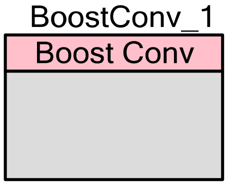
Boost Converter (BoostConv)

1.50

Features



- Produces a selectable output voltage that is higher than the input voltage
- Input voltage range between 0.5 V and 5.5 V
- Boosted output voltage range between 1.8 V and 5.25 V
- Source up to 50 mA depending on the selected input and output voltage parameter values
- Two modes of operation: Active and Standby
- Boost standby mode operation with autothump is not supported on PSoC3 ES2 and PSoC5 ES1. Only Boost active mode operation is supported on these devices.

General Description

The Boost Converter (BoostConv) component provides the ability to configure and control the PSoC boost converter hardware block. The boost converter enables input voltages that are lower than the desired system voltage to be boosted to the desired system voltage level. The converter uses an external inductor to convert the input voltage to the desired output voltage.

The BoostConv component is enabled by default with a selected output voltage of 3.3 V. The BoostConv component parameters can be adjusted at run time through APIs. The configuration specified in the component customizer will be the default configuration.

The boost converter has two main operating modes:

- **Active –** Active mode is the normal mode of operation where the boost regulator actively generates a regulated output voltage.
- **Standby –**Standby mode is a low power mode of operation.

When to use the Boost Component

The BoostConv component should be used when the available voltage source for a system is less than the required voltage level to operate the system. The BoostConv component accepts a battery or other input voltage and produces a higher output voltage

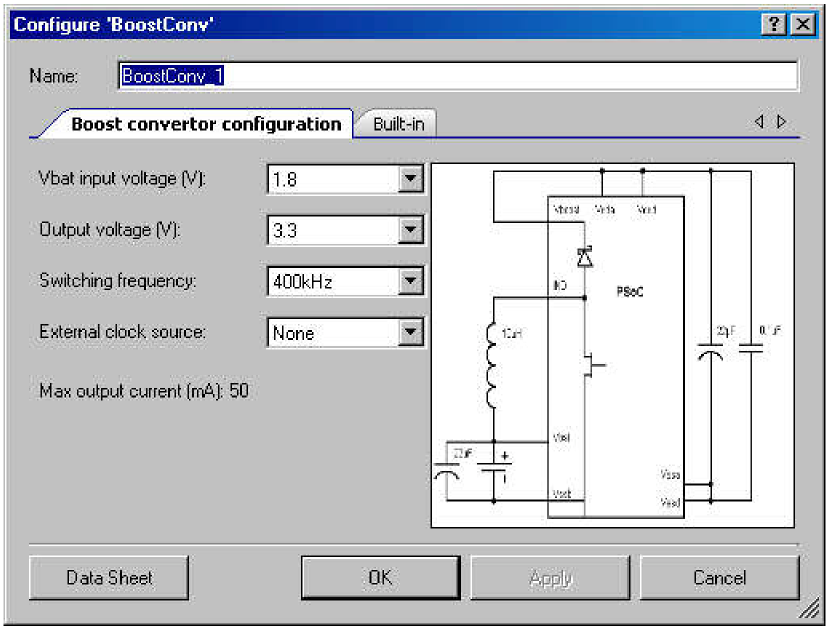
As an example, the system may use a 0.5 V solar cell as the primary power source and rely on the boost block to power the 1.8 V PSoC core. In another application, a 3.3 V system could use the BoostConv component to power a 5.0 V LCD glass.

Input/Output Connections

The BoostConv component requires no connections in the project schematic view. Fixed function pins support the boost converter block circuit. The system circuit must provide connections for the input voltage (Vbat), output voltage (Vout), inductor pin (Ind) and battery ground (Vssb). Refer to the schematic representation shown in the Functional Description section.

Component Parameters

Drag a BoostConv component onto your design and double-click it to open the Configure dialog.



Configure 'BoostConv'

Name: BoostConv_1

Boost convertor configuration | Built-in

Vbat input voltage (V): 1.8

Output voltage (V): 3.3

Switching frequency: 400kHz

External clock source: None

Max output current (mA): 50

Vbat Input Voltage

This is the Vbat or other voltage source that will be used as the input voltage to the boost converter block. This system circuit will connect this voltage to the Vbat PSoC pin. The input voltage can be between 0.5 V and 5.5 V. This value is used to calculate the estimated maximum output current. The default value is 1.8 V.

