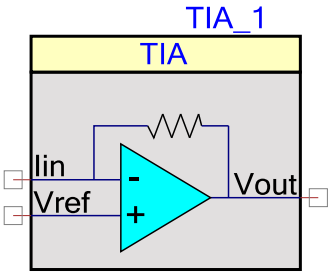
Trans-Impedance Amplifier (TIA)
0.5

Features

- Adjustable conversion gain
- Adjustable corner frequency
- Adjustable power settings
- Selectable input reference voltage



General Description

The Trans-Impedance Amplifier (TIA) component provides an OpAmp-based current to voltage conversion amplifier with resistive gain and capacitive feedback that you can set.

When to use a TIA

The TIA is used to convert an external current to a voltage. Typical applications include the measurement of a current input using a voltage measurement circuit or instrument, or creating current-controlled voltage sources.

Input/Output Connections

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

Iin – Analog

The Iin is the input signal terminal. The Iin is the sum of currents from the global inputs, which may include signals from a current output DAC.

Note This terminal name is `Iin` (capital `i`) **not** `lin` (lowercase `l`).

Vref – Analog

Vref is the input terminal for a reference signal. The reference may be an internal reference, internal VDAC value, or external signal.

Vout – Analog

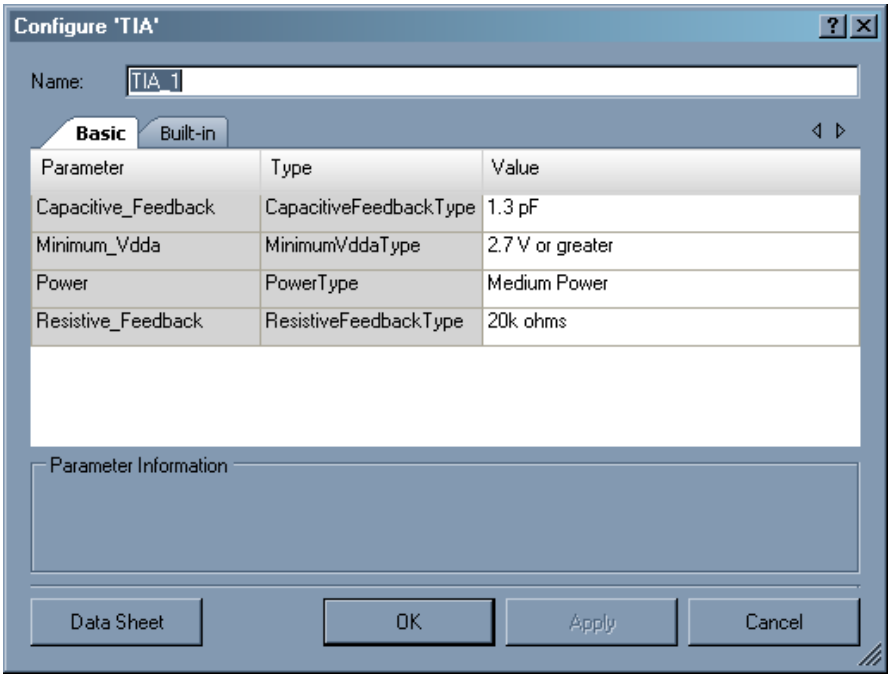
Vout is the output signal terminal. Vout is determined by the following equation, where Rfb is resistive feedback:

$$Vout = Vref - lin * Rfb$$ **Equation 1**

Parameters and Setup

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

Figure 1: Configure TIA Dialog



Resistive Feedback

This sets the nominal resistive feedback for the TIA. The resistive feedback may be selected from the following set of allowed values (in ohms): 20k (default), 30k, 40k, 80k, 120k, 250k, 500k, and 1000k.

Capacitive Feedback

This sets the capacitive feedback for the TIA. The capacitive feedback can be set to None (default), 1.3 pF, 3.4 pF, or 4.7 pF.

Power

This sets the initial drive power of the TIA. The power determines the speed with which the TIA reacts to changes in the input signal. There are four power settings; Low, Medium (default), Medium High and High. A Low Power setting results in the slowest response time and High Power to the fastest.

Minimum Vdda

This parameter is determined by the minimum analog supply voltage expected for the PSoC in the design. The parameter can be set to one of two values “2.7V or greater” (default) or “Less than 2.7V”.

For an analog supply voltage below 2.7V, the amplifier makes use of a boost circuit.

Placement

There are no placement specific options.

Resources

The TIA uses one SC/CT block.

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 "TIA_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 "TIA".

