock.

CONFIGURACION DEL SYSTICK TIMER

Para la configuración se deben seguir los siguientes pasos:

1. Desactivar el contador. ENABLE=0.
2. Cargar el valor de RELOAD.
3. Escribir cualquier valor en la cuenta para que se ponga a 0.
4. Configurar los registros de control y estado, incluyendo la activación.

$$ValorDeRecarga = SysTickCounterClock \times TemporizacionDeseada(s)$$
$$ValorDeRecarga = 16000000 \times 0.001$$
$$ValorDeRecarga = 16000$$

Estos pasos pueden ser realizados por la función **SysTick_Config**

```
__STATIC_INLINE uint32_t SysTick_Config(uint32_t ticks)
{
  if ((ticks - 1UL) > SysTick_LOAD_RELOAD_Msk)
  {
    return (1UL);                                                   /* Reload value impossible */
  }

  SysTick->LOAD  = (uint32_t)(ticks - 1UL);                         /* set reload register */
  NVIC_SetPriority (SysTick_IRQn, (1UL << __NVIC_PRIO_BITS) - 1UL); /* set Priority for Systick Interrupt */
  SysTick->VAL   = 0UL;                                             /* Load the SysTick Counter Value */
  SysTick->CTRL  = SysTick_CTRL_CLKSOURCE_Msk |
                   SysTick_CTRL_TICKINT_Msk   |
                   SysTick_CTRL_ENABLE_Msk;                         /* Enable SysTick IRQ and SysTick Timer */
  return (0UL);                                                     /* Function successful */
}
```

MULTIPLEXACION DE DISPLAY DE 7 SEGMENTOS

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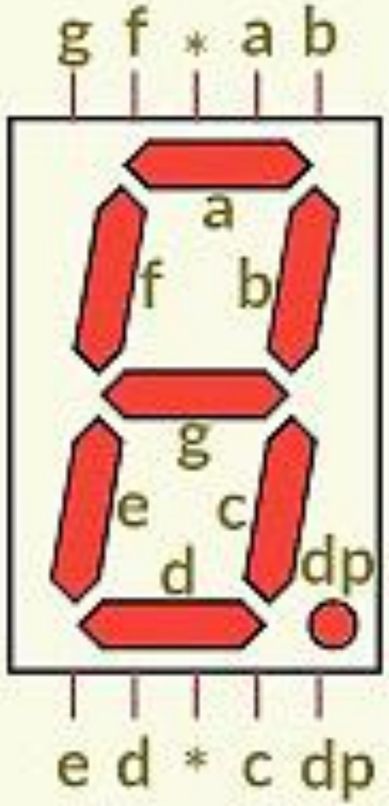
DISPLAY 7 SEGMENTOS CATADO COMUN



Cátodo Cómun									HEX
Común*	Número	g	f	e	d	c	b	a	
GND	0	0	1	1	1	1	1	1	0x3F
GND	1	0	0	0	0	1	1	0	0x06
GND	2	1	0	1	1	0	1	1	0x5B
GND	3	1	0	0	1	1	1	1	0x4F
GND	4	1	1	0	0	1	1	0	0x66
GND	5	1	1	0	1	1	0	1	0x6D
GND	6	1	1	1	1	1	0	1	0x7D
GND	7	0	0	0	0	1	1	1	0x07
GND	8	1	1	1	1	1	1	1	0x7F
GND	9	1	1	0	1	1	1	1	0x67

