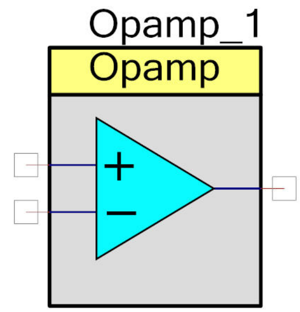
PSoC 4 Operational Amplifier (Opamp)

1.0



Features

- Follower or Opamp configuration
- Rail-to-rail inputs and output
- Output direct low resistance connection to pin
- 1mA or 10mA output current
- Internal connection for follower

General Description

The Opamp operates as an off-the-shelf operation amplifier. A direct connection is made between the Opamp output to a GPIO pin for a low output resistance. Two output current levels (1mA and 10mA) are provided to drive internal or external signals respectively. The 10mA may drive both internal (SAR component) and external signals. The user also has control of different overall power levels that provide a tradeoff between power and bandwidth.

Note External resistors are required to perform amplification.

When to Use the Opamp

The following is a list of common use cases for the Opamp component:

- Gain for SAR ADC
- High impedance buffer for SAR ADC
- General purpose signal amplifier
- Active filter

Input/Output Connections

This section describes the various input and output connections for the Opamp.

Positive Input–Analog Input

When the Opamp is configured as a follower, this I/O is the voltage input. If the Opamp is configured as an Opamp, this I/O acts as the standard Opamp noninverting input.

Negative Input– Analog Input*

When the Opamp component is configured for Opamp mode, this I/O is the normal inverting input. When the Opamp is configured in Follower mode, this I/O is hard-connected to the output and the I/O is unavailable.

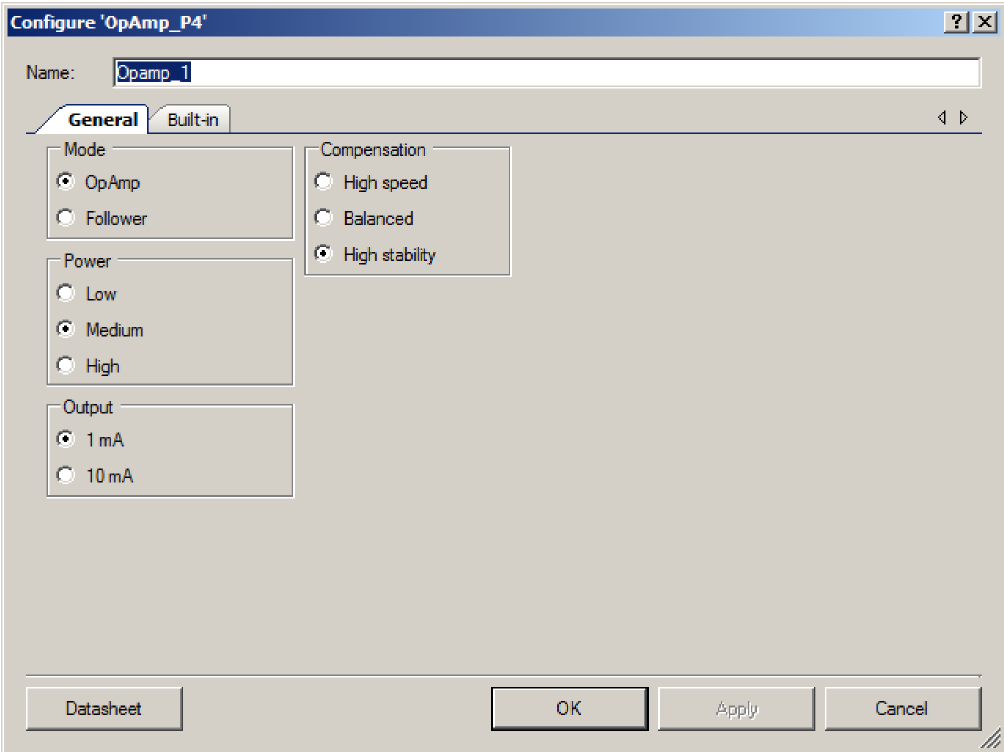
Vout– Analog output

The output can be directly connected to a pin and/or routed to an internal load using the analog routing fabric. The drive strength is selectable as either 10 mA or 1 mA. Connections to pins require the 10 mA setting. Internal connections can operate with either the 1 mA or 10 mA setting, but should normally be configured for 1 mA.

