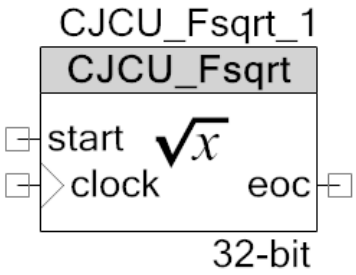
Fixed-Point Square Root Calculator (CJCU_Fsqrt)

1.0



Features

- 8, 16, 24, and 32 bits
- CPU mode for easy API access
- DMA mode for HW-controlled access
- Supports PSoC 3 and PSoC 5 LP

General Description

The Fixed-Point Square Root Calculator (CJCU_Fsqrt) uses hardware resources to compute the fixed-point square root (fsqrt) of a given number. In 32-bit mode, the fsqrt calculation will take a maximum of 220 cycles to complete, and can use up to a 25 MHz clock. See the AC Characteristics section for more performance details.

The resolution of the computed square root is dependent on the Width parameter of the component. The data format (fixed-point representation) of the output is dependent on the data format of the input.

For example, the 8-bit integer 81 (0x51) will produce the Q4.4 result 9.0 (0x90), where the most-significant 4 bits (0x9) represents the integer part, and the least significant 4-bits (0x0) represent the fractional part (in 16ths).

If the input is in Q4.4 format, we can compute the square root of 2.25 (0x24 = 0010.0100 2 + 4/16) to be the Q2.6 value 1.5 (0x60 = 01.100000 = 1 + 32/64).

If the input fixed-point format is Q(m).(n), the output resolution will be Q(m/2).(n-m/2). Examples are provided in the table below.

Width	Input/Output Data Type	Input/Output Data Resolution	Input Data Format	Output Data Format
8-bit	uint8	8 bits	Q8.0 (integer)	Q4.4
			Q4.4	Q2.6
			Q0.8	Q0.8
16-bit	uint16	16 bits	Q16.0 (integer)	Q8.8
			Q8.8	Q4.12
			Q0.16	Q0.16

Width	Input/Output Data Type	Input/Output Data Resolution	Input Data Format	Output Data Format
24-bit	uint32	24 bits	Q24.0 (integer)	Q12.12
			Q12.12	Q6.18
			Q0.24	Q0.24
32-bit	uint32	32 bits	Q32.0 (integer)	Q16.16
			Q24.8	Q12.20
			Q16.16	Q8.24
			Q0.32	Q0.32

When to Use a Fixed-Point Square Root Calculator

Use a Fixed-Point Square Root Calculator to offload the CPU from having to perform the square root calculation. This can be to efficiently calculate several square roots in parallel (CPU mode), or to process data from a peripheral without assistance from the CPU (DMA mode).

Input/Output Connections

This section describes the various input and output connections for the Fixed-Point Square Root Calculator. An asterisk (*) in the list of I/Os indicates that the I/O may be hidden on the symbol under the conditions listed in the description of that I/O.

start – Input *

The start input signal triggers the start of a calculation. The start signal is level triggered, but is ignored during calculation. This terminal is displayed if the **Mode** parameter is set to either **DMA-only** or **CPU/DMA**.