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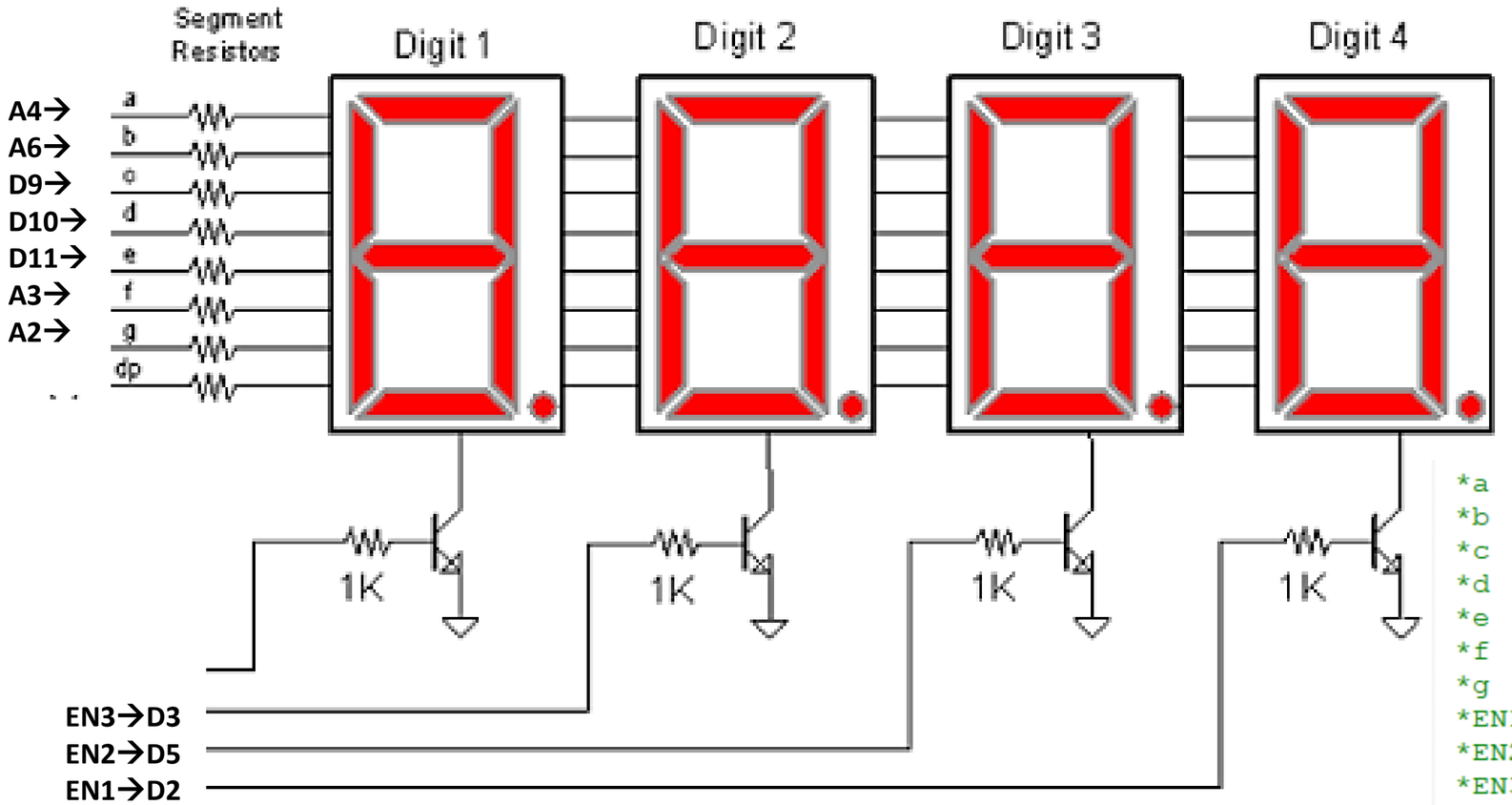
DISPLAY 7 SEGMENTOS CATADO COMUN

MULTIPLEXACION




```
*a    ->A4(PA5)
*b    ->A6(PA7)
*c    ->D9(PA8)
*d    ->D10(PA11)
*e    ->D11(PB5)
*f    ->A3(PA4)
*g    -> A2(PA3)
*EN1  ->D2(PA12)
*EN2  ->D5(PB6)
*EN3  ->D3(PB0)
*Push button-> D6 (PB1)
```

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