# CE204024 - PSoC® CY8C4Axx Programmable Gain Amplifier

## Objective

This example demonstrates how to use the adjustable gain feature of the programmable gain amplifier (PGA) Component in PSoC CY8C4Axx devices during runtime.

## Overview

The project adjusts the gain of the PGA in 3-dB steps from 0 to 30 dB. At each gain, the output of the PGA is measured with the analog-to-digital converter (ADC) and printed out to a terminal emulator with the universal asynchronous receiver transmitter (UART) Component.

## Requirements

**Tool:** PSoC Creator 4.1 or higher

**Programming Language:** C (GCC 4.9.0) or higher

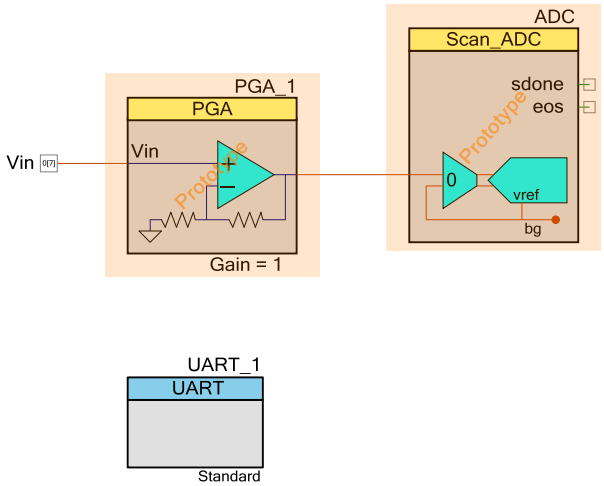
**Associated Parts:** All PSoC CY8C4Axx Analog Coprocessor devices

**Related Hardware:** CY8CKIT-048 PSoC Analog Coprocessor Pioneer Kit

## Design

This project demonstrates the use of a PGA Component in a circuit and how to change the gain during runtime in firmware. An external voltage is applied to the pin labeled “Vin” (P0[7]), which is the input to the PGA. The program slowly increases the PGA’s gain in 3-dB steps from a gain of 1, to a gain of 32, then starts over again at a gain of 1. At each gain step, the ADC will measure the output of the PGA. The ADC’s result and gain will be printed with a UART (UART_1) through P0[5]. The results are printed in the following format: “Gain = xx, yyy mVolts”, where ‘xx’ is the gain in dB and ‘yyy’ is the voltage in millivolts. Any common terminal emulator will be able to display the information.

Figure 1. Project Schematic




### Design Considerations

Because the gain of the PGA will go to 32 (30 dB), and the ADC’s range is 0 to 2.4 volts in this configuration, the maximum voltage that you can apply to Vin without saturating the ADC is about 74 mV (0.074 x 32 = ~2.4 volts). Any voltage between the power supply rails may be applied to Vin without damaging the PGA or the PSoC device.

## Hardware Setup

A power supply and a potentiometer can be used to supply a voltage to Vin (P0[7]). The result will stream out of the PSoC devices' UART TX signal through P0[5].

To see the output of the project, you will need to use a terminal emulator. There are several free emulators such as TeraTerm, Putty, or Hyperterm. The UART terminal settings are 9600 baud, 8 data bits, and 1 stop bit.

## Components

Table 1 lists the PSoC Creator Components used in this example, as well as the hardware resources used by each.

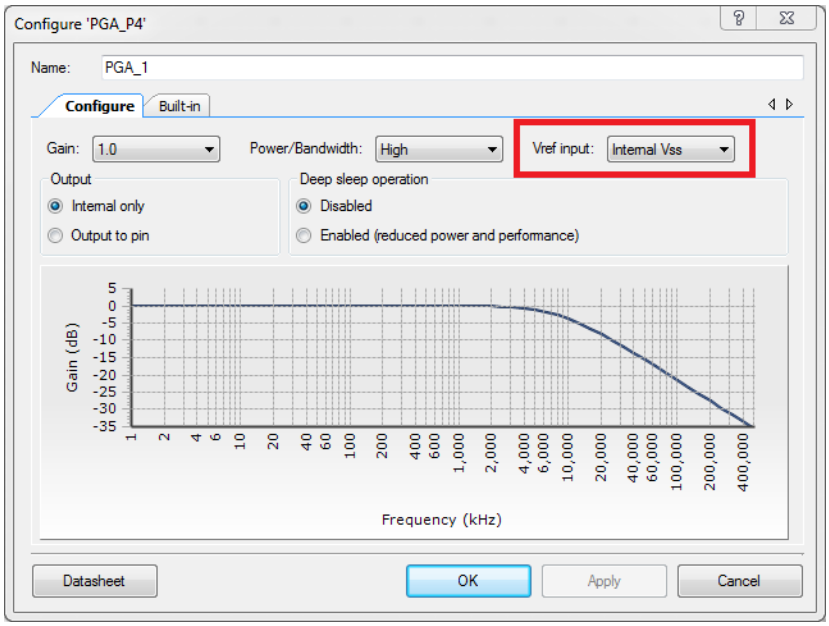
Table 1. List of PSoC Creator Components

