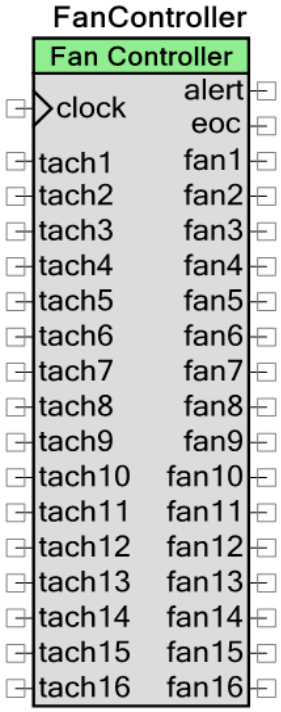
Fan Controller
2.0



Features

- Support for up to 16 PWM controlled, 4-wire brushless DC fans
- Individual or banked PWM outputs with tachometer inputs
- Supports 25 kHz, 50 kHz or user-specified PWM frequencies
- Supports fan speeds up to 25,000 RPM
- Supports 4-pole and 6-pole motors
- Supports fan stall / rotor lock detection on all fans
- Supports firmware controlled or hardware controlled fan speed regulation
- Customizable alert pin for fan fault reporting

General Description

The FanController component enables designers to quickly and easily develop fan controller solutions using PSoC. The component is a system-level solution that encapsulates all necessary hardware blocks including PWMs, tachometer input capture timer, control registers, status registers and a DMA controller reducing development time and effort.

The component is customizable through a graphical user interface enabling designers to enter fan electromechanical parameters such as duty cycle-to-RPM mapping and physical fan bank organization. Performance parameters including PWM frequency and resolution as well as open or closed loop control methodology can be configured through the same user interface. Once the system parameters are entered, the component delivers the most optimal implementation saving resources within PSoC to enable integration of other thermal management and system management functionality. Easy-to-use APIs are provided to enable firmware developers to get up and running quickly.

Note Designs using the Fan Controller component should not use PSoC's low power sleep or hibernate modes. Entering those modes prevents the Fan Controller component from controlling and monitoring the fans.

When to Use a Fan Controller

The Fan Controller component should be used in any thermal management application that needs to drive and monitor 4-wire, PWM based DC cooling fans. If the application requires more than 16 fans, the Fan Controller component can be instantiated multiple times. Similarly, if the fans in the application are organized into banks, designers have the option of instantiating one Fan Controller component per bank or instantiating one component that handles all the banks.

Input/Output Connections

This section describes the various input and output connections for the Fan Controller. An asterisk (*) in the list of I/Os states that the I/O may be hidden on the symbol under the conditions listed in the description of that I/O.

clock – Input *

An input for a user-defined clock source for the fan control PWMs. It is present only when the External Clock option is selected in the component customizer.

tach1..16 – Input *

Tachometer signal from each fan that enables the Fan Controller to measure fan rotational speeds. The component is designed to work with 4-pole DC fans that produce 2 high-low pulse trains per rotation on their tachometer output or 6-pole DC fans that produce 3 high-low pulse trains. tach2..16 inputs are optional.

fan1..16 – Output *

PWM output with variable duty cycle to control the speed of the fans. These output terminals are replaced by the bank1..8 outputs if fan banking is enabled. fan2..16 are optional.

Note that for Hardware UDB mode, the maximum number of fan outputs (and associated tach inputs) is limited to 12 to minimize digital resource utilization.

bank1..8 – Output *

PWM output with variable duty cycle to control the speed of the fan banks. These outputs appear only when banking is enabled.

alert – Output *

Active high output terminal asserted when fan faults are detected (if enabled).

eoc – Output *

End-of-Cycle output is pulsed high each time the tachometer block has measured the speed of all fans in the system. This can be used to synchronize firmware algorithms to the Fan Controller hardware by connecting the terminal to a Status Register component or to an Interrupt component.

