PLAZA, ELMO L.
BSCPE 3A

19. VHDL CODE FOR STEPPER MOTOR INTERFACE

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use IEEE.NUMERIC_STD.ALL;

entity STEPPER_MOTOR_INTERFACE is
Port (
  -- Active-low control inputs
  clk      : in  STD_LOGIC;   -- PIN_23 (50MHz)
  reset_n  : in  STD_LOGIC;   -- PIN_25 (RESET button)
  enable_n : in  STD_LOGIC;   -- PIN_88 (KEY1)
  dir_n    : in  STD_LOGIC;   -- PIN_89 (KEY2)

  -- Active-low outputs (ULN2003 driver compatible)
  coil_n   : out STD_LOGIC_VECTOR(3 downto 0) -- PIN_84-87 (led4-led1)
);
end STEPPER_MOTOR_INTERFACE;

architecture Behavioral of STEPPER_MOTOR_INTERFACE is
  signal step_counter : unsigned(1 downto 0) := "00";
  signal clk_div      : unsigned(20 downto 0) := (others => '0');
  signal step_clk     : STD_LOGIC := '0';
  signal enabled      : STD_LOGIC := '0';
  signal direction    : STD_LOGIC := '0';

  -- Full-step sequence (active-low)
  type step_sequence is array (0 to 3) of std_logic_vector(3 downto 0);
  constant full_step : step_sequence := (
    "1100",  -- Phase A (0x8)
    "0110",  -- Phase B (0x4)
    "0011",  -- Phase C (0x2)
    "1001"   -- Phase D (0x1)
  );
begin

  -- Clock divider (50MHz → ~12Hz stepping)
  process(clk)
  begin
    if rising_edge(clk) then
      clk_div <= clk_div + 1;
      step_clk <= clk_div(20); -- 50MHz/2^21 ≈ 12Hz
    end if;
  end process;

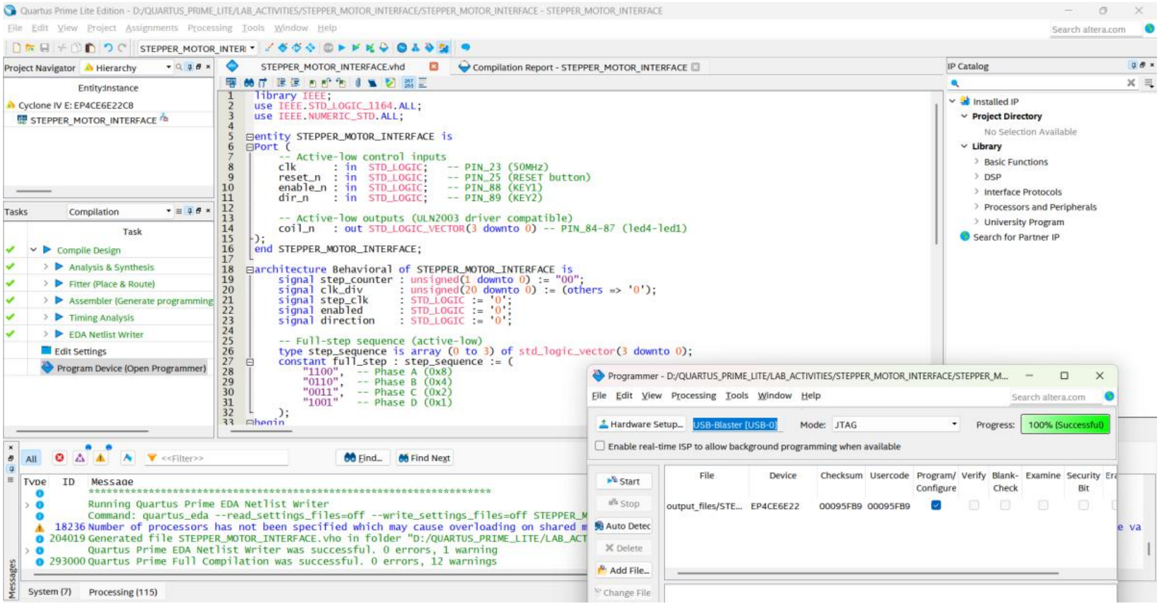
  -- Stepping control
  process(step_clk, reset_n)
  begin
    if reset_n = '0' then
      step_counter <= "00";
```

```
            coil_n <= "1111"; -- All coils OFF (active-low)
        elsif rising_edge(step_clk) then
            if enabled = '1' then
                if direction = '1' then
                    step_counter <= step_counter + 1; -- CW
                else
                    step_counter <= step_counter - 1; -- CCW
                end if;

                -- Output current step phase (active-low)
                coil_n <= full_step(to_integer(step_counter));
            else
                coil_n <= "1111"; -- Disable all coils
            end if;
        end if;
    end process;