Output Voltage

This is the target output voltage that the boost converter block will maintain. Use the pull-down menu to select the desired output voltage. Output voltage levels are provided in 0.1 V increments from 1.8 V to 3.6 V and in 0.25 volt increments from 4.00 V to 5.25 V. The default value is 3.3 V.

An external Schottky diode is required for output voltages above 3.6 V.

The output voltage value can be modified at run time via the BoostConv_SelVoltage() function.

Switching frequency

This is the switching frequency at which the boost converter block will operate. This value is an enumerated type and can be set to any of the following frequencies:

- 100 kHz
- 400 kHz
- 2 MHz
- External 32 kHz

The 100 kHz, 400 kHz, and 2 MHz switching frequencies are generated using an oscillator internal to the boost converter block. The External 32 kHz switching frequency is intended for Standby mode automatic thump regulation.

External clock source

The External 32 KHz to the Boost frequency is the source of the switching signal when the boost converter block is configured to use an external clock. This value can be set to any of the following frequencies:

- None
- ECO 32kHz
- ILO 32kHz

Note The external 32 kHz clock (ECO or ILO) selection is only supported in ES3 silicon. Select "None" for PSoC 3 ES2 or PSoC 5 ES1 silicon.

Max output current

This is an estimate of the maximum output current available from the boost converter block based on the specified Vbat and Output Voltage values. This is a read-only value.

Placement

The BoostConv component uses the dedicated boost converter hardware block in the silicon. No placement options are available.

Resources

Resources	Digital Blocks					API Memory (Bytes)		Pins (per External I/O)
	Datapaths	Macro cells	Status Registers	Control Registers	Counter7	Flash	RAM	
BoostConv fixed HW *	N/A	N/A	N/A	N/A	N/A	450	2	N/A

* The BoostConv component utilizes the dedicated boost converter hardware block in the silicon.

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 "BoostConv_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 "BoostConv".

Function	Description
BoostConv_Start	Starts the BoostConv component and puts the boost block into Active mode.
BoostConv_Stop	Disables the BoostConv component. Turns off power to the boost converter circuitry.
BoostConv_EnableInt	Enables the boost block Under-Voltage interrupt generation.
BoostConv_DisableInt	Disables the boost block Under-Voltage interrupt generation.
BoostConv_SetMode	Sets the boost converter mode to Active or Standby.
BoostConv_SelVoltage	Selects the target output voltage the boost converter will maintain.
BoostConv_SelFreq	Sets the switching frequency to one of four possible values: 100 kHz, 400 kHz, and 2 MHz (generated internal to the boost converter block) or 32 kHz (sourced external to the boost converter block from the chip ECO-32 kHz oscillator).
BoostConv_EnableAutoThump	Enables automatic thump mode (only available when the boost block is in Standby mode and the switching frequency is set to 32 kHz)
BoostConv_DisableAutoThump	Disables automatic thump mode
BoostConv_ManualThump	Forces a single pulse of the boost converter switch transistors.
BoostConv_ReadStatus	Returns the boost block status register.

Function	Description
BoostConv_SelExtClk	Sets the source of 32 kHz frequency: the 32 kHz ECO or 32 kHz ILO.
BoostConv_ReadIntStatus	Returns the contents of the boost block interrupt status register.
BoostConv_Init	Initializes BoostConv registers with initial values provided from customizer.
BoostConv_Enable	This function enables the boost block (only valid when in Active mode). Component is enabled by default.
BoostConv_Disable	Disables the boost block.

Global Variables

Function	Description
BoostConv_initVar	Indicates whether the Boost Converter has been initialized. The variable is initialized to 0 and set to 1 the first time BoostConv_Start() is called. This allows the component to restart without reinitialization after the first call to the BoostConv_Start() routine. If reinitialization of the component is required, then the BoostConv_Init() function can be called before the BoostConv_Start() or BoostConv_Enable() function.

void BoostConv_Start(void)

Description: Starts the BoostConv component and puts the boost block into Active mode. The component is in this state when the chip powers up. This is the preferred method to begin component operation. BoostConv_Start() sets the initVar variable, calls the BoostConv_Init() function, and then calls the BoostConv_Enable() function.