Component Parameters

Drag Opamp onto your design and double-click it to open the Configure dialog. Figure 1 shows the Configure dialog.

Figure 1.Configure Opamp Dialog



The Opamp provides the following parameters.

Mode

This parameter allows you to select between two configurations: **Opamp** and **Follower**. **Opamp** is the default configuration. In this mode, all three terminals are available for connection. In follower mode, the inverting input is internally connected to the output to create a voltage follower.

Power

The Opamp works over a wide range of operating currents. Higher operating current increases Opamp bandwidth. The **Power** parameter allows you to select the power level: High Power, Medium Power, and Low Power.

Output

Selects output mode: 1 mA – internal connections or 10 mA – connection to pin.

Compensation

The opamp offers three compensation settings: High Speed, Balanced and High Stability. This allows for reducing the compensation (hence increase bandwidth) when the Opamp's loop gain is reduced.

Placement

Each Opamp is directly connected to specific GPIOs along with being connected to the internal fabric. Output connection to a GPIO requires the use of the directly connected pin. Refer to the device datasheet for the part being used for the specific physical pin connections.

Resources

The Opamp uses one of the opamp (Constant Time Block – mini (CTBm)) blocks in PSoC 4. No other resources are required.

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 "Opamp_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 "Opamp"

Functions

Function	Description
Opamp_Init()	Initializes or restores the component according to the customizer Configure dialog settings.
Opamp_Enable()	Activates the hardware and begins component operation.
Opamp_Start()	Performs all of the required initialization for the component and enables power to the block.
Opamp_Stop()	Turns off the Opamp block.
Opamp_SetPower()	Sets the drive power to one of three settings; LOWPOWER, MEDPOWER, HIGHPOWER.
Opamp_PumpControl()	Turn the boost pump on or off.
Opamp_Sleep()	This is the preferred API to prepare the component for sleep.

Function	Description
Opamp_Wakeup()	This is the preferred API to restore the component to the state when Opamp_Sleep() was called.
Opamp_SaveConfig()	Saves the configuration of the component.
Opamp_RestoreConfig()	Restores the configuration of the component.

void Opamp_Init(void)

Description: Initializes or restores the component according to the customizer Configure dialog settings. It is not necessary to call Opamp_Init() because the Opamp_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 Opamp_Enable(void)

Description: Activates the hardware and begins component operation. It is not necessary to call Opamp_Enable() because the Opamp_Start() API calls this function, which is the preferred method to begin component operation.

Parameters: None

Return Value: None

Side Effects: None

void Opamp_Start(void)

Description: Performs all of the required initialization for the component and enables power to the block. The first time the routine is executed, the power level, Mode, and Output mode is set. When called to restart the Opamp following a Opamp_Stop() call, the current component parameter settings are retained.

Parameters: None

Return Value: None

Side Effects: None

void Opamp_Stop(void)

Description: Turn off the Opamp block.

Parameters: None

Return Value: None

Side Effects: Does not affect Opamp mode or power settings

void Opamp_SetPower(uint32 power)

Description: Sets the drive power to one of three settings; Opamp_LOWPOWER, Opamp_MEDPOWER, Opamp_HIGHPOWER.

Parameters: (uint32) power: Opamp_LOWPOWER, Opamp_MEDPOWER, Opamp_HIGHPOWER.

Return Value: None

void Opamp_PumpControl(uint32 onOff)

Description: Allows user to turn the Opamp's boost pump on or off. By Default the Opamp_Start() function turns on the pump. Use this command to turn it off.

Parameters: (uint32) onOff: Opamp_PUMPON will turn on the pump, Opamp_PUMPOFF will turn off the pump.