| Component or User Module | Hardware Resources |
|---|---|
| PGA_1 | ½ CTB (Continuous Time Block) |
| ADC | Scan_ADC |
| UART_1 | Serial Communication Block (SCB) |
| Vin | General Purpose Input Output (GPIO ) P0[7] |
| UART_1:tx | GPIO (P0[5]) |

### Parameter Settings

There is only one change in the default PGA settings to make it work for this code example. The Vref input was changed from "External" to "Internal Vss". All other parameters were left as default as shown in Figure 2.

Figure 2. PGA User Interface



Several parameters were changed in the ADC's interface. Figure 3 highlights where each of these changes in the list below are made.

A. Sequenced channels set to '1'.

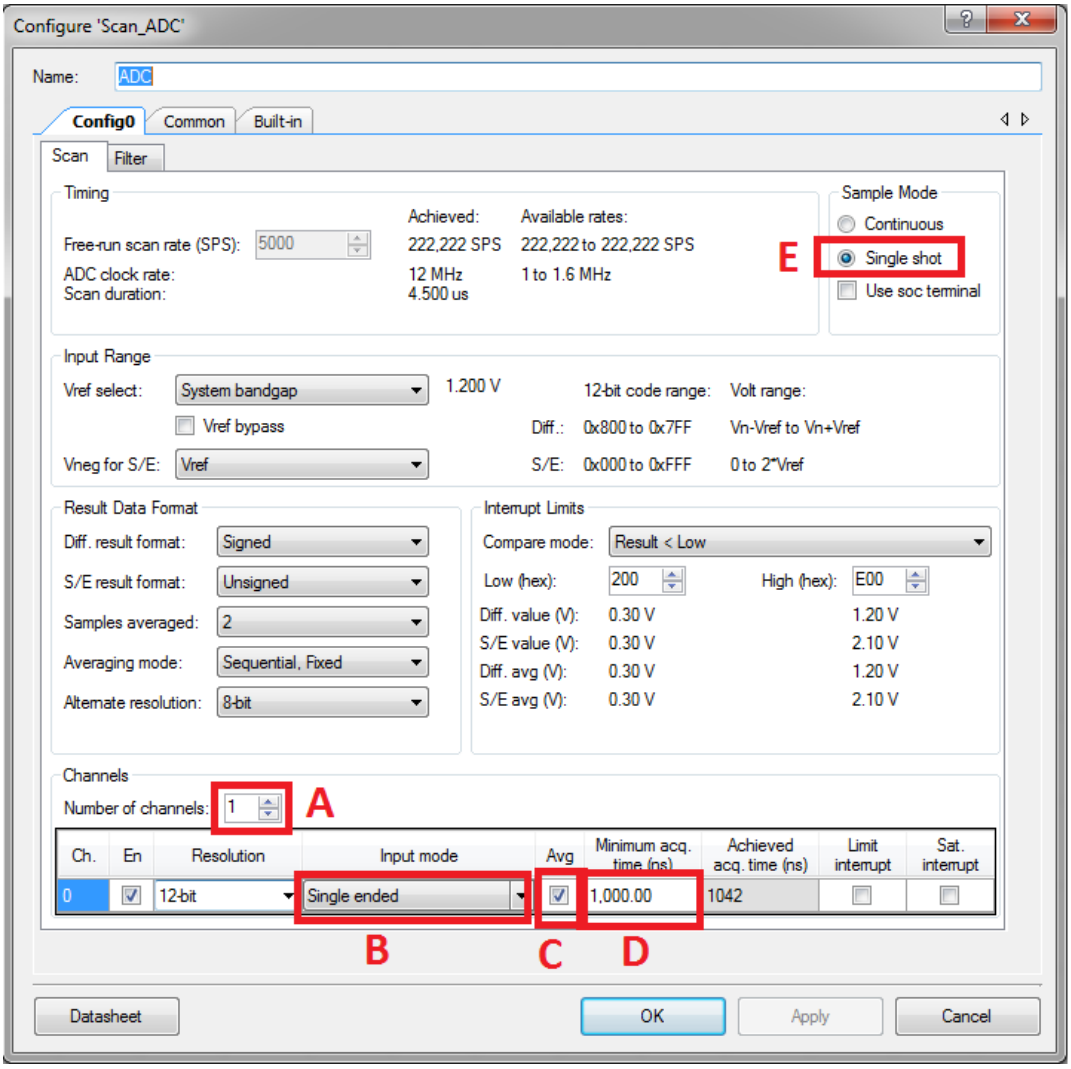
B. Changed Input mode to 'Single ended'.