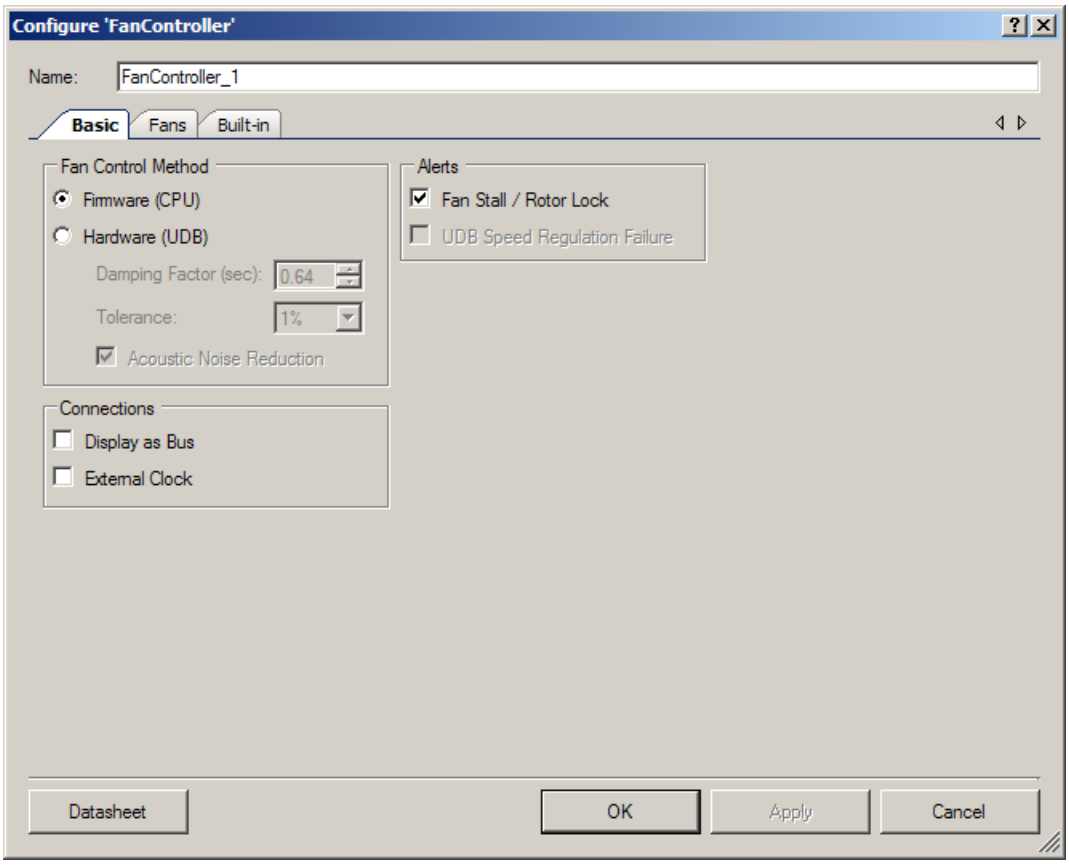
Component Parameters

Drag a Fan Controller onto your design and double click it to open the Configure dialog. Figure 1 shows the Configure dialog.

BasicTabOptions

This tab is used to configure the fundamental operating parameters of the component.

Figure 1.Basic Configuration Dialog



Fan Control Method – Firmware/Hardware

This parameter determines how the fan speeds are controlled. Firmware (CPU) setting is used when user firmware controls fan speed regulation. Firmware can set PWM duty cycles and read back fan speeds to determine the appropriate action.

Hardware (UDB) setting dictates that hardware blocks inside PSoC control fan speed regulation automatically without any CPU intervention. Firmware sets the desired speed for each fan and the hardware automatically adjusts the PWM duty cycle to achieve and maintain the desired speed within specified tolerance limits. Default setting is Firmware (CPU).

Firmware (CPU) setting should be selected in cases where:

1. The designer has a complex or custom fan control algorithm to be implemented in firmware within PSoC.
2. Anexternal host controller is responsible formanaging the fan speed algorithm and the Fan Controller component is simply being used as the hardware interface to the fans.
3. Multiple fans areorganized into banks sharing a common PWM drive signal.

Hardware (UDB) setting should be selected in cases where the designer wants to control multiple fans independently and wants to do so with minimal firmware development.

Hardware Control Mode – Damping Factor

In hardware controlled fan mode, this parameter controls the dynamic response time of the hardware control loop. This parameter controls how frequently the hardware adjusts the PWM duty cycles for each fan.

In situations where there are only a few fans, a higher damping factor ensures that the control loop can regulate to the desired speed without oscillating around the desired speed target. In situations where many fans are being controlled, a lower damping factor ensures adequate response time to changes in fan speed. This parameter enables fine tuning of the hardware control logic to match the selected fan's electromechanical characteristics. The valid range for this parameter is 0..1.27 (specified in seconds). Default setting is 0.64.

Hardware Control Mode – Tolerance

In hardware controlled fan mode, this parameter sets the acceptable tolerance when specifying desired fan speed targets. The tolerance is specified as a percentage relative to the desired speed setting. This parameter enables fine tuning of the hardware control logic to match the selected fans electromechanical characteristics.

The valid range for this parameter is 1..10%. Default setting is 1%. If 8-bit PWM resolution is selected in the Fan Controller Fans tab as shown in Figure 2, a Tolerance parameter setting of 5% is recommended.

Hardware Control Mode – Acoustic Noise Reduction

In hardware controlled fan mode, this parameter limits audible noise from fans by limiting the positive rate of change of speed. If enabled, and firmware requests an increase in desired fan

speed, the PWM duty cycle applied to the fan increases gradually to the new setting rather than applying a sudden step change. This eliminates noisy fan whir from sudden speed increases. Default setting is checked.

Alerts – FanStall / RotorLock

The Fan Controller can be configured to generate an active-high alert signal when a fan stalls or stops rotating due to a mechanical obstruction. Default setting is checked.

Alerts – UDB SpeedRegulationFailure

The Fan Controller can be configured to generate an active-high alert signal in hardware controlled fan mode when the hardware control loop is not able to achieve the desired speed. Default setting is un-checked.

Connections – Display as Bus

If checked, the tach inputs and fan/bank outputs will be displayed as buses. Otherwise, they are displayed as individual terminals.