Return Value: None

Side Effects: Turning this pump off will reduce the opamp input range by 1.5 volts or (Vssa to (Vdda – 1.5 volts))

void Opamp_Sleep(void)

Description: This is the preferred API to prepare the component for sleep. The Opamp_Sleep() API saves the current component state. Then it calls the Opamp_Stop() function and calls Opamp_SaveConfig() to save the hardware configuration. Call the Opamp_Sleep() function before calling the CySysPmDeepSleep() or the CySysPmHibernate() functions.

Parameters: None

Return Value: None

Side Effects: None

void Opamp_Wakeup(void)

Description: This is the preferred API to restore the component to the state when Opamp_Sleep() was called. The Opamp_Wakeup() function calls the Opamp_RestoreConfig() function to restore the configuration. If the component was enabled before the Opamp_Sleep() function was called, the Opamp_Wakeup() function will also re-enable the component.

Parameters: None

Return Value: None

Side Effects: Calling the Opamp_Wakeup() function without first calling the Opamp_Sleep() or Opamp_SaveConfig() function may produce unexpected behavior.

void Opamp_SaveConfig(void)

Description: This function saves the component configuration and non-retention registers. This function is called by the Opamp_Sleep() function.

Parameters: None

Return Value: None

Side Effects: None

void Opamp_RestoreConfig(void)

Description: This function restores the component configuration and non-retention registers. This function is called by the Opamp_Wakeup() function.

Parameters: None

Return Value: None

Side Effects: None

MISRA Compliance

This section describes the MISRA-C:2004 compliance and deviations for the component. There are two types of deviations defined: project deviations – deviations that are applicable for all PSoC Creator components and specific deviations – deviations that are applicable only for this component. This section provides information on component specific deviations. The project deviations are described in the MISRA Compliance section of the *System Reference Guide* along with information on the MISRA compliance verification environment.

The Opamp component does not have any specific deviations.

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.

Functional Description

This component is a basic operational amplifier. You may configure power, output strength, and interconnect the Opamp to other components. Low resistive connections are made from the Opamp to three select pins to provide optimal performance.

Using of the Compensation option

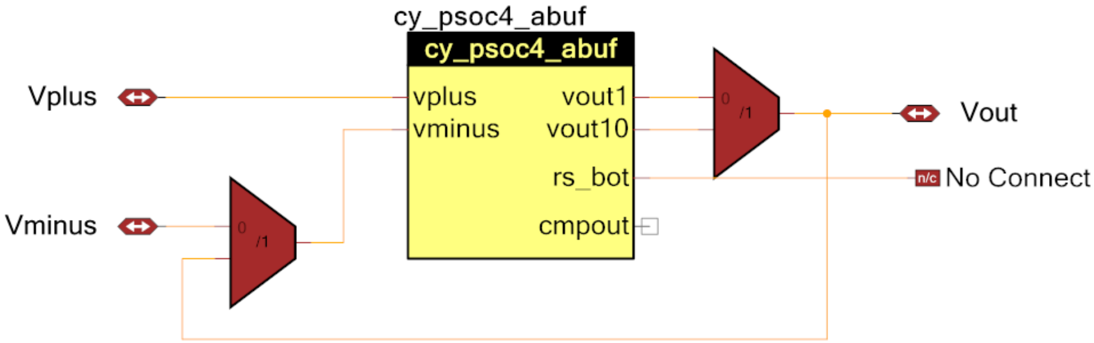
There are recommended settings for the Compensation option:

Loop Gain	Power Mode	Load Capacitance	
		50 pF	125 pF (max)
1-6	Low	Balanced	High Stability
	Medium	Balanced	High Stability
	High	Balanced	High Stability
7 or more	Low	High Speed	Balanced
	Medium	High Speed	Balanced
	High	High Speed	Balanced

These settings are applicable for 10 mA output, which is capable to drive a pin. 125 pF is the maximum load capacitance for this output. 50 pF is listed as a value “in the middle”.

Block Diagram and Configuration

Component uses cy_psoc4_abuf primitive.