Function	Description
void TIA_Start(void)	Power up the TIA.
void TIA_Stop(void)	Power down the TIA.
void TIA_SetPower(uint8 power)	Set drive power to one of four levels.
void TIA_SetResFB(uint8 res_feedback)	Set the resistive feedback to one of 8 values.
void TIA_SetCapFB(uint8 cap_feedback)	Set the capacitive feedback to one of 4 values.

void TIA_Start(void)

Description: Performs all of the required initialization for the component and enables power to the amplifier. The first time the routine is executed, the resistive and capacitive feedback and amplifier power are set based on the values provided during the configuration. When called to restart the TIA following a TIA_Stop() call, the current component parameter settings are retained.

Parameters: None

Return Value: None

Side Effects: None

void TIA_Stop(void)

Description: Turn off the TIA block.

Parameters: None

Return Value: None

Side Effects: Does not affect power, resistive or capacitive feedback settings

void TIA_SetPower(uint8 power)

Description: Sets the drive power to one of four settings; low, medium, medium high or high.

Parameters: (uint8) power: See the following table for valid power settings.

Power Setting	Notes
TIA_LOWPOWER	Lowest active power and slowest reaction time.
TIA_MEDIUMPOWER	Medium power and speed.
TIA_MEDIUMHIGHPOWER	Medium high power and speed.
TIA_HIGHPOWER	Highest active power and fastest reaction time.

Return Value: None

Side Effects: None

(void) TIA_SetResFB(uint8 res_feedback)

Description: Set the amplifier resistive feedback value.

Parameters: uint8 res_feedback: See table below for valid resistive feedback settings.

Gain Setting	Notes
TIA_RES_FEEDBACK_20K	Feedback resistor = 20k
TIA_RES_FEEDBACK_30K	Feedback resistor = 30k
TIA_RES_FEEDBACK_40K	Feedback resistor = 40k
TIA_RES_FEEDBACK_80K	Feedback resistor = 80k
TIA_RES_FEEDBACK_120K	Feedback resistor = 120k
TIA_RES_FEEDBACK_250K	Feedback resistor = 250k
TIA_RES_FEEDBACK_500K	Feedback resistor = 500k
TIA_RES_FEEDBACK_1000K	Feedback resistor = 1000k

Return Value: None

Side Effects: None

(void) TIA_SetCapFB(uint8 cap_feedback)

Description: Set the amplifier capacitive feedback value.

Parameters: uint8 cap_feedback: See table below for valid capacitive feedback settings.

Gain Setting	Notes
TIA_CAP_FEEDBACK_NONE	No capacitive feedback
TIA_ CAP_FEEDBACK_1_3PF	Feedback capacitor = 1.3 pF
TIA_ CAP_FEEDBACK_3_4PF	Feedback capacitor = 3.4 pF
TIA_ CAP_FEEDBACK_4_7PF	Feedback capacitor = 4.7 pF

Return Value: None

Side Effects: None

Sample Firmware Source Code

The following is a C language example demonstrating the basic functionality of the TIA component. This example assumes the component has been placed in a design with the default name "TIA_1."

Note If you renamed your component you must also edit the example code as appropriate to match the component name you specified; otherwise, this example code will not work.

If the TIA component will be used with the parameter settings configured during the project design phase, only a call to the associated Start() routine is required to use this component.

```
#include <device.h>
#include <TIA_1.h>

void main()
{
    TIA_1_Start();
}
```

The remaining TIA component API routines can be used to change the component parameter settings at run time.

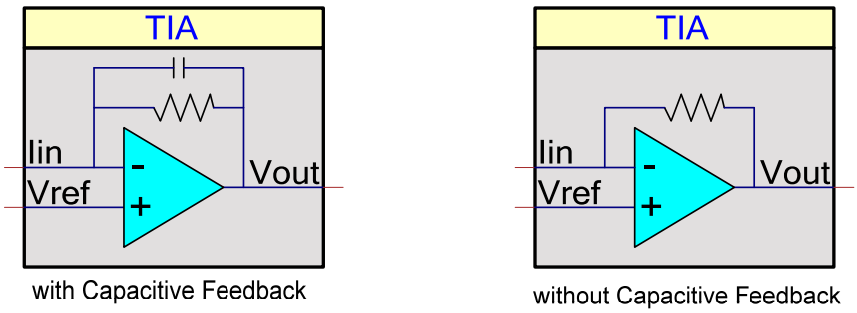
```
#include <device.h>
#include <TIA_1.h>

void main()
{
    TIA_1_Start();
    TIA_1_SetResFB(TIA_1_RES_FEEDBACK_250K);
    TIA_1_SetCapFB(TIA_1_CAP_FEEDBACK_4_7PF);
    TIA_1_SetPower(TIA_1_MEDIUMHIGHPOWER);
}
```

Functional Description

The TIA is constructed from a generic SC/CT block. The topology is an OpAmp with a selectable feedback resistor from the output to the inverting input. Optionally a selectable feedback capacitor can also be configured between the output and the inverting input. Reference Figure 2 for TIA configurations.