Parameters: None

Return Value: None

Side Effects: If the initVar variable is already set, this function only calls the BoostConv_Enable() function.

void BoostConv_Stop(void)

Description: Disables the BoostConv component. Turns off power to the boost converter circuitry.

Parameters: None

Return Value: None

Side Effects: None

void BoostConv_SetMode (uint8 mode)

Description: This function sets the boost converter mode: Active or Standby.

Parameters: (uint8) mode – sets the operational mode for the boost block:

Mode	Notes
BoostConv_BOOSTMODE_ ACTIVE	In the active mode the boost block maintains the selected output voltage.
BoostConv_BOOSTMODE_STANDBY	Low power state, only bandgap and comparator circuitry is active. Automatic Thump mode is used with the external 32 kHz clock to regulate output voltage

Return Value: None

Side Effects: For Standby mode, this function enables automatic thump mode and sets the switching frequency clock source to the 32 kHz external clock.

void BoostConv_SelVoltage (uint8 voltage)

Description: This function selects the target output voltage the boost converter will maintain.

Parameters: (uint8) voltage – target output voltage for the boost converter block. Output voltages above 3.6 V require an external Schottky diode

Power Setting	Value	Notes
BoostConv_VOUT_OFF	0x00	Off - High-Z
BoostConv_VOUT_1_8V	0x03	1.8 V
BoostConv_VOUT_1_9V	0x04	1.9 V
BoostConv_VOUT_2_0V	0x05	2.0 V
BoostConv_VOUT_2_1V	0x06	2.1 V
BoostConv_VOUT_2_2V	0x07	2.2 V
BoostConv_VOUT_2_3V	0x08	2.3 V
BoostConv_VOUT_2_4V	0x09	2.4 V
BoostConv_VOUT_2_5V	0x0A	2.5 V
BoostConv_VOUT_2_6V	0x0B	2.6 V
BoostConv_VOUT_2_7V	0x0C	2.7 V
BoostConv_VOUT_2_8V	0x0D	2.8 V
BoostConv_VOUT_2_9V	0x0E	2.9 V
BoostConv_VOUT_3_0V	0x0F	3.0 V
BoostConv_VOUT_3_1V	0x10	3.1 V
BoostConv_VOUT_3_2V	0x11	3.2 V
BoostConv_VOUT_3_3V	0x12	3.3 V
BoostConv_VOUT_3_4V	0x13	3.4 V
BoostConv_VOUT_3_5V	0x14	3.5 V
BoostConv_VOUT_3_6V	0x15	3.6 V
BoostConv_VOUT_4_0V	0x16	4.00 V (external Schottky diode required)
BoostConv_VOUT_4_25V	0x17	4.25 V (external Schottky diode required)
BoostConv_VOUT_4_5V	0x18	4.50 V (external Schottky diode required)
BoostConv_VOUT_4_75V	0x19	4.75 V (external Schottky diode required)
BoostConv_VOUT_5_0V	0x1A	5.00 V (external Schottky diode required)
BoostConv_VOUT_5_25V	0x1B	5.25 V (external Schottky diode required)

Return Value: None

Side Effects: None

void BoostConv_SelFreq(uint8 frequency)

Description: This function sets the switching frequency to one of four possible values

Parameters: (uint8) switch_freq: desired switching frequency

Switch Frequency	Notes
BoostConv__SWITCH_FREQ_100KHZ	Generated internal to the Boost Converter block with a dedicated oscillator
BoostConv__SWITCH_FREQ_400KHZ	
BoostConv__SWITCH_FREQ_2MHZ	
BoostConv__SWITCH_FREQ_32KHZ	Comes from the ECO-32kHz or ILO-32kHz

Return Value: None

Side Effects: None

void BoostConv_SelExtClk(uint8 source)

Description: This function sets the source of 32 kHz frequency: the chips ECO-32 kHz or ILO-32 kHz.

Parameters: (uint8) source: source of 32 kHz frequency

Name	Description
BoostConv__EXTCLK_ECO	Set chip ECO-32 kHz as the source of 32 kHz frequency
BoostConv__EXTCLK_ILO	Set chip ILO-32 kHz as the source of 32 kHz frequency

Return Value: None

Side Effects: None

void BoostConv_EnableAutoThump(void)

Description: This function enables automatic thump mode. The AutoThump mode is available only when the boost block is in the Standby mode. The switching frequency clock source for the boost block must be set to the 32kHz external clock. In this mode standby boost operation is accomplished by generating a boost switch pulse on each edge of the switching clock when the output voltage is below the selected value.