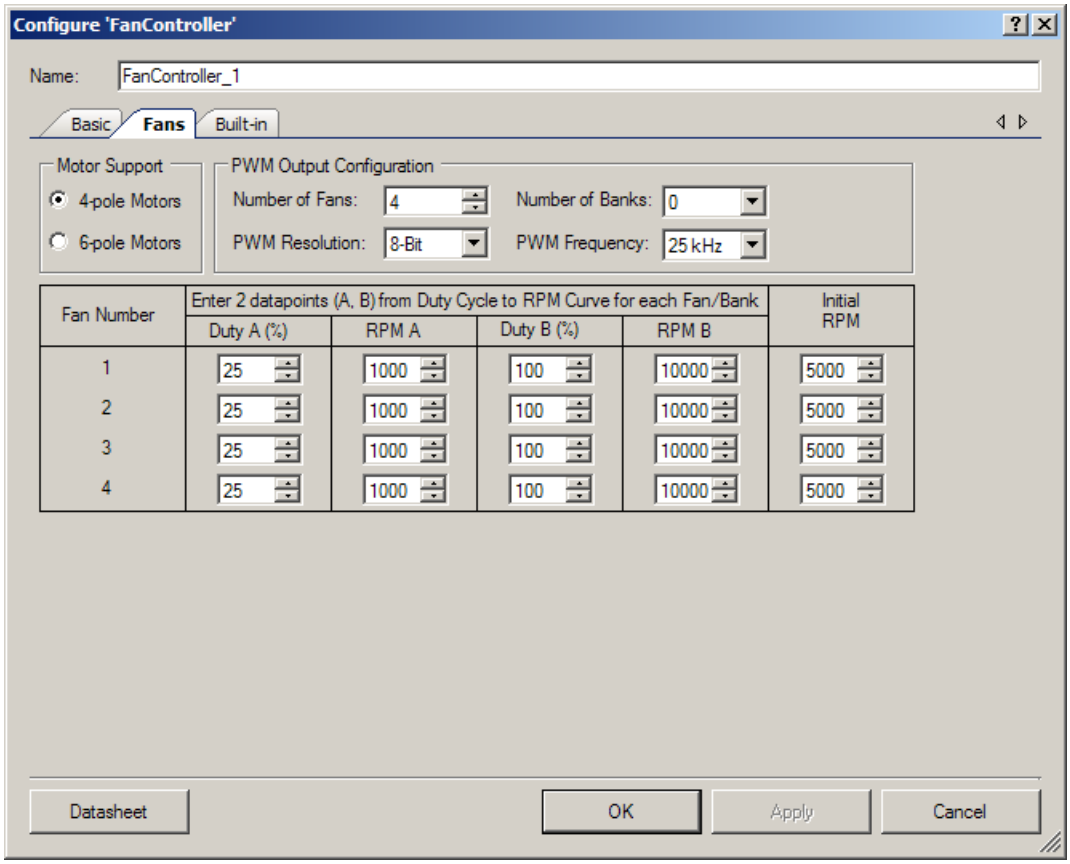
Connections – External Clock

If checked, it allows the user to connect an external clock source to the component clock input. If unchecked, then an internal clock source will be used.

Fans Tab Options

This tab is used to configure fan-specific parameters.

Figure 2. Fans Configuration Dialog



Motor Support

This parameter specifies the number of high – low pulses that appear on the fan's tachometer output per revolution. The 4-pole option means there are 2 high and 2 low pulses per fan revolution, while the 6-pole option means that there are 3 high and 3 low pulses per fan revolution.

PWM Output Configuration – Number of Fans

This parameter specifies how many fans are in the system. The valid range for this parameter is 1..16. Default setting is 4.

PWM Output Configuration – Number of Banks

This parameter is only visible in firmware control mode and specifies how many fan banks are in the system. It is assumed that when fans are organized into banks, each bank has the same number of fans. Therefore, the number of fans must be divisible by the number of banks. The value 0 indicates that the fans are not banked. For banked operation, the valid range for this parameter is from 1to (Number of Fans/2). Default setting is 0.

PWM Output Configuration – PWM Resolution

This parameter specifies the resolution of the duty cycle for the modulated PWM signal that drives the fans to control rotational speed. Valid options for this parameter are 8-bit or 10-bit. Default setting is 8-bit.

PWM Output Configuration – PWM Frequency

This parameter specifies the frequency of the modulated PWM signal that drives the fans. Valid options for this parameter are 25 kHz or 50 kHz when internal clock is used. Default setting is 25 kHz. When an external clock is used, this parameter is grayed out since the PWM frequency depends on the input clock source. See the Functional Description section for more details.

Fan Specifications – Duty A (%), RPM A

These parameters together specify one data point on the duty cycle-to-RPM transfer function for the selected fan or bank of fans. The RPM A parameter specifies the speed the fan nominally runs at when driven by a PWM with a duty cycle of Duty A (%). This information is available from the fan manufacturer's datasheet. It should be noted that the Fan Controller component may drive PWM duty cycles down to 0% even if Duty A (%) is set to a non-zero value.

The valid range for the Duty A (%) parameter is 0-99. Default setting is 25.

The valid range for the RPM A parameter is 500..24,999. Default setting is 1,000.