Registers

See the chip Technical Reference Manual (TRM) for more information about registers.

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 4 (GCC)	
	Flash Bytes	SRAM Bytes
Default	252	12

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.

Opamp DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{DD}	Opamp Block current. No load.	–	–	–	–	
I_{DD_HI}	Power = high	–	1000	1300	µA	
I_{DD_MED}	Power = medium	–	320	500	µA	
I_{DD_LOW}	Power = low	–	250	350	µA	
I_{OUT_MAX}	V_{DDA} ≥ 2.7 V, 500 mV from rail	–	–	–	–	
$I_{OUT\_MAX\_HI}$	Power = high	10	–	–	mA	
$I_{OUT\_MAX\_MID}$	Power = medium	10	–	–	mA	
$I_{OUT\_MAX\_LO}$	Power = low	10	5	–	mA	
I_{OUT}	V_{DDA} = 1.71 V, 500 mV from rail	–	–	–	–	
$I_{OUT\_MAX\_HI}$	Power = high	4	–	–	mA	
$I_{OUT\_MAX\_MID}$	Power = medium	4	–	–	mA	
$I_{OUT\_MAX\_LO}$	Power = low	4	2	–	mA	
V_{IN}	Charge pump on, V_{DDA} ≥ 2.7 V	–0.05	–	VDDA – 0.2	V	
V_{CM}	Charge pump on, V_{DDA} ≥ 2.7 V	–0.05	–	VDDA – 0.2	V	
V_{OUT}	V_{DDA} ≥ 2.7 V	–	–	–		
V_{OUT_1}	Power = high, Iload=10 mA	0.5	–	VDDA – 0.5	V	
V_{OUT_2}	Power = high, Iload=1 mA	0.2	–	VDDA – 0.2	V	
V_{OUT_3}	Power = medium, Iload=1 mA	0.2	–	VDDA – 0.2	V	
V_{OUT_4}	Power = low, Iload=0.1mA	0.2	–	VDDA – 0.2	V	
V_{OS_TR}	Offset voltage, trimmed	1	±0.5	1	mV	High mode
V_{OS_TR}	Offset voltage, trimmed	–	±1	–	mV	Medium mode
V_{OS_TR}	Offset voltage, trimmed	–	±2	–	mV	Low mode
$V_{OS\_DR\_TR}$	Offset voltage drift, trimmed	–10	±3	10	µV/C	High mode
$V_{OS\_DR\_TR}$	Offset voltage drift, trimmed	–	±10	–	µV/C	Medium mode
$V_{OS\_DR\_TR}$	Offset voltage drift, trimmed	–	±10	–	µV/C	Low mode
CMRR	DC	70	80	–	dB	VDDD = 3.6 V
PSRR	At 1 kHz, 100 mV ripple	70	85	–	dB	VDDD = 3.6 V

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
Cload	Stable up to maximum load. Performance specs at 50 pF.	–	–	125	pF	

Opamp AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
GBW	Load = 20 pF, 0.1 mA. V_{DDA} = 2.7 V	–	–	–	–	
GBW_HI	Power = high	6	–	–	MHz	
GBW_MED	Power = medium	4	–	–	MHz	
GBW_LO	Power = low	2	–	–	MHz	
Noise		–	–	–	–	
V_{N1}	Input referred, 1 Hz - 1GHz, power = high	–	94	–	µVrms	
V_{N2}	Input referred, 1 kHz, power = high	–	72	–	nV/rtHz	
V_{N3}	Input referred, 10kHz, power = high	–	28	–	nV/rtHz	
V_{N4}	Input referred, 100kHz, power = high	–	15	–	nV/rtHz	
Cload	Stable up to maximum load. Performance specs at 50 pF.	–	–	125	pF	
Slew_rate	Cload = 50 pF, Power = High, $V_{DDA} \geq$ 2.7 V	6	–	–	V/µsec	
T_op_wake	From disable to enable, no external RC dominating	–	300	–	µSec	

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.a	Updated datasheet.	Corrected specs to match device datasheet.
1.0	First release	