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Anexo A

Programas en VHDL

La estrategia de conmutación se realizó utilizando dispositivos de lógica programable. De forma general, todos los programas contaban con los siguientes bloques:

- Sincronización de entradas.
- Diagrama de estados del convertidor cc/ca.
- Tabla de verdad para el accionamiento del convertidor ca/ca.
- Descripción mediante diagrama de estados del convertidor ca/ca.
- Salidas correspondientes a cada transistor de los convertidores.

A.1. Programa realizado para el accionamiento de un convertidor cc/ca puente completo

A continuación se presenta el programa realizado para accionar un convertidor cc/ca puente completo modulado en anchura de pulso.

```

-----
LIBRARY ieee;
USE ieee.std_logic_1164.all;
-----
-- Máquina de estado para el control del convertidor cc/ca      --
-----
-- clk : reloj de la pld                                       --
-- stop: señal de paro del convertidor                          --
-- bt: Tiempo de blanqueo                                       --

```

```
-- S : Valor discreto del ciclo de trabajo          --
-- Vab : Signo de la tensión Vab                  --
-- Output : Vector de salida (Vab SA SB SC SD)     --
```

```
-----
ENTITY dcacfbpwm IS
PORT (clk : in STD_LOGIC;
      stop : in STD_LOGIC;
      bt : in STD_LOGIC;
      S: in STD_LOGIC;
      Output : out STD_LOGIC_VECTOR (4 downto 0));
END dcacfbpwm;
```

```
ARCHITECTURE maquina_1 OF dcacfbpwm IS
  TYPE estado IS (es, e1, e2, e3, e4, e5, e6, e7, e8);
  SIGNAL e_actual, e_futuro : estado;
BEGIN
```

```
-----
-- Combinaciones que determinan el estado próximo --
-----
```

```
e_futuro <= e1 WHEN (e_actual=es AND S='1') OR
                (e_actual=e1 AND S='1') OR
                (e_actual=e8 AND bt='0')
  ELSE e2 WHEN (e_actual=e1 AND S='0') OR
                (e_actual=e2 AND bt='1')
  ELSE e3 WHEN (e_actual=e2 AND bt='0') OR
                (e_actual=e3 AND S='0')
  ELSE e4 WHEN (e_actual=e3 AND S='1') OR
                (e_actual=e4 AND bt='1')
  ELSE e5 WHEN (e_actual=e4 AND bt='0') OR
                (e_actual=e5 AND S='1')
```



```

ELSE e6 WHEN (e_actual=e5 AND S='0') OR
              (e_actual=e6 AND bt='1')
ELSE e7 WHEN (e_actual=e6 AND bt='0') OR
              (e_actual=e7 AND S='0')
ELSE e8 WHEN (e_actual=e7 AND S='1') OR
              (e_actual=e8 AND bt='1');

```

```
-----
-- Transición de estados                                     --
-----
```

```

estado1: PROCESS
BEGIN
  WAIT UNTIL (clk'EVENT and clk='1');
  IF stop='1' THEN
    e_actual <= es;
  ELSE
    e_actual <= e_futuro;
  END IF;
END PROCESS estado1;

```

```
-----
-- Asignación del control de los dispositivos interruptores --
-----
```

```

output (5 downto 0) <=  "10000" when (e_actual=es)
                      ELSE  "11001" when (e_actual=e1)
                      ELSE  "11000" when (e_actual=e2)
                      ELSE  "11100" when (e_actual=e3)
                      ELSE  "10100" when (e_actual=e4)
                      ELSE  "00110" when (e_actual=e5)
                      ELSE  "00010" when (e_actual=e6)
                      ELSE  "00011" when (e_actual=e7)
                      ELSE  "00001" when (e_actual=e8);

```

```
END maquina_1;
```

Además de la información para la activación de los transistores, también se da el signo de la tensión de salida del convertidor cc/ca (*bit* menos significativo).

A.2. Programa en VHDL para el accionamiento del convertidor ca/ca

A continuación se muestra un programa que decide los pares de interruptores que serán activados en el convertidor ca/ca medio puente de dos niveles.

```
-----
LIBRARY ieee;
USE ieee.std_logic_1164.all;

-----
-- Sistema combinacional para el control del convertidor CA/CA      --
-----
-- Vab: fija el signo de la tensión de salida del convertidor      --
-- de alta frecuencia cc/ca Vab                                     --
-- S: valor discreto del ciclo de trabajo                            --
-- sp: semiperiodo de la senoidal a producir                       --
-- S1q: señal que indicará el estado de conmutación del interruptor --
-- bi-direccional formado por S11 y S12                            --
-----
ENTITY fbhb2ncomb IS
PORT (Vab : in STD_LOGIC;
      S : in STD_LOGIC;
      sp : in STD_LOGIC;
      S1q : out STD_LOGIC);
END fbhb2ncomb;

ARCHITECTURE s_c_1 OF fbhb2ncomb IS
BEGIN
```

```
-----
-- Asignación del control de las variables de salida --
-----
```

```

S1q <= '1' WHEN ((sp='0' AND Vab='0' AND S='1') OR
                 (sp='0' AND Vab='1' AND S='0') OR
                 (sp='1' AND Vab='0' AND S='0') OR
                 (sp='1' AND Vab='1' AND S='1') )
        ELSE '0';
END s_c_1;
-----
```

En este programa se utiliza únicamente el valor de S_{1q} dado que el valor de S_{2q} es el valor complementario.

