UG0690
User Guide
Hall Interface v4.1

Power Matters.™

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1 Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

1.1 Revision 2.0

The following is a summary of the changes in revision 2.0 of this document.

- Added the IP version to the document title.
- Updated Figure 3, page 4.
- Removed Configuration Parameters of Hall Interface Block section.

1.2 Revision 1.0

Revision 1.0 is the first publication of this document.

2 Introduction

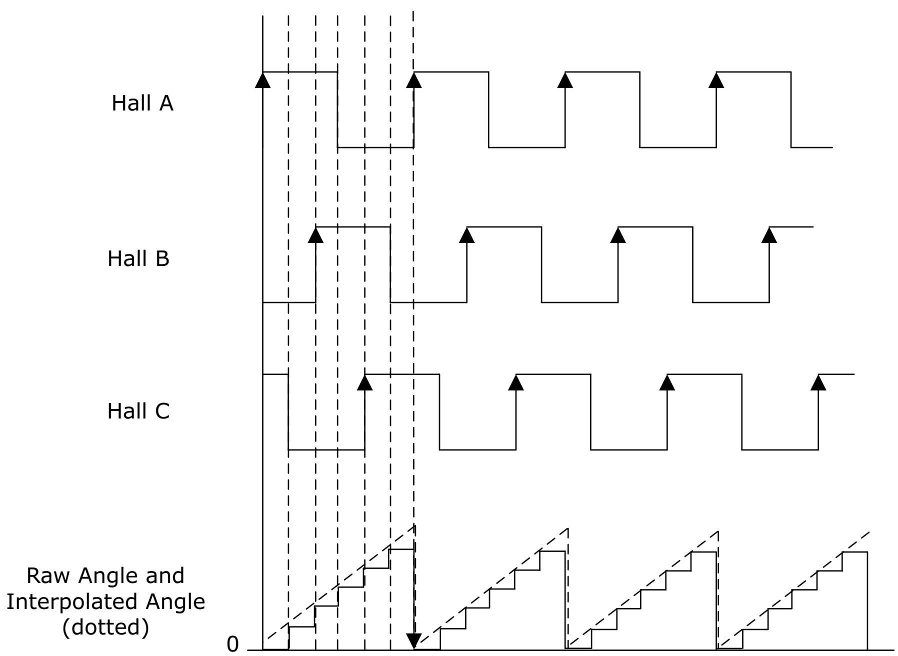
Brush less DC (BLDC) motors are fitted with digital Hall sensors that provides rotor information for commutation of phases. The Hall sensors are used for block commutation of BLDC phases and provide rotor position with poor resolution. Block commutation has drawbacks like torque ripple and reduced efficiency. It is proven that vector control gives the best performance for the BLDC motor in terms of efficiency and torque ripple. However, because of poor angle resolution Hall sensors cannot be used for vector control. The Hall interface block generates high resolution angle from the low resolution angle provided by Hall sensors. It also computes the speed of the motor based on Hall signals.

2.1 Angle Generation

A Hall event is a change of state of the Hall signal. In one cycle of the Hall signal, six Hall events can be detected. Each event indicates an angle movement of one sixth of the total cycle. This means that each Hall event indicates a change of 60° (electrical).

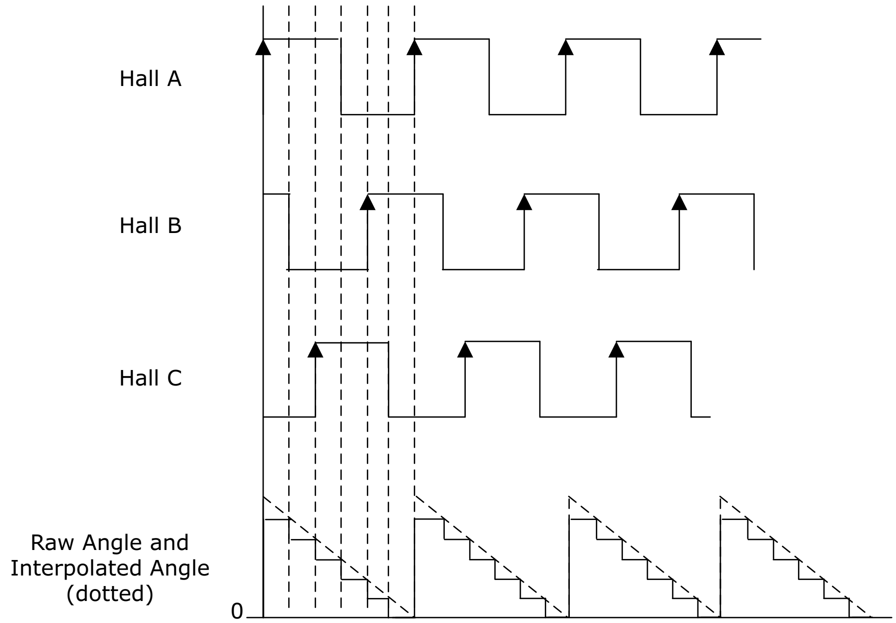
For ripple free operation, the raw angle is smoothened by interpolation to obtain a finer angle. This angle is used in the field oriented control (FOC) transformation. The following figure shows the Hall angle signals and the angle generated from these signals (assuming the Hall signals are active high).