Fan Specifications – Duty B (%), RPM B

These parameters together specify a 2nd data point on the duty cycle-to-RPM transfer function for the selected fan or bank of fans. The RPM B parameter specifies the speed the fan nominally runs at when driven by a PWM with a duty cycle of Duty B (%). This information is available from the fan manufacturer's datasheet. It should be noted that the Fan Controller component may drive PWM duty cycles up to 100% even if Duty B (%) is set below 100%.

The valid range for the Duty B (%) parameter is 1-100. Default setting is 100.

The valid range for the RPM B parameter is 501..25,000. Default setting is 10,000.

Fan Specifications – Initial RPM

This parameter specifies the initial RPM of an individual fan. The value of Initial RPM is converted into a duty cycle and set as the initial duty cycle for an individual fan. The Initial RPM parameter may be set lower than the RPM A parameter.

Clock Selection

The component uses clock tree sources for its operation. These clocks are: Bus Clock, Tachometer Clock (500 kHz) and PWM Clock (6, 12 or 24 MHz depending on the configuration). The component has an option to connect an external clock source instead of the PWM Clock.

Application Programming Interface

Application Programming Interface (API) routines allow you to interact with the component using firmware. 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 FanController_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 FanController.

Functions

Function	Description
FanController_Start()	Start the component
FanController_Stop()	Stop the component and disable hardware blocks
FanController_Init()	Initializes the component
FanController_Enable()	Enables hardware blocks inside the component
FanController_EnableAlert()	Enables alerts from the component
FanController_DisableAlert()	Disables alerts from the component
FanController_SetAlertMode()	Configures alert sources
FanController_GetAlertMode()	Returns currently enabled alert sources
FanController_SetAlertMask()	Enables masking of alerts from each fan
FanController_GetAlertMask()	Returns alert masking status of each fan
FanController_GetAlertSource()	Returns pending alert source(s)
FanController_GetFanStallStatus()	Returns a bit mask representing the stall status of each fan

Function	Description
FanController_GetFanSpeedStatus()	Returns a bit mask representing the speed regulation status of each fan in hardware control mode
FanController_SetDutyCycle()	Sets the PWM duty cycle for the specified fan or fan bank
FanController_GetDutyCycle()	Returns the PWM duty cycle for the specified fan or fan bank
FanController_SetDesiredSpeed()	Sets the desired fans speed for the specified fan in hardware control mode
FanController_GetDesiredSpeed()	Returns the desired fans speed for the specified fan in hardware control mode
FanController_GetActualSpeed()	Returns the actual speed for the specified fan
FanController_OverrideHardwareControl()	Enables firmware to override hardware (UDB) fan control

Global Variables

Variable	Description
FanController_initVar(static)	The initVar variable is used to indicate initial configuration of this component. This variable is pre-pended with the component name. The variable is initialized to zero and set to 1 the first time FanController_Start() is called. This allows for component initialization without re-initialization in all subsequent calls to the FanController_Start() routine. If re-initialization of the component is required the FanController_Stop() routine should be called followed by the FanController_Init() and FanController_Enable().

voidFanController_Start(void)

Description: Enables the component. Calls the Init() API if the component has not been initialized before. Calls the Enable() API.

Parameters: None

Return Value: None

Side Effects: None

voidFanController_Stop(void)

Description: Disables the component. All PWM outputs will be driven to 100% duty cycle to ensure cooling continues while the component is not operational.

Parameters: None

Return Value: None

Side Effects: Alert pin is de-asserted.

voidFanController_Init(void)

Description: Initializes the component.

Parameters: None

Return Value: None

Side Effects: None

voidFanController_Enable(void)

Description: Enables hardware blocks within the component.

Parameters: None

Return Value: None

Side Effects: None

voidFanController_EnableAlert(void)

Description: Enables generation of the alert signal. Specifically which alert sources are enabled is configured using the FanController_SetAlertMode() and the FanController_SetAlertMask() APIs.

Parameters: None

Return Value: None

Side Effects: None

voidFanController_DisableAlert(void)

Description: Disables generation of the alert signal.

Parameters: None

Return Value: None

Side Effects: Alert pin is de-asserted.

voidFanController_SetAlertMode(uint8 alertMode)

Description: Configures alert sources from the component. Two alert sources are available: 1) Fan Stall or Rotor Lock, 2) Hardware control mode speed regulation failure.

Parameters: uint8 alertMode

Bit Field	Enabled Alert Source
FanController_STALL_ALERT	1=Enable fanstall / rotorlockalert
FanController_SPEED_ALERT	1=Enable ClosedLoopspeedregulationfailurealert

Return Value: None

Side Effects: None

uint8FanController_GetAlertMode(void)

Description: Returns the alert sources that are enabled.

Parameters: None

Return Value: uint8 alertMode

Bit Field	Enabled Alert Source
FanController_STALL_ALERT	1=Enable fanstall / rotorlockalert
FanController_SPEED_ALERT	1=Enable ClosedLoopspeedregulationfailurealert

Side Effects: None

voidFanController_SetAlertMask(uint16 alertMask)

Description: Enables or disables alerts from each fan through a mask. Masking applies to both fan stall alerts and speed regulation failure alerts.

