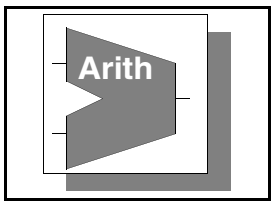
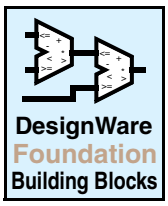




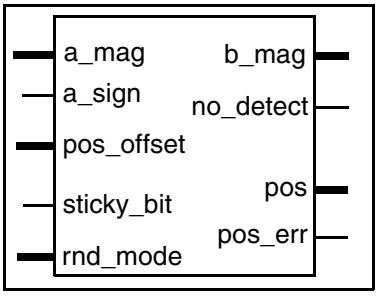
DW_norm_rnd

Normalization and rounding

Version, STAR and Download Information: IP Directory

Features and Benefits

- Parameterized word lengths
- Parameterized search window
- Exponent calculation useful for floating-point numbers
- Implements the most used rounding modes
- Provides status indications for exceptional cases
- DesignWare datapath generator is employed for better timing and area



Description

DW_norm_rnd is a general-purpose normalization and rounding module for a value represented in the sign-and-magnitude number system (*a_sign*, *a_mag*). The value represented in this system corresponds to $(-1)^{a\_sign} a\_mag$. The magnitude of the number is a positive fixed-point value in the format $a = (a_0.a_1\ a_2\ a_3\ a_4\ a_5\ ...a_{a\_width-1})$, where a_i represents a bit. This means that *a_mag* has 1 integer bit and (*a_width*-1) fractional bits.

The normalization process consists in generating an output in the range $1 \leq b\_mag < 2$ (the output bit-vector has a 1 in the MS bit position) when there is a 1 bit in the search window provided as a parameter.

The rounding is done using a method controlled by one of the component inputs. Output *pos* carries information about the position of binary point (exponent), and it is affected by the normalization shifts performed on the main input (*a_mag*). A list of pins for this component is provided in Table 1.

The number of bit positions in *a_mag* shifted during initial normalization and post-rounding normalization (*n* bit positions) is reflected in the value of *pos*. This output corresponds to (*pos_offset* + n) when parameter *exp_ctr* = 0, or to (*pos_offset* - n) when *exp_ctr* = 1. When the result of this operation does not fit in the bit-vector used for *pos* or it is negative, the output *pos_err* is set to 1.

Table 1-1 Pin Description

Pin Name	Width	Direction	Function
a_mag	*a_width* bit(s)	Input	Input data
a_sign	1 bit	Input	0 = positive 1 = negative
pos_offset	*exp_width* bit(s)	Input	Offset value for the position of the binary point

Table 1-1 Pin Description (Continued)

Pin Name	Width	Direction	Function
sticky_bit	1 bit	Input	Indicates the presence of non-zero bits in fractional bit positions beyond bit $a\_mag_{a\_width-1}$
rnd_mode	3 bits	Input	Rounding mode 000 – Round to nearest even 001 – Round towards zero 010 – Round to plus infinity 011 – Round to minus infinity 100 – Round up 101 – Round away from zero
no_detect	1 bit	Output	Result of MS 1 bit search in the search window. 0 = bit found 1 = bit not found
pos_err	1 bit	Output	Value provided at output pos cannot fit in an *exp_width* - bit vector or *pos* is negative
b_mag	*b_width* bit(s)	Output	Normalized and rounded output data
pos	*exp_width* bit(s)	Output	pos_offset combined with the number of bit positions that input `a_mag` was shifted (*n*): *exp_ctr* = 0 → pos_offset+*n* *exp_ctr* = 1 → pos_offset-*n*

Table 1-2 Parameter Description

Parameter	Values	Description
a_width	≥ 2 Default: 16	Word length of `a_mag`
srch_wind	2 to *a_width* Default: 4	Search window for the MS 1 bit (from left to right, or from bit 0 to *a_width - 1*)
exp_width	≥ 1 Default: 4	Word length of *pos_offset* and *pos*
b_width	2 to *a_width* Default: 10	Word length of *b_mag*
exp_ctr	0 or 1 Default: 0	Controls computation of the binary point position (`pos` output)

Table 1-3 Synthesis Implementations

Implementation Name	Function	License Feature Required
rtl	Synthesis model	DesignWare

Table 1-4 Simulation Models

Model	Function
DW01.DW_NORM_RND_CFG_SIM	Design unit name for VHDL simulation
dw/dw01/src/DW_norm__rnd_sim.vhd	VHDL simulation model source code
dw/sim_ver/DW_norm_rnd.v	Verilog simulation model source code

The input *pos_offset* is provided by the user to indicate that pre-shifting of the input operand was already done to adjust it to the required input format. For example, if the actual fixed-point value is (101.0011), the input for the DW_norm_rnd component could be *a_mag* = (0.01010011) and *pos_offset* = (0100) for the parameters *a_width* = 9 and *exp_width* = 4. Observe that the designer can use other input combinations as needed.