Parameters: None

Return Value: None

Side Effects: None

void BoostConv_DisableAutoThump(void)

Description: This function disables automatic thump mode.

Parameters: None

Return Value: None

Side Effects: None

void BoostConv_ManualThump(void)

Description: This function forces a single pulse of the boost converter switch transistors.

Parameters: None

Return Value: None

Theory:

Side Effects: Thump produces one ~500ns pulse when set. This routine writes a ‘0’ followed by a ‘1’ to the bit 7 "thump" bit in the boost block BOOST_CR0 register

uint8 BoostConv_ReadStatus(void)

Description: This function returns the contents of the boost block status register

Parameters: None

Return Value: (uint8) boost block status register: BOOST_SR:

Bit	Name	Description
7	BoostConv_RDY	When set, internal circuits have been initialized
6	BoostConv_START	When set, converter is in startup mode
5	–	Reserved
4	BoostConv_OV	Output above overvoltage limit when 1, below limit when 0
3	BoostConv_VHI	Output is above vhigh limit when 1, below limit when 0
2	BoostConv_VNOM	Output is above nominal when 1, below nominal when 0
1	BoostConv_VLO	Output is above vlow limit when 1, below limit when 0
0	BoostConv_UV	Output is above undervoltage limit when 1, below limit when 0

Side Effects: None

void BoostConv_EnableInt(void)

Description: This function enables the boost block Output Under-Voltage interrupt generation.

Parameters: None

Return Value: None

Side Effects: None

void BoostConv_DisableInt(void)

Description: This function disables the boost block Output Under-Voltage interrupt generation.

Parameters: None

Return Value: None

Side Effects: None

void BoostConv_ReadIntStatus(void)

Description: This function returns the contents of the boost block interrupt status register.

Parameters: None

Return Value: (uint8) Boost interrupt status register BOOST_SR2 bit 0: When set, a Boost Output Undervoltage event has occurred.

Side Effects: None

void BoostConv_Init(void)

Description: Initializes or restores the component according to the customizer Configure dialog settings. It is not necessary to call BoostConv_Init() because the BoostConv_Start() API calls this function and is the preferred method to begin component operation.

Parameters: None

Return Value: None

Side Effects: All registers will be set to values according to the customizer Configure dialog.

void BoostConv_Enable(void)

Description: This function enables the boost block when in Active mode. The component is enabled by default. Activates the hardware and begins component operation. It is not necessary to call BoostConv_Enable() because the BoostConv_Start() API calls this function, which is the preferred method to begin component operation.

Parameters: None

Return Value: None

Side Effects: None

void BoostConv_Disable(void)

Description: This function disables the boost block.

Parameters: None

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.

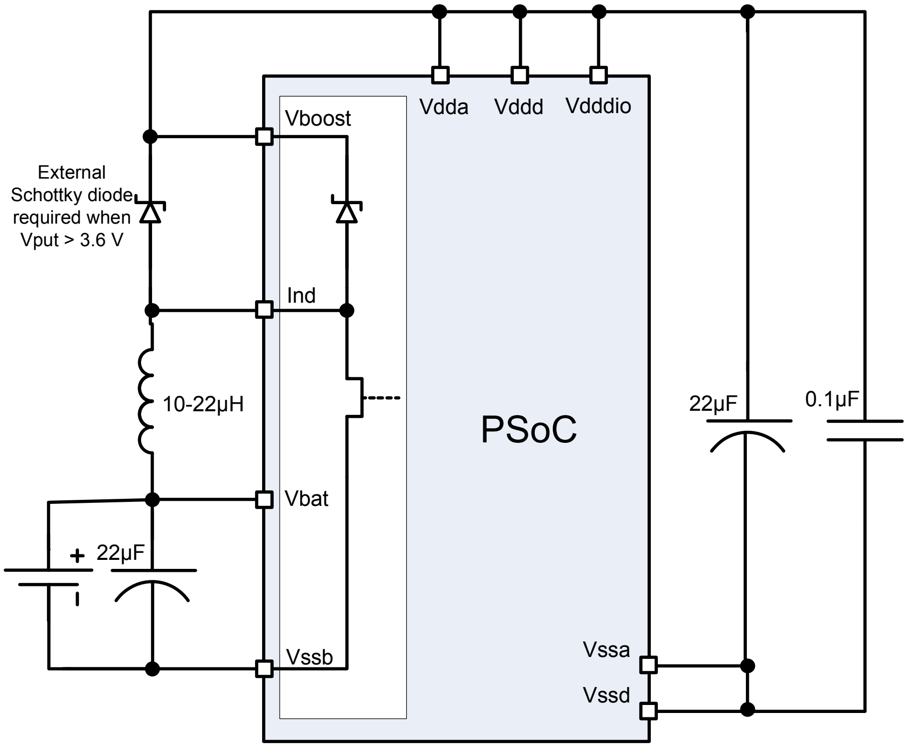
Refer to the "Find Example Project" topic in the PSoC Creator Help for more information.