A.3. Programa en VHDL para realizar la conexión del punto e del convertidor ca/ca

Finalmente se presenta el programa utilizado para realizar la conexión del punto e a la entrada del filtro pasa bajos del convertidor ca/ca medio puente de dos niveles.

```
-----
LIBRARY ieee;
USE ieee.std_logic_1164.all;
-----
-- Máquina de estado para el control del convertidor ca/ca --
-- medio puente de dos niveles --
-----
-- iL: Signo de la corriente por la bobina --
-- stop: señal de paro del convertidor --
-- tt: Tiempo de traslape --
-- Vab: Signo de la tensión Vab --
-- Output :Vector de salida --
-- Valor asignado a S1q --
-----
```

```

ENTITY acachb2e IS
PORT (clk : in STD_LOGIC;
      iL : in STD_LOGIC;
      stop : in STD_LOGIC;
      tt : in STD_LOGIC;
      S1q : in STD_LOGIC;
      Vab: in STD_LOGIC;
      Output : out STD_LOGIC_VECTOR (3 downto 0));
END acachb2e;
ARCHITECTURE maquina_1 OF acachb2e IS
  TYPE estado IS (es, e1, e2, e3, e4, e5, e6, e7, e8);
  SIGNAL e_actual, e_futuro : estado;

BEGIN
-----
-- Combinaciones que determinan el estado próximo --
-----
  e_futuro <= e1 WHEN (e_actual=es AND S1q='1') OR
                 (e_actual=e1 AND S1q='1') OR
                 (e_actual=e2 AND S1q='1'AND tt='0') OR
                 (e_actual=e3 AND S1q='1' AND tt='0') OR
                 (e_actual=e4 AND S1q='1' AND Vab='1' AND tt='0') OR
                 (e_actual=e5 AND S1q='1'AND Vab='0' AND tt='0')
  ELSE e2 WHEN (e_actual=e1 AND S1q='0'AND iL='1' AND Vab='0') OR
                 (e_actual=e2 AND tt='1') OR
                 (e_actual=e4 AND S1q='1' AND Vab='0' AND tt='0')
  ELSE e3 WHEN (e_actual=e1 AND S1q='0' AND iL='0' AND Vab='1') OR
                 (e_actual=e3 AND tt='1') OR
                 (e_actual=e5 AND S1q='1' AND Vab='1' AND tt='0')
  ELSE e4 WHEN (e_actual=e1 AND S1q='0' AND iL='1' AND Vab='1') OR

```

```

(e_actual=e2 AND S1q='0' AND tt='0') OR
(e_actual=e4 AND tt='1') OR
(e_actual=e6 AND S1q='1' AND tt='0') OR
(e_actual=e8 AND S1q='1' AND iL='1' AND Vab='0')
ELSE e5 WHEN (e_actual=e1 AND S1q='0' AND iL='0' AND Vab='0') OR
(e_actual=e3 AND S1q='0' AND tt='0') OR
(e_actual=e5 AND tt='1') OR
(e_actual=e7 AND S1q='1' AND tt='0') OR
(e_actual=e8 AND S1q='1' AND iL='0' AND Vab='1')
ELSE e6 WHEN (e_actual=e4 AND S1q='0' AND Vab='1' AND tt='0') OR
(e_actual=e6 AND tt='1') OR
(e_actual=e8 AND S1q='1' AND iL='1' AND Vab='1')
ELSE e7 WHEN (e_actual=e5 AND S1q='0' AND Vab='0' AND tt='0') OR
(e_actual=e7 AND tt='1') OR
(e_actual=e8 AND S1q='1' AND iL='0' AND Vab='0')
ELSE e8 WHEN (e_actual=es AND S1q='0') OR
(e_actual=e8 AND S1q='0') OR
(e_actual=e4 AND S1q='0' AND Vab='0' AND tt='0') OR
(e_actual=e5 AND S1q='0' AND Vab='1' AND tt='0') OR
(e_actual=e6 AND S1q='0' AND tt='0') OR
(e_actual=e7 AND S1q='0' AND tt='0');

```

-- Transición de estados

--

```

-----
estado1: PROCESS
BEGIN
  WAIT UNTIL (clk'EVENT and clk='1');
  IF stop='1' THEN
    e_actual <= es;
  ELSE

```

```
    e_actual <= e_futuro;  
    END IF;  
END PROCESS estado1;
```

-- Asignación del control de los dispositivos interruptores --

```
output (4 downto 0) <= "0000" when (e_actual=es)  
                    ELSE "1100" when (e_actual=e1)  
                    ELSE "1000" when (e_actual=e2)  
                    ELSE "0100" when (e_actual=e3)  
                    ELSE "1010" when (e_actual=e4)  
                    ELSE "0101" when (e_actual=e5)  
                    ELSE "0010" when (e_actual=e6)  
                    ELSE "0001" when (e_actual=e7)  
                    ELSE "0011" when (e_actual=e8);  
END maquina_1;
```