    -- Control signal processing (active-low to active-high)
    enabled <= not enable_n;
    direction <= not dir_n;

end Behavioral;
```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File Edit View Project Assignments Processing Tools Window Help
Search altera.com
STEPPER_MOTOR_INTER
Project Navigator
Hierarchy
Entity:Instance
Cyclone IV E: EP4CE6E22C8
STEPPER_MOTOR_INTERFACE
Tasks
Compilation
Task
Compile Design
Analysis & Synthesis
Fitter (Place & Route)
Assembler (Generate programming
Timing Analysis
EDA Netlist Writer
Edit Settings
Program Device (Open Programmer)
STEPPER_MOTOR_INTERFACE.vhd
Compilation Report - STEPPER_MOTOR_INTERFACE
IP Catalog
Installed IP
Project Directory
No Selection Available
Library
Basic Functions
DSP
Interface Protocols
Processors and Peripherals
University Program
Search for Partner IP
All
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Find...
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Messages
System (7)
Processing (115)
Programmer - D:/QUARTUS_PRIME_LITE/LAB_ACTIVITIES/STEPPER_MOTOR_INTERFACE/STEPPER_M...
File Edit View Processing Tools Window Help
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Hardware Setup...
Start
Stop
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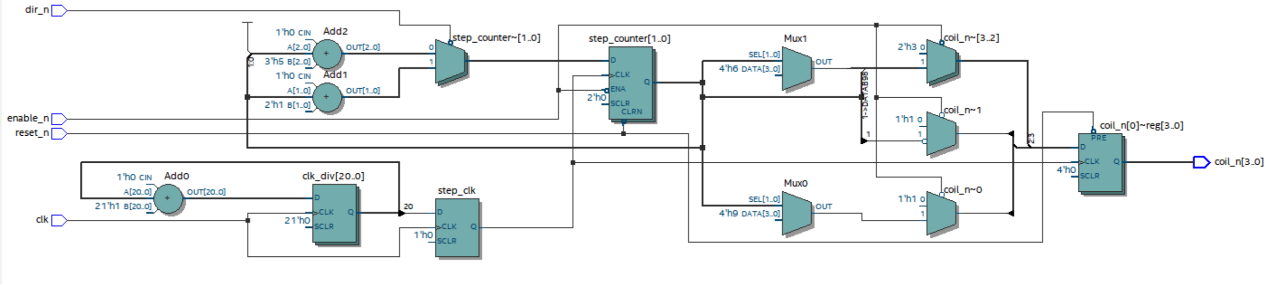
begin
```

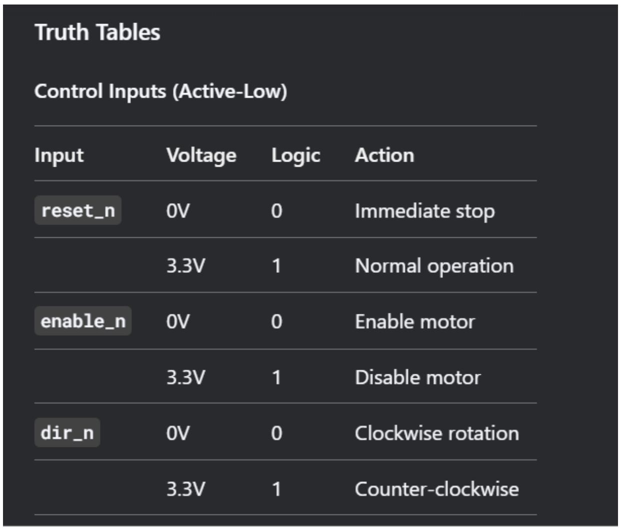
```
Type   ID      Message
                *******************************************************************
                Running Quartus Prime EDA Netlist Writer
                Command: quartus_eda --read_settings_files=off --write_settings_files=off STEPPER_M
        18236   Number of processors has not been specified which may cause overloading on shared m
        204019  Generated file STEPPER_MOTOR_INTERFACE.vho in folder "D:/QUARTUS_PRIME_LITE/LAB_ACT
                Quartus Prime EDA Netlist Writer was successful. 0 errors, 1 warning
        293000  Quartus Prime Full Compilation was successful. 0 errors, 12 warnings
```

USB-Blaster [USB-0]   Mode: JTAG   Progress: 100% (Successful)

☐ Enable real-time ISP to allow background programming when available

File	Device	Checksum	Usercode	Program/ Configure	Verify	Blank- Check	Examine	Security Bit	Era
output_files/STE...	EP4CE6E22	00095FB9	00095FB9	☑	☐	☐	☐	☐	☐