Parameters: uint16 alertMask

Bit Field	Enabled Alert Source
bit0	1=Enable alerts for Fan1
bit1	1=Enable alerts for Fan2
…	…
bit15	1=Enable alerts for Fan16

Return Value: None

Side Effects: None

uint16FanController_GetAlertMask(void)

Description: Returns alert mask status from each fan. Masking applies to both fan stall alerts and speed regulation failure alerts.

Parameters: None

Return Value: uint16 alertMask

Bit Field	Enabled Alert Source
bit0	1=Enable alerts for Fan1
bit1	1=Enable alerts for Fan2
…	…
bit15	1=Enable alerts for Fan16

Side Effects: None

uint8FanController_GetAlertSource(void)

Description: Returns pending alert sources from the component. This API can be used to poll the alert status of the component. Alternatively, if the alert pin is used to generate interrupts to PSoC's CPU core, the interrupt service routine can use this API to determine the source of the alert. In either case, when this API returns a non-zero value, the FanController_GetFanStallStatus() and FanController_GetFanSpeedStatus() APIs can provide further information on which fan(s) has(have) a fault.

Parameters: uint8 alertMode

Bit Field	Pending Alert
FanController_STALL_ALERT	1=Fanstall / rotorlockalert pending
FanController_SPEED_ALERT	1=Closed Loopspeedregulationfailurealert pending

Return Value: None

Side Effects: None

uint16FanController_GetFanStallStatus(void)

Description: Returns the stall / rotor lock status of all fans.

Parameters: None

Return Value: uint16 stallStatus

Bit Field	Status
bit0	Fan1 stall status (1=stall, 0=OK)
bit1	Fan2 stall status
…	…
bit15	Fan16 stall status

Side Effects: Calling this API clears all pending fan stall alerts and de-asserts the alert pin. If stall alerts are pending, the alert pin is re-asserted synchronous to the next end-of-cycle (eoc) pulse.

uint16FanController_GetFanSpeedStatus(void)

Description: Returns the hardware fan control mode speed regulation status of all fans. Speed regulation failures occur in two cases: 1) if the desired fan speed exceeds the current actual fan speed but the fan's duty cycle is already at 100%, 2) if the desired fan speed is below the current actual fan speed, but the fan's duty cycle is already at 0%.

Parameters: None

Return Value: uint16 speedStatus

Bit Field	Status
bit0	Fan1 speed regulation status (1=failure, 0=OK)
bit1	Fan2 speed regulation status
…	…
bit15	Fan16 speed regulation status

Side Effects: Calling this API clears all pending speed regulation alerts and de-asserts the alert pin. If speed regulation alerts are pending, the alert pin is re-asserted synchronous to the next end-of-cycle (eoc) pulse.

voidFanController_SetDutyCycle(uint8 fanOrBankNumber, uint16 dutyCycle)

Description: Sets the PWM duty cycle of the selected fan or fan bank in hundredths of a percent. In hardware fan control mode, if manual duty cycle control is desirable, call the FanController_OverrideHardwareControl() API prior to calling this API.

Parameters: uint8 fanOrBankNumber
Valid range is 1..16 but should not exceed the number of fans or banks in the system.

uint16 dutyCycle
Duty cycle in hundredths of a percent. For example, 50% duty cycle = 5000. Valid range is 0..10000.

Return Value: None

Side Effects: None

uint16FanController_GetDutyCycle(uint8 fanOrBankNumber)

Description: Returns the current PWM duty cycle of the selected fan or fan bank in hundredths of a percent.

Parameters: uint8 fanOrBankNumber
Valid range is 1..16 but should not exceed the number of fans or banks in the system.

Return Value: Duty cycle in hundredths of a percent. For example, 50% duty cycle = 5000.

Side Effects: None

voidFanController_SetDesiredSpeed(uint8 fanNumber, uint16 rpm)

Description: Sets the desired speed of the specified fan in revolutions per minute (RPM). In hardware fan control mode, the RPM parameter is passed to the control loop hardware as the new target fan speed for regulation. In firmware fan control mode, the RPM parameter is converted to a duty cycle based on the fan parameters entered into the Fans tab of the customizer and written to the appropriate PWM. This provides firmware with a method for initiating coarse level speed control. Fine level firmware speed control can then be achieved using the FanController_SetDutyCycle() API.

Parameters: uint8 fanNumber
Valid range is 1..16 but should not exceed the number of fans in the system.
uint16 rpm
Valid range is 500..25,000 but should not exceed the maximum RPM that the fan is capable of running at. Doing so will cause a speed regulation failure.

Return Value: None

Side Effects: None

uint16FanController_GetDesiredSpeed(uint8 fanNumber)

Description: Returns the currently desired speed for the selected fan.

Parameters: uint8 fanNumber
Valid range is 1..16 but should not exceed the number of fans in the system.

Return Value: Currently desired speed for the selected fan in RPM

Side Effects: None

uint16 FanController_GetActualSpeed(uint8 fanNumber)

Description: Returns the current actual speed for the selected fan.

Parameters: uint8 fanNumber
Valid range is 1..16 but should not exceed the number of fans in the system.

Return Value: Current actual speed for the selected fan in RPM

Side Effects: None

Note On PSoC3 devices, when operating in Hardware mode, FanController_GetActualSpeed() should be called within a specific time window. Refer to Functional description section for more details.

voidFanController_OverrideHardwareControl(uint8 override)

Description: Allows firmware to take over fan control in hardware fan control mode. Note that this API cannot be called in firmware fan control mode.