Figure 2: TIA Configurations

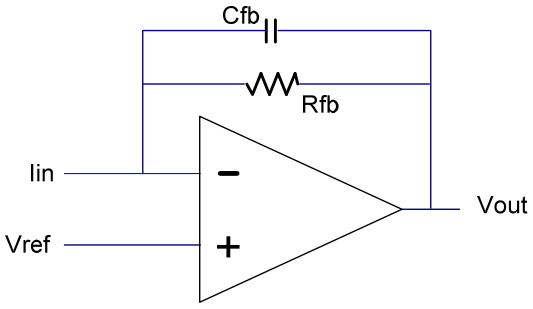


The output voltage is controlled by adjusting the Rfb feedback resistor. (See Figure 3). Rb may be set to one of 8 values, between 20K and 1000K ohms, selectable in either the parameter dialog or the using the SetResFB() API function.

The DC output level can be adjusted by adding current to the Iin terminal. Positive current (into the terminal) pushes the output negative; negative current (pulling current from the terminal) pushes the output positive. The source of the current may be an internal DAC.

The amplifier bandwidth is determined by the interaction between the feedback resistor Rfb and the selection of the capacitor in parallel with Rfb. The capacitive feedback value Cfb can be set to one of four values in either the parameter dialog or by using the SetCapFB() API function.

Figure 3: TIA Schematic



The -3 dB frequency for the amplifier is:

$$Freq - 3dB = 1/(2 * \pi * Rfb * Cfb$$ **Equation 2**

The following table shows the minimum capacitive feedback value that can be used with each power setting and still guarantee TIA circuit stability.

Minimum Capacitive Feedback values to guarantee stability

Power Setting	Minimum Capacitive Feedback	Units	Conditions and Notes
Low		pF	
Medium		pF	
Medium High		pF	
High		pF	

DC and AC Electrical Characteristics

The following values are indicative of expected performance and based on initial characterization data. Unless otherwise specified in the tables below, all T_A = 25°C, V_{dd} = 5.0V, Power HIGH, Op-Amp bias LOW, output referenced to 1.024V.

Note Characteristic data table will be updated following silicon characterization.

5.0V/3.3V DC Electrical Characteristics

Parameter	Typical	Min	Max	Units	Conditions and Notes
Resistive Feedback Deviation from Nominal					
20 kΩ	20	14	28	kΩ	
30 kΩ	30	21	42	kΩ	
40 kΩ	40	28	56	kΩ	
80 kΩ	80	56	112	kΩ	
120 kΩ	120	84	168	kΩ	
250 kΩ	250	175	350	kΩ	
500 kΩ	500	350	700	kΩ	
1000 kΩ	1000	700	1400	kΩ	
Input					
Input Offset Voltage		1.3	10	mV	
Input Voltage Range				V	

Parameter	Typical	Min	Max	Units	Conditions and Notes
Input Current (linear) Rfb = 20 kΩ			+/- 120	uA	Vdda = 5.0V Vref = Vdda/2 Linearity +/1 1%
Input Current (linear) Rfb = 1000 kΩ			+/- 2.5	uA	Vdda = 5.0V Vref = Vdda/2 Linearity +/1 1%
Operating Current					
Off		0	0.1	uA	Output tri-stated
Low Power		80	100	uA	
Medium Power					
Medium High Power					
High Power		400	500	uA	

5.0V/3.3V AC Electrical Characteristics

Parameter	Typical	Min	Max	Units	Conditions and Notes
AC Electrical Characteristics					
-3 dB Bandwidth					Power = HighPower 50 pF External Load
20 kΩ		1250	2000	kHz	
30 kΩ		1000	1500	kHz	
40 kΩ		800	1100	kHz	
80 kΩ		450	660	kHz	
120 kΩ		280	280	kHz	
250 kΩ		130	180	kHz	
500 kΩ		63	88	kHz	
1000 kΩ		31	42	kHz	
Slew Rate (20% to 80%)					
Low Power				V/uS	
Med Power				V/uS	

Parameter	Typical	Min	Max	Units	Conditions and Notes
MedHigh Power				V/uS	
High Power				V/uS	
Settling Time					
Low Power				uS	
Med Power				uS	
MedHigh Power				uS	
High Power				uS	
Noise					
Low Power				nV/√Hz	
Med Power				nV/√Hz	
MedHigh Power				nV/√Hz	
High Power				nV/√Hz	
CMRR	90	60			at 1.0 kHz, 1.0V headroom
PSRR		69		dB	at 100 kHz, 1.0V headroom

Note More specifications at other voltages and graphs will be added after characterization.