The *srch_wind* parameter reduces the complexity of this component when it is known that the MS 1 bit resides in a limited group of MS bit positions. When there is no 1 bit in the search window, the input *a_mag* is shifted to the left by (*srch_wind* - 1) bit positions and *no_detect* is set to 1.

Once the input is normalized, a rounding method is applied to it according to the *rnd_mode* input. Rounding consists in truncating the normalized input vector (*a_norm*) to *b_width* bits and adding 1 or 0 (value called *rnd* in the following equations) to the least-significant bit position of this truncated normal vector (fractional bit $L = a\_norm_{b\_width - 1}$). In order to make a decision about the value of *rnd*, the rounding procedure makes use of two extra bits called round bit (*R*) and sticky bit (*T*). These bits are also obtained from the normalized vector *a_norm*, and for this reason the user must make sure that enough significant bits are provided to the normalization and rounding unit to allow proper rounding. The round bit corresponds to $a\_norm_{b\_width}$, when *b_width* < *a_width*; otherwise it has value 0. The sticky bit is a combination of input *sticky_bit* and any other bits beyond $a\_norm_{b\_width}$ (value after normalization). The *sticky_bit* input indicates that there are other non-zero bits beyond the fractional bit position *a_width* - 1 in the main input *a_mag*.

Once the bits *R* and *T* are determined, the value of *rnd* used for rounding is generated as:

- RNE: *rnd* = *R* and (*L* or *T*)
- Rzero: *rnd* = 0 (only truncated value)
- Rpos: *rnd* = not *a_sign* and (*R* or *T*)
- Rneg: rnd = *a_sign* and (*R* or *T*)
- Rup: *rnd* = *R*
- Raway: *rnd* = *R* + *T*

The component detects the cases that require post-rounding normalization and adjusts the *pos* output accordingly. For these cases, when *exp_ctr* = 0, the exponent value at output *pos* is decremented by 1, and when *exp_ctr* = 1, the exponent value is incremented by 1.

Related Topics

- Datapath– Arithmetic Overview
- DesignWare Building Block IP Documentation Overview

HDL Usage Through Component Instantiation - VHDL

```
library IEEE,DWARE,DWARE;
use IEEE.std_logic_1164.all;
use DWARE.DWpackages.all;
use DWARE.DW_foundation_comp.all;

entity DW_norm_rnd_inst is
      generic (
        inst_a_width : POSITIVE := 16;
        inst_srch_wind : POSITIVE := 4;
        inst_exp_width : POSITIVE := 4;
        inst_b_width : POSITIVE := 10
        );
      port (
        inst_a_mag : in std_logic_vector(inst_a_width-1 downto 0);
        inst_pos_offset : in std_logic_vector(inst_exp_width-1 downto 0);
        inst_sticky_bit : in std_logic;
        inst_a_sign : in std_logic;
        inst_rnd_mode : in std_logic_vector(2 downto 0);
        pos_err_inst : out std_logic;
        no_detect_inst : out std_logic;
        b_inst : out std_logic_vector(inst_b_width-1 downto 0);
        pos_inst : out std_logic_vector(inst_exp_width-1 downto 0)
        );
    end DW_norm_rnd_inst;


architecture inst of DW_norm_rnd_inst is

begin

    -- Instance of DW_norm_rnd
    U1 : DW_norm_rnd
    generic map ( a_width => inst_a_width, srch_wind => inst_srch_wind, exp_width =>
inst_exp_width, b_width => inst_b_width )
    port map ( a_mag => inst_a_mag, pos_offset => inst_pos_offset, sticky_bit =>
inst_sticky_bit, a_sign => inst_a_sign, rnd_mode => inst_rnd_mode, pos_err =>
pos_err_inst, no_detect => no_detect_inst, b => b_inst, pos => pos_inst );


end inst;
```

HDL Usage Through Component Instantiation - Verilog

```
module DW_norm_rnd_inst( inst_a_mag, inst_pos_offset, inst_sticky_bit, inst_a_sign,
inst_rnd_mode,
          pos_err_inst, no_detect_inst, b_inst, pos_inst );

parameter a_width = 16;
parameter srch_wind = 4;
parameter exp_width = 4;
parameter b_width = 10;
parameter exp_ctr = 0;


input [a_width-1 : 0] inst_a_mag;
input [exp_width-1 : 0] inst_pos_offset;
input inst_sticky_bit;
input inst_a_sign;
input [2 : 0] inst_rnd_mode;
output pos_err_inst;
output no_detect_inst;
output [b_width-1 : 0] b_inst;
output [exp_width-1 : 0] pos_inst;

    // Instance of DW_norm_rnd
    DW_norm_rnd #(a_width, srch_wind, exp_width, b_width, exp_ctr)
      U1 ( .a_mag(inst_a_mag), .pos_offset(inst_pos_offset),
.sticky_bit(inst_sticky_bit), .a_sign(inst_a_sign), .rnd_mode(inst_rnd_mode),
.pos_err(pos_err_inst), .no_detect(no_detect_inst), .b(b_inst), .pos(pos_inst) );

endmodule
```

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Synopsys, Inc.
690 E. Middlefield Road
Mountain View, CA 94043

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