Parameters: uint8 override
0 = hardware assumes control of fans
1 = firmware assumes control of fans
Valid range is 0..1. Default is 0

Return Value: None

Side Effects: None

Sample Firmware Source Code

PSoC Creator provides numerous example projects that include schematics and example code in the Find Example Project dialog. For component-specific examples, open the dialog from the Component Catalog or an instance of the component in a schematic. For general examples, open the dialog from the Start Page or **File** menu. As needed, use the **Filter Options** in the dialog to narrow the list of projects available to select.

Refer to the "Find Example Project" topic in the PSoC Creator Help for more information.

Interrupt Service Routine

The Fan Controller component does not provide any interrupt service routine APIs automatically. To use interrupts for this component add an interrupt component from the Cypress standard catalog in PSoC Creator.

Functional Description

Custom Clock

The component has a feature that allows the connection of an external clock. The frequency of the clock source determines the PWM output frequency, and the relation between the input clock frequency(f_{CLK}) and output PWM frequency(f_{PWM}) is shown in the following equations:

$$f_{PWM} = f_{CLK} / 240, \text{ for 8 bit resolution;}$$

$$f_{PWM} = f_{CLK} / 960, \text{ for 10 bit resolution.}$$

(where the 240 and 960 constants are Maximum periods for the 8-bit and 10-bit resolution modes, respectively).

Actual Speed

When this component is used in a PSoC 3 design, there is a requirement that this API be called within a specific time frame (tACT) after the "eoc" pulse is generated to ensure reliable capture of the 16-bit speed value. This restriction is due to the 8051 CPU core reading the 16-bit value 8-bits at a time. Outside of this region the possibility exists that the actual speed MSB and actual speed LSB read could contain data from two different fan speed measurements (previous and current).

To guarantee that this does not happen, the GetActualSpeed() API must be called within this time period after the "eoc" pulse has been generated:

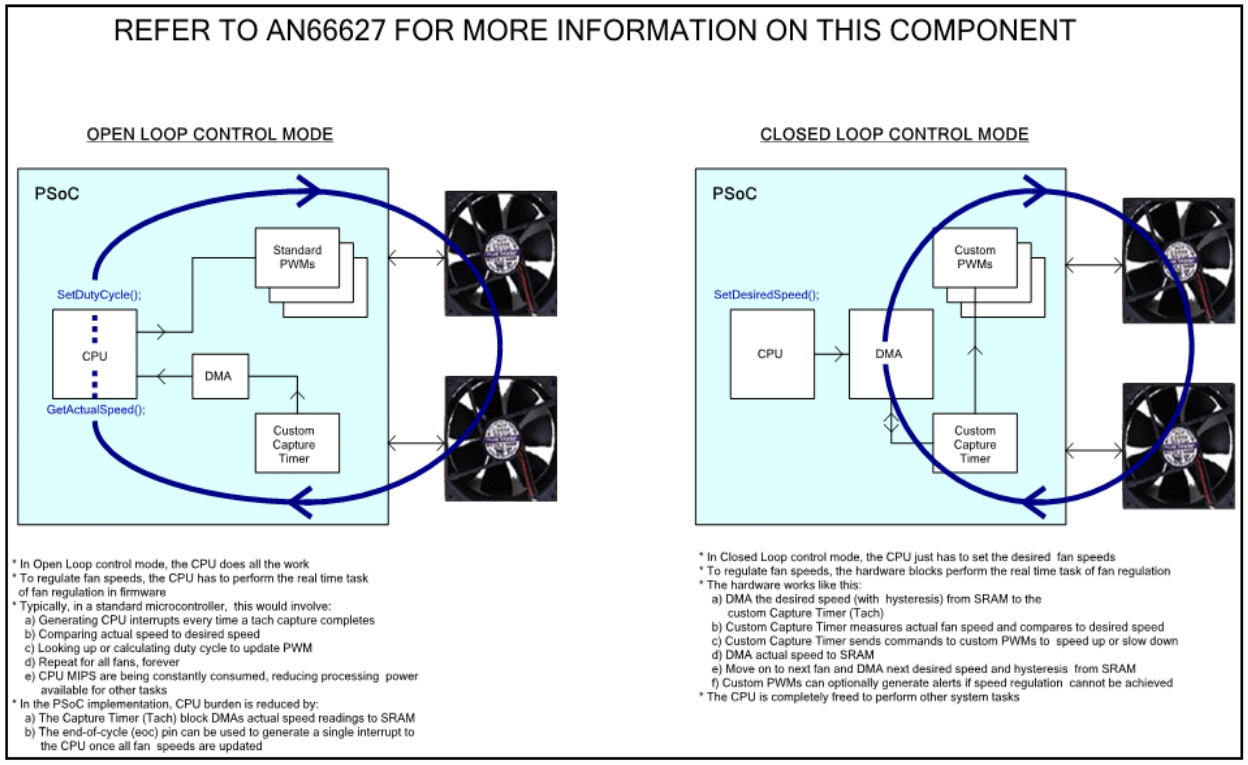
$$t_{ACT} = 2 * 60/RPMn_{MAX}$$

Note $RPMn_{MAX}$ is the maximum rotation speed of fanN – the last fan that is used in the configuration.

