PmodHB5™ Demo Project

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Overview

The PmodHB5 Reference Project instantiates a HB5 Reference Component which controls the En and Dir pins of a PmodHB5 board to drive a DC motor. It is designed to be used on a Digilent Nexys3 board. The PmodHB5 Reference Project can also drive a PmodHB3, with no change to the code (Please read the note at the end of this document if using a PmodHB3 for setup). This project was developed using Xilinx ISE 13.4.

In this demo, buttons are used to set a BCD value for the duty factor of the signal driving the motor. One switch - SW0 - is used to set the rotation direction and another one - SW1 - is used to select what parameter the user wants to watch on the seven-segment display (Speed / Duty Factor). The PmodHB5 Reference Component used implements safe direction switching. For more information and details about this module please read PmodHB5 reference component from digilentinc.com. The SA and SB Hall sensor signals are used to measure the motor speed <RPM> but no loop control is implemented. Figure 1 below shows the main diagram of the project.

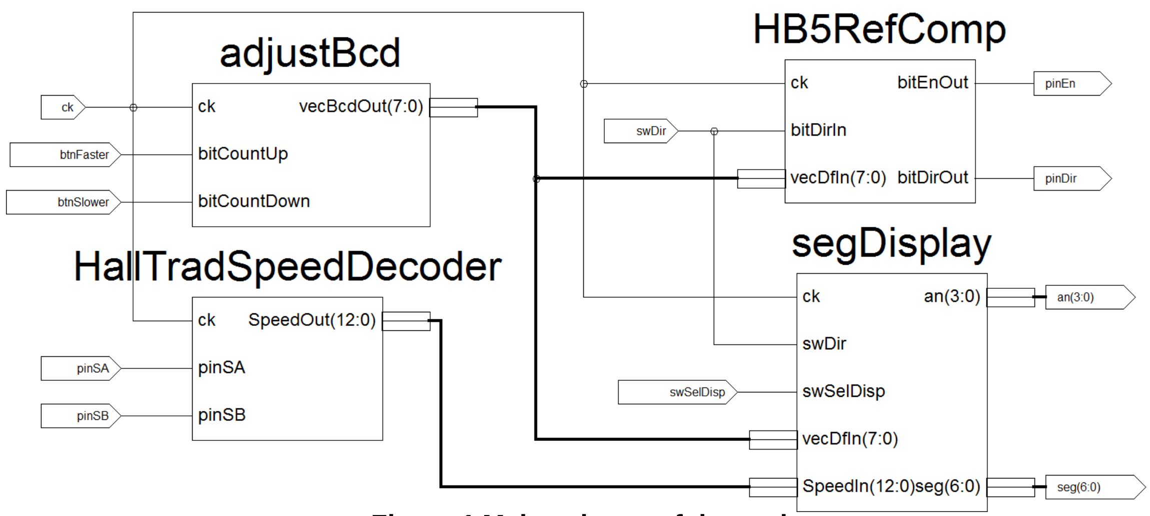


Figure 1 Main scheme of the project

Functional Description

The project instantiates a PmodHB5 Reference Component (HB5RefComp). For details about this component, see the *PmodHB5 Reference Component* document and the source file comments. The component is set to work in BCD mode.

The **adjustBcd** component is also instantiated. It implements a BCD Up / Down counter with no rollover. That means the counter is prevented from counting up when reached 99, and counting down when reached 0 value. The 50MHz system clock is pre-divided to 10Hz, which is the clock signal for the actual Up/Down counter. Two enable signals (bitCountUp, bitCountDown) are used for the respective count directions, and bitCountUp has priority over bitCountDown.

The **HallTradSpeedDecoder** component is used to measure the speed of the motor expressed in RPMs (rotations/minute). The main idea of this measurement process is to count the signal switches, given by Hall sensors, which appear in a specified time. The motor mechanical structure consists of two axes: an external one used for attaching, for example, a wheel and an internal one directly connected to it. The connection between them is described by the reduction factor: the number of rotations that have to be performed by the internal axis in order to obtain one rotation of the external one. There are two Hall sensors used for detecting the rotation of the internal axis. One internal axis rotation leads to 6 changes of the signal provided by one Hall sensor which leads to 12 edges per rotation for both sensors.
Because the value that has to be measured is a time-dependent value, a time-base is required. The mathematical deduction shows that choosing a correct time-base the final value of the speed counter can be used as the speed of the motor expressed in RPMs. Considering that:

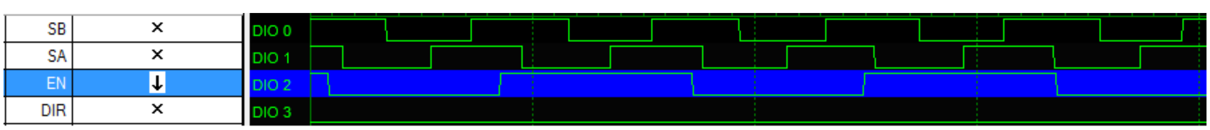
- Z_{RPM} is the speed
- Z_R is the number of rotations for the external motor
- R_F is the reduction factor
- T_B is the desired time base

The mathematical deduction of the time-base goes as it follows:

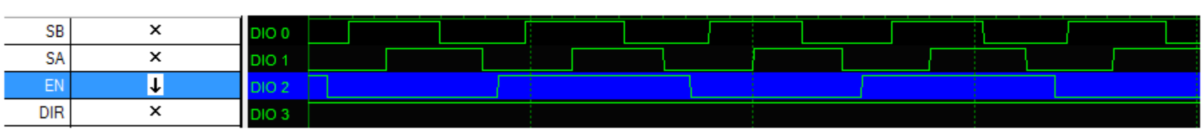
$$Z_{RPM} = \frac{Z_R}{\min} = \frac{Z_R}{60\sec} = \frac{Z_R \cdot (R_F \cdot 12)}{60} \cdot \frac{edges}{\sec} = \frac{Z_R \cdot edges}{T_B}$$

$$\Rightarrow \quad T_B = \frac{60}{R_F \cdot 12}\sec$$

To obtain the speed of the motor, the edges (changes) detected on SA and SB signals have to be counted. When one edge is detected, either on the SA or SB signal, according to the edge detected and the value of the other signal, the speed counter is incremented or decremented. The direction set according to SA and SB signals can be seen in the figure below.



a. Forward



b. Backward

Figure 2 Hall Sensors and Direction - signal diagrams

After the Time-Base counter has finished counting, the value reached by the speed counter represents the speed of the motor (RPM) expressed in BCD (Two's Complement Representation Code), as shown below:

1001 => -999 RPM

…

1999 => -1 RPM
0000 => 0 RPM
0001 => 1 RPM
…
0999 => 999 RPM

This value will be translated to BCD (Measure and Sign Representation Code) and sent to the seven-segment display module.

A modified seven-segment display controller is used. For displaying the Duty Factor value, only the three least significant digits are used (MSB digit for sign - if needed - and 2 digits for BCD value). For displaying Speed, all digits are used (MSB digit for sign - if needed - and 3 digits for BCD value).

Project Setup

1. Build a new Verilog project and add copies of the provided source files.
2. Set the Project Properties according to the target Digilent FPGA system board.
3. Choose a connector on the system board for the PmodHB5.
4. Add a .ucf file to assign signals to pins (as follows) and then compile the project.

ck	system clock (50MHz)
btnFaster	button to increase the Duty Factor value
btnSlower	button to decrease the Duty Factor value
swDir	switch to set the Direction
pinEn	HB5 (or HB3) En pin
pinDir	HB5 (or HB3) Dir pin
seg	segment outputs
an	anode select signals
pinSA	HB5(HB3) SA pin
pinSB	HB5(HB3) SB pin

5. Connect the PmodHB5 to the DC motor and to the system board.
6. Connect the programming cable.
7. Supply power to the PmodHB5 and the system board.
8. Configure the FPGA.
9. Press buttons to change the motor speed and use the switches to revert direction and watch the speed of the motor.
10. Use a scope to visualize the safe direction switching.

Note:

This demo project may easily be used with a PmodHB3 module, with no changes. Please note however that if the user is controlling the Motor/Gearbox that is typically paired with the PmodHB5, the GND pin on the HB3 must be connected to the GREEN wire on the motor, and the Vcc pin on the HB3 must be connected to the BROWN pin on the motor. Failure to follow these instructions will result in the decoder on the Motor/Gearbox malfunctioning, and the RPM will not be displayed.