clock – Input

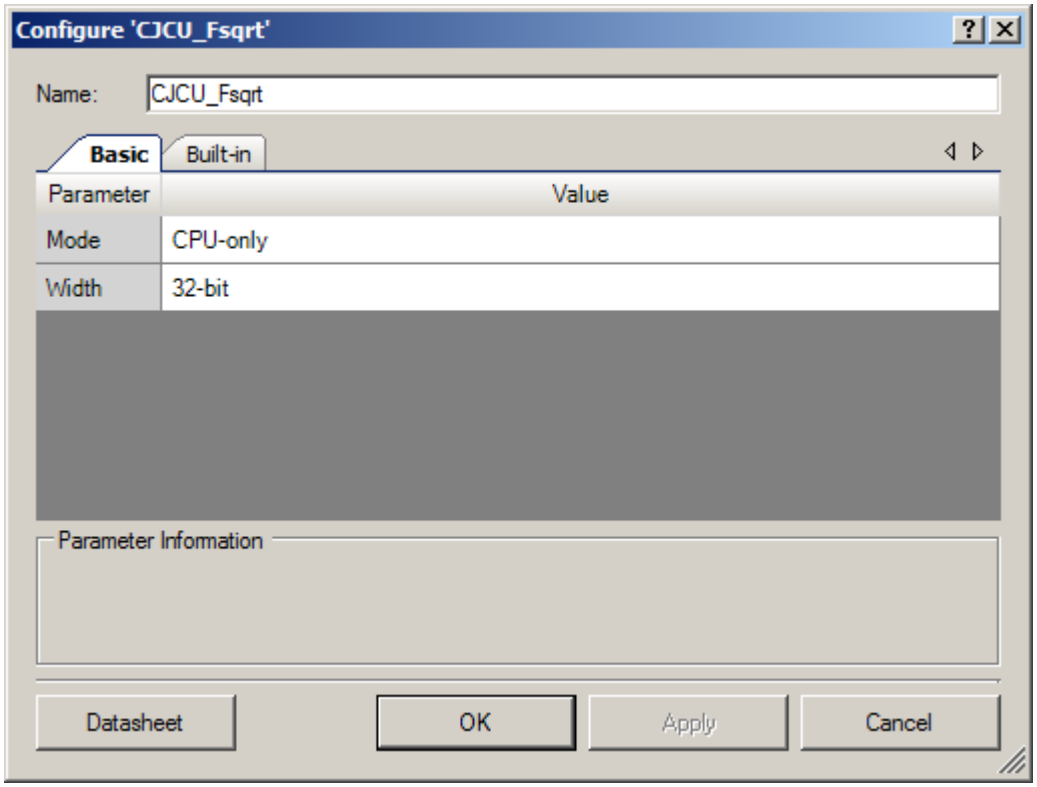
Clock source for the component. A higher frequency clock will result in faster calculations.

eoc – Output *

A rising edge on the End of Calculation (eoc) output indicates that the previously requested calculation has completed. The signal will pulse high for one clock period. This terminal is displayed if the **Mode** parameter is set to either **DMA-only** or **CPU/DMA**.

Component Parameters

Drag a Fixed-Point Square Root Calculator component onto your design and double-click it to open the **Configure** dialog.



Mode

This parameter determines the access mode of the component. Valid values are **DMA-only**, **CPU-only**, and **CPU/DMA**. The default is **CPU-only**.

See the Functional Description section for descriptions of the three modes.

Width

This parameter determines the bit width of the component. Valid values are **8-bit**, **16-bit**, **24-bit**, and **32-bit**. The default is **32-bit**.

Clock Selection

There is no internal clock in this component. You must attach a clock source. This component operates from a single clock connected to the component.

Application Programming Interface

Application Programming Interface (API) routines allow you to configure the component using software. The following table lists and describes the interface to each function. The subsequent sections cover each function in more detail.

By default, PSoC Creator assigns the instance name “CJCU_Fsqrt_1” to the first instance of a component in a given design. You can rename it to any unique value that follows the syntactic rules for identifiers. The instance name becomes the prefix of every global function name, variable, and constant symbol. For readability, the instance name used in the following table is “CJCU_Fsqrt.”

Function	Description
uint8/16/32 CJCU_Fsqrt_ComputeFsqrt(uint8/16/32 square)	Computes a fixed-point square root and returns the computed value.
void CJCU_Fsqrt_ComputeFsqrtAsync(uint8/16/32 square)	Initiates the computation of a fixed-point square root.
uint8/16/32 CJCU_Fsqrt_ReadFsqrtAsync()	Reads the result of the previously requested calculation.
uint8 CJCU_Fsqrt_AsyncComplete()	Reads the status of an asynchronously requested calculation.

uint8/16/32 CJCU_Fsqrt_ComputeFsqrt(uint8/16/32 square)

Description: Computes the fixed-point square root (fsqrt) of a given number. This is a blocking call, and will not return until the calculation is complete. To perform a non-blocking calculation, use the ComputeFsqrtAsync API.

Parameters: uint8/16/32 square: The radicand of which to compute the root. Data type is determined by the “Width” component parameter (uint8 for 8-bit, uint16 for 16-bit, uint32 for 24-bit and 32-bit).

Return Value: uint8/16/32 Computed fixed-point square root. Data type is determined by the “Width” component parameter (uint8 for 8-bit, uint16 for 16-bit, uint32 for 24-bit and 32-bit).