Block Diagram and Configuration

The schematic shown in Figure 3 shows high level block diagrams of the two fundamental operating modes of the component: 1) open loop control mode (firmware regulates fan speeds) and 2) closed loop control mode (hardware regulates fan speeds).

Figure 3. Fan Controller Block Diagram



Registers

The Fan Controller has several control and status registers that are used by the firmware APIs to control operation and monitor status. None of these registers are directly accessible by user firmware.

Resources

The Fan Controller component is placed throughout the UDB array. The component utilizes the following resources:

Configuration[1]	Resource Type					
	Datapath Cells	PLDs	Status Cells	Control Cells	DMA Channels	Interrupts
Firmware mode, 8-bit, 4 Fans	4	11	2	4	1	–
Firmware mode, 8-bit, 8 Fans	6	14	2	4	1	–
Firmware mode, 8-bit, 12 Fans	8	19	2	4	1	–
Firmware mode, 8-bit, 16 Fans	10	22	2	4	1	–
Firmware mode, 10-bit, 4 Fans	6	11	2	4	1	–
Firmware mode, 10-bit, 8 Fans	10	14	2	4	1	–
Firmware mode, 10-bit, 12 Fans	14	19	2	4	1	–
Firmware mode, 10-bit, 16 Fans	18	22	2	4	1	–
Hardware mode, 8-bit, 4 Fans	6	19	3	8	2	–
Hardware mode, 8-bit, 8 Fans	10	30	3	12	2	–
Hardware mode, 8-bit, 12 Fans	14	42	5	17	2	–
Hardware mode, 10-bit, 4 Fans	14	19	3	8	2	–
Hardware mode, 10-bit, 8 Fans	18	30	3	12	2	–

1. For the Hardware mode, resources used by the Damping Factor feature are not included.

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[2]	PSoC 3 (Keil_PK51)		PSoC 5 (GCC)	
	Flash Bytes	SRAM Bytes	Flash Bytes	SRAM Bytes
Firmware mode, 8-bit, 4 Fans	1279	87	856	106
Firmware mode, 8-bit, 8 Fans	1279	171	840	206
Firmware mode, 8-bit, 12 Fans	1297	255	876	306
Firmware mode, 8-bit, 16 Fans	1296	339	884	406
Firmware mode, 10-bit, 4 Fans	1308	87	872	106
Firmware mode, 10-bit, 8 Fans	1308	171	856	206
Firmware mode, 10-bit, 12 Fans	1324	255	888	306
Firmware mode, 10-bit, 16 Fans	1325	339	896	406
Hardware mode, 8-bit, 4 Fans	2013	129	1384	163
Hardware mode, 8-bit, 8 Fans	2014	253	1384	319
Hardware mode, 8-bit, 12 Fans	2036	377	1428	475
Hardware mode, 10-bit, 4 Fans	2030	129	1396	163
Hardware mode, 10-bit, 8 Fans	2031	253	1392	319

2. For the Hardware mode, resources used by the Damping Factor feature are not included.

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.

DC Characteristics (PWM clock – 6MHz)

Parameter	Description	Min	Typ[3]	Max	Unit
Idd	Component current consumption(Firmware mode, 4 Fans)				
	8-bit resolution	–	108	–	µA
	10-bit resolution	–	139	–	µA
	Component current consumption(Firmware mode, 8 Fans)				
	8-bit resolution	–	194	–	µA
	10-bit resolution	–	260	–	µA
	Component current consumption(Firmware mode, 12 Fans)				
	8-bit resolution	–	307	–	µA
	10-bit resolution	–	395	–	µA
	Component current consumption(Firmware mode, 16 Fans)				
	8-bit resolution	–	392	–	µA
	10-bit resolution	–	505	–	µA
	Component current consumption(Hardware mode, 4 Fans)				
	8-bit resolution	–	225	–	µA
	10-bit resolution	–	269	–	µA
	Component current consumption(Hardware mode, 8 Fans)				
	8-bit resolution	–	417	–	µA
	10-bit resolution	–	518	–	µA
	Component current consumption(Hardware mode, 12 Fans)				
	8-bit resolution	–	636	–	µA

3. Device IO and clock distribution current not included. Other factors such as routing conditions, frequency of tach inputs and temperature also have an impact on the current consumption. The values are at 25 °C.

DC Characteristics (PWM clock – 12MHz)

Parameter	Description	Min	Typ	Max	Unit
Idd	Component current consumption(Firmware mode, 4 Fans)				
	8-bit resolution	–	169	–	µA
	10-bit resolution	–	233	–	µA
	Component current consumption(Firmware mode, 8 Fans)				
	8-bit resolution	–	310	–	µA
	10-bit resolution	–	439	–	µA
	Component current consumption(Firmware mode, 12 Fans)				
	8-bit resolution	–	498	–	µA
	10-bit resolution	–	677	–	µA
	Component current consumption(Firmware mode, 16 Fans)				
	8-bit resolution	–	641	–	µA
	10-bit resolution	–	871	–	µA
	Component current consumption(Hardware mode, 4 Fans)				
	8-bit resolution	–	403	–	µA
	10-bit resolution	–	492	–	µA
	Component current consumption(Hardware mode, 8 Fans)				
	8-bit resolution	–	756	–	µA
	10-bit resolution	–	951	–	µA
	Component current consumption(Hardware mode, 12 Fans)				
	8-bit resolution	–	1162	–	µA