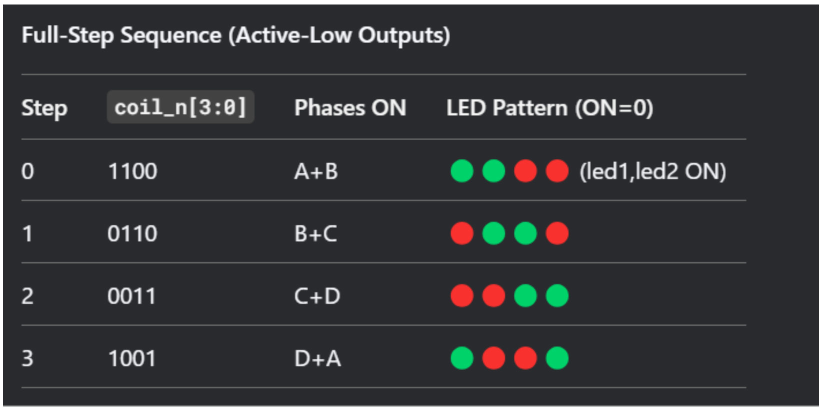




Truth Tables

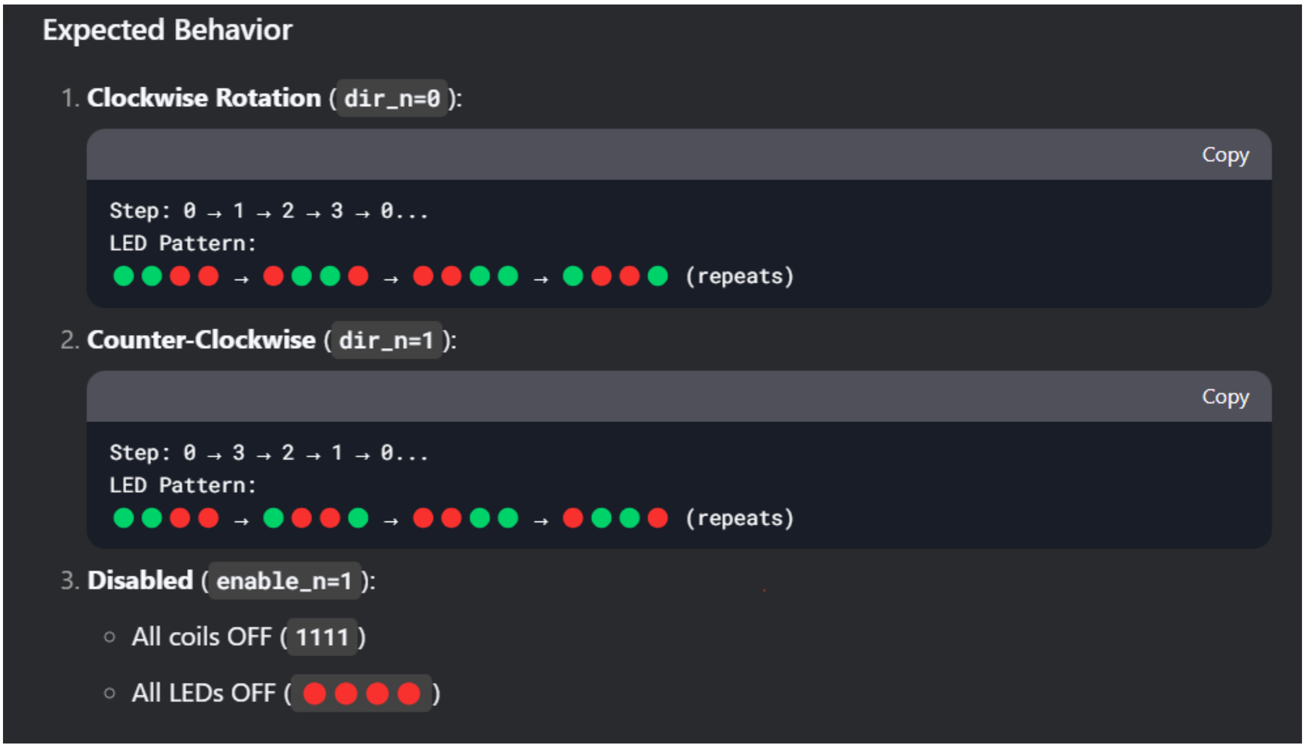
Control Inputs (Active-Low)

Input	Voltage	Logic	Action
`reset_n`	0V	0	Immediate stop
	3.3V	1	Normal operation
`enable_n`	0V	0	Enable motor
	3.3V	1	Disable motor
`dir_n`	0V	0	Clockwise rotation
	3.3V	1	Counter-clockwise



Full-Step Sequence (Active-Low Outputs)

Step	`coil_n[3:0]`	Phases ON	LED Pattern (ON=0)
0	1100	A+B	🟢🟢🔴🔴 (led1,led2 ON)
1	0110	B+C	🔴🟢🟢🔴
2	0011	C+D	🔴🔴🟢🟢
3	1001	D+A	🟢🔴🔴🟢



Expected Behavior

1. **Clockwise Rotation** (`dir_n=0`):

```
Step: 0 → 1 → 2 → 3 → 0...
LED Pattern:
🟢🟢🔴🔴 → 🔴🟢🟢🔴 → 🔴🔴🟢🟢 → 🟢🔴🔴🟢 (repeats)
```

2. **Counter-Clockwise** (`dir_n=1`):

```
Step: 0 → 3 → 2 → 1 → 0...
LED Pattern:
🟢🟢🔴🔴 → 🟢🔴🔴🟢 → 🔴🔴🟢🟢 → 🔴🟢🟢🔴 (repeats)
```

3. **Disabled** (`enable_n=1`):
   - All coils OFF (`1111`)
   - All LEDs OFF (🔴🔴🔴🔴)