Figure 1 • **Hall Signals and Angle Generation**



The following figure shows the computed angle generation for the reverse direction of the active high Hall signals.

Figure 2 • **Hall Signals and Angle Generation for Reverse Direction**



2.2 Speed Calculation

The rotor speed is calculated based on the change of angle in a given time window. The time window varies based on the motor speed and the speed obtained is scaled appropriately.

The Hall sensors provide the electrical angle of the rotor. The mechanical speed is affected by the number of pole pairs. The Hall interface block uses the number of pole pairs to compute the scaling factor. The speed factor is calculated as:

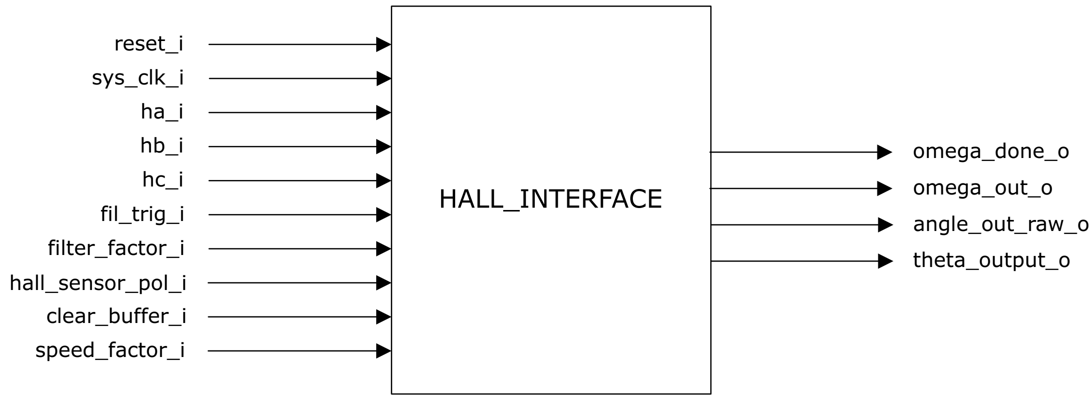
$$\text{Speed Factor} = \frac{384 \times \text{Motors speed} \times \text{Number of pole pairs}}{1600}$$

3 Hall Interface Implementation

This section describes the implementation details of the Hall interface block.

The following figure shows the system level block diagram of the Hall interface.

Figure 3 • **System Level Block Diagram of Hall Interface Block**



The Hall interface block generates the rotor angle based on three Hall inputs:

- The angle_out_raw_o output is the raw angle generated based on Hall events
- The theta_output_o output is the smoothened interpolated angle.
- The hall_sensor_pol_i input is used to indicate, if the Hall signals are active high or active low.

The angle generated is used to determine the rotor speed. The clear_buffer_i input is used to clear the speed filter buffer when the motor is stopped. The computed speed is filtered using a filter block. The filter block computation is triggered by the fil_trig_i input and the filter time constant is decided by the filter_factor_i input. The filtered speed is available at omega_out_o output, and the omega_done_o output (pulse of one clock cycle width) indicates the speed is ready for use by the subsequent blocks.

3.1 Inputs and Outputs of Hall Interface Block

The following table lists the input and output ports of the Hall Interface block.

Table 1 • **Input and Output Ports of Hall Interface**

Signal Name	Direction	Description
reset_i	Input	Asynchronous reset signal to design (active low)
sys_clk_i	Input	System clock
ha_i	Input	Hall A input signal
hb_i	Input	Hall B input signal
hc_i	Input	Hall C input signal
fil_trig_i	Input	Filter trigger input (must go high for one clock cycle to start filter operation)
filter_factor_i	Input	Represents the speed filter time constant – input as an exponent of 2 2^(ebeta_filter_factor_i) * sampling time
hall_sensor_pol_i	Input	Polarity of Hall sensor inputs, When 1, Active high When 0, Active low
clear_buffer_i	Input	When 1, clears internal speed filter buffer When 0, normal operation of buffer
speed_factor_i	Input	Speed factor input. see, Speed Calculation, page 3
omega_done_o	Output	Speed computation done signal (pulse of one clock cycle width)
omega_out_o	Output	Speed output
angle_out_raw_o	Output	Raw angle output
theta_output_o	Output	Angle output

3.2 Resource Utilization of Hall Interface Block

The following table lists the resource utilization report of the Hall interface block implemented on the SmartFusion2 or IGLOO2 device.

Table 2 • **Rate Limiter Block – Resource Utilization**

Resource	Usage
Sequential elements	340
Combinational logic	670
MACC	2
RAM1kx18	0
RAM64x18	0