Interrupt Service Routine

None

Functional Description

Figure 1. Application for Boost Converter

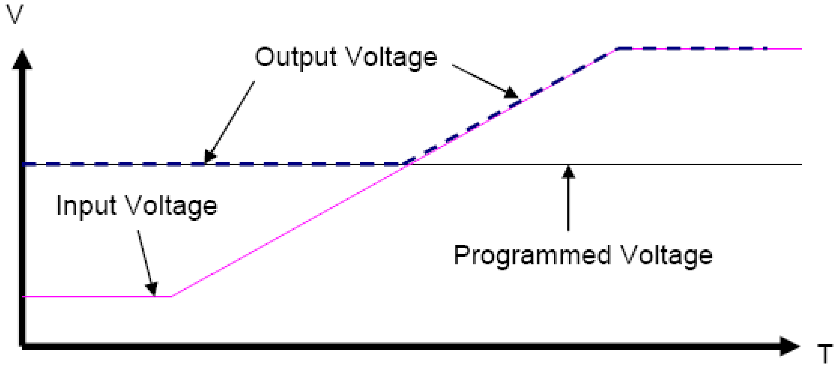


The boost block circuit is enabled by default to support scenarios in which startup of the processor will be powered by the Vboost voltage. The boost block is configured for Active mode with an output voltage of 1.8 V by default. When a BoostConv component is placed in a project, it provides access to the configuration registers for the boost hardware block. The BoostConv_Start() function configures the BoostConv component with the settings made in the component configuration dialog.

The boost converter hardware makes use of fixed function pins on the chip shown in the schematic above. These signals are not shown on the BoostConv component.

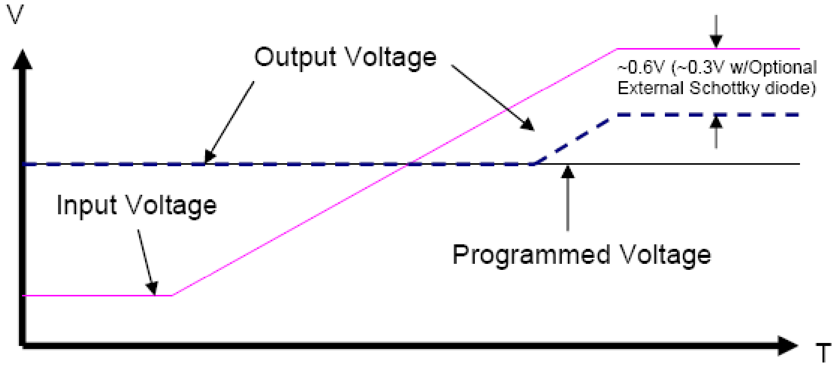
Operation with input voltage greater than programmed output voltage

When Control register 2 (BOOST_CR2): Bit 1 (eqoff) =1, the output voltage will track the input voltage when the input is greater than the programmed output voltage. This is shown below:



- Output Voltage = Programmed voltage when Input < Programmed
- Output Voltage = Input voltage when Input > Programmed

When Control register 2 (BOOST_CR2): Bit 1 (eqoff) = 1, the output voltage does not track until either the optional external schottky diode or inherent internal silicon diode between the inductor pin and output are forward biased. The effect of this is the output voltage tracks input with a diode drop as shown below:



- Output Voltage = Programmed voltage when Input < Programmed
- Output Voltage = Input voltage – diode drop when Input > Programmed + diode drop

DC and AC Electrical Characteristics

The following values indicate expected performance and are based on initial characterization data. Unless otherwise specified in the tables below, all T_A = 25°C, V_{dd} = 5.0 V