C. Enabled averaging by selecting the check box.

D. Set the Minimum acquisition time to '1000'.

E. Changed Sample mode to 'Single shot, triggered'.

Figure 3. ADC User Interface

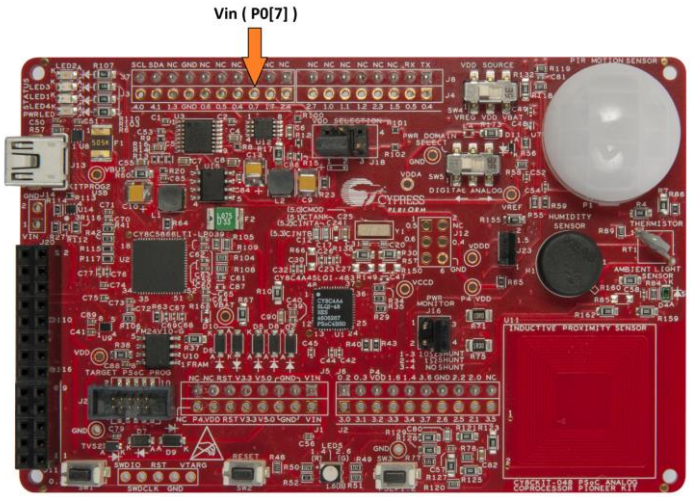


## Operation

To test the project, compile and program the PSoC device. Connect the test voltage to pin P0[7] as indicated in Figure 4. The input voltage should be between 0 and ~74 millivolts because the PGA will provide a gain between 1 and 32. An input voltage above ~74 mV will saturate the ADC because in this configuration, the maximum input to the ADC is 2.4 volts.

The CY8CKIT-048 development kit has a serial-to-USB converter built into the kit. Port P0[5] is connected directly to the RX input of the serial-to-USB converter, so no additional connection is required. Run a terminal emulator on your development PC and set it to 9600 baud, 8 data bits, and 1 parity bit. Select the COM port that is labeled “Cypress KitProg2 USB-UART” in the port selection of your terminal emulator settings. The ADC reading for each gain setting should be scrolling down the screen. Use a voltmeter to measure the input voltage and compare with the results on the terminal emulator. Remember that input voltages above ~74 mV will saturate the ADC with a gain of 32.

Figure 4. CY8CKIT-048




## Related Documents

Table 2 lists all relevant application notes, device datasheets, and Component datasheets.

Table 2. Related Documents

| | |
|---|---|
| Application Notes | |
| AN211293 | Getting Started with PSoC Analog Coprocessor |
| PSoC Creator Component Datasheets | |
| PGA | Programmable Gain Amplifier |
| ADC | PSoC 4 Scanning SAR ADC |
| Pins | General Purpose IO Pins |
| Device Documentation | |
| Cy8C4Axx Datasheet | PSoC Analog Coprocessor: CY8C4Axx Family Datasheet |
| Development Kit (DVK) Documentation | |
| CY8CKIT-048 PSoC Analog Coprocessor Pioneer Kit | |
| PSoC® Family Web Page | |
| PSoC Analog Coprocessor | |

## Document History

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Document Number: 002-04024

| Revision | ECN | Orig. of Change | Submission Date | Description of Change |
|---|---|---|---|---|
| ** | 5262424 | MEH | 05/06/2016 | New Code Example |
| *A | 5435468 | MEH | 09/28/2016 | Updated project with version 1.20 of Scan ADC.<br>Updated template |
| *B | 5723938 | MEH | 05/19/2017 | Changed ADC type from ADC_SAR_SEQ to Scan_ADC |

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