DC Characteristics (PWM clock – 24MHz)

Parameter	Description	Min	Typ	Max	Unit
Idd	Component current consumption(Firmware mode, 4 Fans)				
	8-bit resolution	–	290	–	µA
	10-bit resolution	–	417	–	µA
	Component current consumption(Firmware mode, 8 Fans)				
	8-bit resolution	–	545	–	µA
	10-bit resolution	–	798	–	µA
	Component current consumption(Firmware mode, 12 Fans)				
	8-bit resolution	–	887	–	µA
	10-bit resolution	–	1243	–	µA
	Component current consumption(Firmware mode, 16 Fans)				
	8-bit resolution	–	1150	–	µA
	10-bit resolution	–	1607	–	µA
	Component current consumption(Hardware mode, 4 Fans)				
	8-bit resolution	–	753	–	µA
	10-bit resolution	–	938	–	µA
	Component current consumption(Hardware mode, 8 Fans)				
	8-bit resolution	–	1446	–	µA
	10-bit resolution	–	1826	–	µA
	Component current consumption(Hardware mode, 12 Fans)				
	8-bit resolution	–	2220	–	µA

AC Specifications

Parameter	Description	Min	Typ	Max	Unit
f_{pwm_clk}	Input clock frequency[4]				
	Firmware mode, 8-bit, 4 Fans	–	–	54	MHz
	Firmware mode, 8-bit, 8 Fans	–	–	46	MHz
	Firmware mode, 8-bit, 12 Fans	–	–	39	MHz
	Firmware mode, 8-bit, 16 Fans	–	–	28	MHz
	Firmware mode, 10-bit, 4 Fans	–	–	42	MHz
	Firmware mode, 10-bit, 8 Fans	–	–	42	MHz
	Firmware mode, 10-bit, 12 Fans	–	–	41	MHz
	Firmware mode, 10-bit, 16 Fans	–	–	37	MHz
	Hardware mode, 8-bit, 4 Fans	–	–	57	MHz
	Hardware mode, 8-bit, 8 Fans	–	–	57	MHz
	Hardware mode, 8-bit, 12 Fans	–	–	40	MHz
	Hardware mode, 10-bit, 4 Fans	–	–	50	MHz
	Hardware mode, 10-bit, 8 Fans	–	–	47	MHz
f_{tach_clk}	Tachometer clock frequency	–	500	–	kHz
Tach Resolution	Tachometer counter resolution	–	16	–	Bits
f_{tach}	Tachometer Speed	500[5]	–	25000	RPM

4. The values provide a maximum safe operating PWM frequency for the Fans. The component may run at higher clock frequencies, at which point you will need to validate the timing requirements with Static Timing Analysis results.

5.Speed less than the minimum willbe interpreted as halted.

Component Changes

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

Version	Description of Changes	Reason for Changes / Impact
2.0	Added component characterization data.	
	Changed Damping Factor behavior.	In previous versions Damping Factor specified a delay between speed measurements of each fan and the value of delay wasn't specified in any units. In this version, Damping Factor specifies a delay between start-to-start of speed measurements of all fans. In addition, this delay is now specified in seconds.
	Added new parameter Initial RPM to every fan in the configuration.	This parameter specifies approximate speed of rotation of the specific fan at component start. In previous versions all fans were initialized with maximum speed.
	Added new feature of selecting the type of motors that are supported by the component.	This parameter specifies the number of high – low pulses per fan revolution. 2 high-low pulses for4 pole motors, 3 high-low pulses - 6 pole motors.
	Component symbol was extended with a functionality of adding external clock source to drive internal PWMs. This option is accessible in customizer's GUI.	New component feature. Allows connection to an external clock. Based on the value of the source clock and the resolution of PWMs in the configuration it is possible to regulate the PWM Output Frequency.
	Added new feature, that is selectable in the customizer's GUI and used to display components inputs and output as a bus.	Now the sets of tach1-tachN, fan1-fanN and bank1-bankN connections can be shown as buses. This allows space to be saved on the schematic as this option reduces the size of component symbol.
	AddedKeilfunctionreentrancysupporttothe APIs.	Add the capability for customers to specify any individual generated functions as reentrant.
	Removed obsolete function name - FanController_OverrideClosedLoop(), which was a simple #define of FanController_OverrideHardwareControl().	As this was marked obsolete in previous versions, it is removed in this version.
1.20	1. Updated for compatibility with PSoC Creator v2.0 2. Re-classified as "Concept" component 3. SetDesiredSpeed() API modified for improved accuracy	
1.10	1. SetDesiredSpeed() API corrected 2. Glitch filter added to tachometer inputs 3. Fan control terminology changed from Open/Closed loop to Firmware/Hardware control method 4. Symbol colors and size updated	

Version	Description of Changes	Reason for Changes / Impact
	5. Resource utilization updated (reduced) 6. References to power management APIs removed (not supported)	
1.0	First release	

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