Inductive Boost Regulator DC Specifications

Parameter	Description	Conditions	Min	Typ	Max	Units
V_{bat}	Input voltage	Includes startup	0.5	–	5.5	V
I_{boost}	Load current [1, 2]	V_{IN} = 1.6 – 5.5 V, V_{out} = 1.6 – 5.0 V, external diode	–	–	50	mA
		V_{IN} = 1.6 – 3.6 V, V_{out} = 1.6 – 3.6 V, internal diode	–	–	75	mA
		V_{IN} = 0.8 – 1.6 V, V_{out} = 1.6 – 3.6 V, internal diode	–	–	30	mA
		V_{IN} = 0.8 – 1.6 V, V_{out} = 3.6 – 5.0 V, external diode	–	–	20	mA
		V_{IN} = 0.5 – 0.8 V, V_{out} = 1.6 – 3.6 V, internal diode	–	–	15	mA
L_{boost}	Boost inductor	10 µH specified	4.7	10	47	µH
C_{boost}	Filter capacitor [3]	22 µF || 0.1 µF specified	10	22	47	µF
I_f	External Schottky diode average forward current	External Schottky diode is required for V_{boost} > 3.6 V	1	–	–	A
V_r	External Schottky diode peak reverse voltage	External Schottky diode is required for V_{boost} > 3.6 V	20	–	–	V
I_{lpk}	Inductor peak current		–	–	700	mA
	Quiescent current	Boost active mode	–	200	–	µA
		Boost standby mode, 32 kHz external crystal oscillator, Iboost < 1 µA	–	12	–	µA
V_{boost}	Boost output voltage range [3, 4]					
	1.8 V		1.71	1.80	1.89	V
	1.9 V		1.81	1.90	2.00	V
	2.0 V		1.90	2.00	2.10	V

[1] For output voltages above 3.6 V, an external diode is required.

[2] Maximum output current applies for output voltages < 4x input voltage.

[3] Based on device characterization (Not production tested).

[4] At boost frequency of 2 MHz, Vboost is limited to 2 x Vbat. At 400 kHz, Vboost is limited to 4 x Vbat.

Parameter	Description	Conditions	Min	Typ	Max	Units
	2.4 V		2.28	2.40	2.52	V
	2.7 V		2.57	2.70	2.84	V
	3.0 V		2.85	3.00	3.15	V
	3.3 V		3.14	3.30	3.47	V
	3.6 V		3.42	3.60	3.78	V
	5.0 V	External diode required	4.75	5.00	5.25	V
	Load regulation		–	–	2.5	%
	Line regulation		–	–	3	%
	Efficiency	VBAT = 2.4 V, VOUT = 2.7 V, IOUT = 10 mA, Fsw = 400 kHz, Lboost = 22 uH, Cboost = 22 uF || 0.01 uF	82	90	–	%

Inductive Boost Regulator AC Specifications

Parameter	Description	Conditions	Min	Typ	Max	Units
V_{RIPPLE}	Ripple voltage (peak-to-peak)	V_{OUT} = 1.8 V, F_{SW} = 400 kHz, I_{OUT} = 10 mA	–	–	100	mV
F_{SW}	Switching frequency		–	0.1, 0.4, or 2	–	MHz
	Duty cycle		20	–	80	%

Component Changes

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

Version	Description of Changes	Reason for Changes / Impact
1.50.a	Added autothump support note to Features in datasheet	Silicon bug in PSoC3 ES2 and PSoC5 ES1
	Added information to the component that advertizes its compatibility with silicon revisions.	The tool reports an error/warning if the component is used on incompatible silicon. If this happens, update to a revision that supports your target device.
	Added characterization data to datasheet	
	Removed reference to sleep mode from datasheet	Component doesn't support sleep mode.
	Minor datasheet edits and updates	

1.50	Added support of PSoC3 ES3 silicon. Three API functions have been added:
	void BoostConv_EnableInt(void);
	void BoostConv_DisableInt(void);
	uint8 BoostConv_ReadIntStatus(void);
		Boost Converter supports generation of undervoltage signal.

	API function has been added: void BoostConv_SelExtClk(uint8);	To support selection of external switching clock sources of Boost Converter: ILO or ECO.
	Added BoostConv_Init() function.	To comply with corporate standard and provide an API to initialize/restore the component without starting it.

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