Side Effects: None

void CJCU_Fsqrt_ComputeFsqrtAsync(uint8/16/32 square)

Description: Initiates the computation of an fixed-point square root. After calculation has completed (when AsyncComplete() returns 0x01), the result can be retrieved using the ReadIsqrtAsync() API.

Parameters: uint8/16/32 square: The radicand of which to compute the root. Data type is determined by the “Width” component parameter (uint8 for 8-bit, uint16 for 16-bit, uint32 for 24-bit and 32-bit).

Return Value: None

Side Effects: None

uint8/16/32 CJCU_Fsqrt_ReadFsqrtAsync (void)

Description: Reads the result of the previously requested calculation. This API will only return a valid result after the AsyncComplete API returns 0x01.

Parameters: None

Return Value: uint8/16/32 Computed fixed-point square root. Data type is determined by the “Width” component parameter (uint8 for 8-bit, uint16 for 16-bit, uint32 for 24-bit and 32-bit).

Side Effects: None

uint8 CJCU_Fsqrt_AsyncComplete (void)

Description: Reads the status of an asynchronously requested calculation.

Parameters: None

Return Value: uint8 calculation status.
0x00 indicates that the component is busy or that no calculation has been requested.
0x01 indicates that the requested calculation has completed.
The value is clear-on-read, so successive calls after 0x01 is returned will return 0x00.

Side Effects: Value of CJCU_Fsqrt_STS is cleared.

Defines

- CJCU_Fsqrt_WIDTH – Defines Fixed-Point Square Root Calculator width in bits.
- CJCU_Fsqrt _CPU_MODE – Defines whether the component has CPU access enabled. A value of 1 indicates that the access mode is CPU-only or CPU/DMA, and APIs are available.
- CJCU_Fsqrt_F1 – Defines the address of this component’s FIFO1.
- CJCU_Fsqrt_CTL – Defines the address of this component’s Control Register. Only valid if the component is in CPU-only or CPU/DMA mode. Under normal use, it is not necessary to manipulate the component’s Control Register. The define is included for more advanced users. For more information, see the Registers section.
- CJCU_Fsqrt_STS – Defines the address of this component’s Status Register. Only valid if the component is in CPU-only or CPU/DMA mode. Under normal use, it is not necessary to manipulate the component’s Status Register. The define is included for more advanced users. For more information, see the Registers section.

Sample Firmware Source Code

```
#include <device.h>
```

```
uint32 square;
uint32 root;

void main()
{
      /* First, compute a straightforward square root with the blocking call. */
      square = 1000000;
      root = CJCU_Fsqrt_1_ComputeFsqrt(square);
      /* root should now be 0x03E80000, representing 1000.000 in Q16.16 format. */

      /* Now, a square root with a non-integer result using the non-blocking API. */
      square = 4294967295;
      CJCU_Fsqrt_1_ComputeFsqrtAsync(square);
      while (CJCU_Fsqrt_1_AsyncComplete() != 0x01)
      {
            /* Go do some other CPU work while we wait. */
      }
      root = CJCU_Fsqrt_1_ReadFsqrtAsync();
      /* root should now be 0xFFFFFFFF, representing 65535.9999 in Q16.16 format. */
}
```

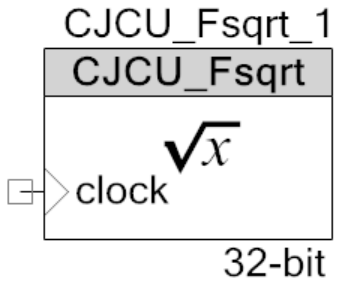
For more sample code, an example project and a unit test for the Fixed-Point Square Root Calculator component can be found in CJCU_FsqrtTest/CJCU_Fsqrt_Tests.cywrk.

Functional Description

The Fixed-Point Square Root Calculator can interface with the CPU, with DMA, or with both.

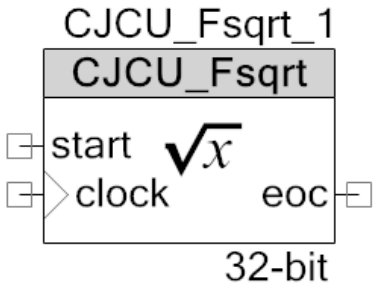
CPU-only

The default configuration of the Fixed-Point Square Root Calculator is CPU-only. This configuration provides APIs that coordinate the movement of data in and out of the component's internal FIFOs and the timing and state of the other component internals.



DMA-only

DMA-only mode allows the user to define the data flow and timing of the component. This allows the component to calculate without any CPU intervention. An example where this is useful would use a DMA component to transfer data into the Fixed-Point Square Root Calculator. This DMA's nrq terminal would hook up to the Fsqrt's start terminal. Another DMA component could be used to transfer data out. Its drq would be driven by the Fsqrt's eoc.



CPU/DMA

CPU/DMA mode provides the most flexibility to the user. APIs are available to use the prescribed CPU-driven data flow. Control and status signals are also exposed for the user to interface the component with hardware. An example where this is useful might use the APIs to have the CPU initiate a calculation, followed by a DMA component automatically responding to the completion of the calculation with no further CPU intervention. The symbol for CPU/DMA mode appears the same as for DMA-only mode.

It is important to ensure that the FIFO data is written and read correctly when accessed without the APIs provide in CPU mode. Before the start signal is asserted, F1 should contain N, where N is the square of which to compute the root. After the component asserts the eoc signal, F1 contains the root. F0 is not available for CPU/DMA access. Reads and writes to F0 will be ignored.

Registers

CJCU_Fsqrt_CTL

Note: This register does not exist if the component is in DMA-only mode. The register uses pulse mode: written values are present for one clock cycle, and then reset to '0'.

Bits	7	6	5	4	3	2	1	0
Value	Reserved							start

- start: Initiate a calculation.

CJCU_Fsqrt_STS

Note: This register does not exist if the component is in DMA-only mode. The register uses sticky mode: A read will reset the register to '0'.

Bits	7	6	5	4	3	2	1	0
Value	Reserved							complete

- complete: Requested calculation has completed.

Resources

The Fixed-Point Square Root Calculator component is placed throughout the UDB array. The component utilizes the following resources.

Configuration	Resource Type					
	Datapath Cells	Macrocells	Status Cells	Control Cells	DMA Channels	Interrupts
8-bit	1	10	1*	1*	–	–
16-bit	2	10	1*	1*	–	–
24-bit	3	10	1*	1*	–	–
32-bit	4	10	1*	1*	–	–

*Reported Status/Control usage is for CPU mode. In DMA-only mode, the component uses 0 Status Cells and 0 Control Cells.

API Memory Usage

The component memory usage varies significantly, depending on the compiler, device, number of APIs used and component configuration. The following table provides the memory usage for all APIs available in the given component configuration.

The measurements have been done with the associated compiler configured in Release mode with optimization set for Size. For a specific design the map file generated by the compiler can be analyzed to determine the memory usage.

Configuration	PSoC 3 (Keil_PK51)		PSoC 5LP (GCC)	
	Flash Bytes	SRAM Bytes	Flash Bytes	SRAM Bytes
8-bit	40	0	76	0
16-bit	52	0	76	0
24-bit	48	0	88	0
32-bit	48	0	76	0

DC and AC Electrical Characteristics

Specifications are valid for –40 °C ≤ T_A ≤ 85 °C and T_J ≤ 100 °C, except where noted.
Specifications are valid for 1.71 V to 5.5 V, except where noted.

AC Characteristics

Parameter	Description	Min	Typ	Max[1]	Units
f_{CLOCK}	Component clock frequency				
	8-bit			29	MHz
	16-bit			28	MHz
	24-bit			26	MHz
	32-bit			25	MHz
$t_{COMPUTE}$	Maximum computation time from start pulse to eoc pulse (Using Max f_{CLOCK})				
	8-bit (52 cycles max)	1.8			µs
	16-bit (108 cycles max)	3.9			µs
	24-bit (164 cycles max)	6.3			µs
	32-bit (220 cycles max)	8.8			µs

[1]. The values provide a maximum safe operating frequency of the component. The component may run at higher clock frequencies, at which point you will need to validate the timing requirements with STA results.

Component Changes

This section lists the major changes in the component from the previous version.

Version	Description of Changes	Reason for Changes / Impact
1.0	Initial component version	

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