Cypress MicroSystems

Application Note AN2xxx

High-Reliability Analog Filter

Author: Melique Hoover, Joe McGee, Dimitrios Pantazis
Associated Project: No
Associated Part Family: CY8C27xxx
PSoC Designer Version: 4.00

Summary
The purpose of this project is to develop a high–reliability analog filter. Simply stated, when any part of the analog filter circuit fails, the system will be able to dynamically reconfigure itself to solve the error and function as it did before the error occurred through the use of redundant logic. This application is useful for situations where the hardware is not easily accessible, such as a deep space satellite.

Introduction
Many applications, such as space systems, need highly reliable components that can compensate for errors without human intervention. This proposal is for a high-reliability analog filter. This device will automatically compensate for faulty sub-components. The first step in compensation is error detection. The error detection circuitry will be built into the device. The next step is to compensate for any errors. Error compensation will be implemented automatically replacing subcomponents and rewiring the circuit. Finally there should be a method to alert monitor that there is an error. Error monitoring will be done with the error communication system. All of these features will be implemented using the Programmable System on Chip (PSoC).

Setup
The High-Reliability circuit (shown in Figure 1) is composed of two low pass bi-quad filters, an analog comparator and a digital-to-analog converter (ADC).

Both filters are connected to the same input, but only one filter output is available for use outside the chip. Internally, both filter outputs are connected to the comparator. The comparator, a differential amplifier with gain of one, connects directly to an ADC. The results from the ADC are used by the PSoC micro-controller to test if both filters are operating identically.
In the event of a filter failure the PSoC will change configurations. Each configuration uses the same setup, but occupies different analog blocks. This allows the filters to be moved to an undamaged area of the chip.

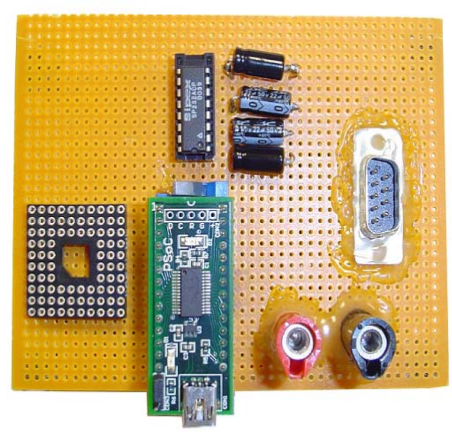

Figure 1

Also this design provides a PC interface using a UART and an external RS-232 chip. The PC interface allows the user to modify and monitor the high-reliability analog filter.

Comparator Circuit

The differential amplifier is made using one Generic switched capacitor block. This allows the two signals to be compared without latency, as it would be in the case with digital only comparison. The micro-controller is unable to process an analog input therefore this design requires an ADC.

The SAR6 (6 bit successive approximation register) is used to perform the analog-to-digital conversion. The SAR6 requires only one switched-capacitor analog block, which is less than any other ADC available in PSoC's library. Also the SAR6 has the highest sampling rate, which allows for a higher filter cut-off frequency. The 6-bit resolution provides more than enough accuracy for this application.

The results from the ADC are compared with zero since the filter outputs should be identical. In the case that the results differ it is assumed that some area in the PSoC is damaged.

Automatic Circuit Testing

The testing algorithm is invoked by a counter interrupt. The algorithm compares the SAR output of the current configuration, with zero, and changes the configuration if necessary. There are 3 predefined configurations. The program proceeds through these configurations in a specified order. After all of the configurations have been used, PSoC will remain in the final configuration until restarted.

Communication

The PC-interface, or communication circuit, provides the user a way to reconfigure the PSoC dynamically and check the status of the chip. The PC-interface is composed of:

- UART (PSoC module).
- RS-232 (external chip).
- DB-9 (serial port connector).

HyperTerminal or any other terminal program can be used to communicate with chip. Once connected the user will be prompted with a menu (shown in Figure 2). The menu options will guide the user through the necessary operations.

Applications

Hardware is always subject to faults. This increases the demands for more reliable and durable hardware. This is especially relevant in space, nuclear, avionic and biomedical industries. One example is the hardware used on a satellite. Since satellites in space are subjected to stress (heat, radiation, pressure), the hardware contained in them has an increased chance of becoming faulty. Since it is not practical to travel in space to fix every problem on a satellite, it is more useful have hardware that can self-test and self-repair itself. In addition, this allows the hardware to gain maximum usage of its hardware capabilities. It does not let a piece of hardware go to waste, which can ultimately save money. This is especially important when there is tight budget on projects as is the case in many NASA projects.

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Welcome to the High Reliability Filter, Environment
------------------------------------------------

C - Configure Filters
I - Induce an Error (On current Filter)
S - Print STATUS of PSoC
m - Print Menu again
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Type in a 'character', and press <ENTER>:
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Figure 2

List of Hardware

- PSoC CY8C27443.
- MAX232CPE.
- DB-9 (serial port connector).
- 4 22uF Capacitors.

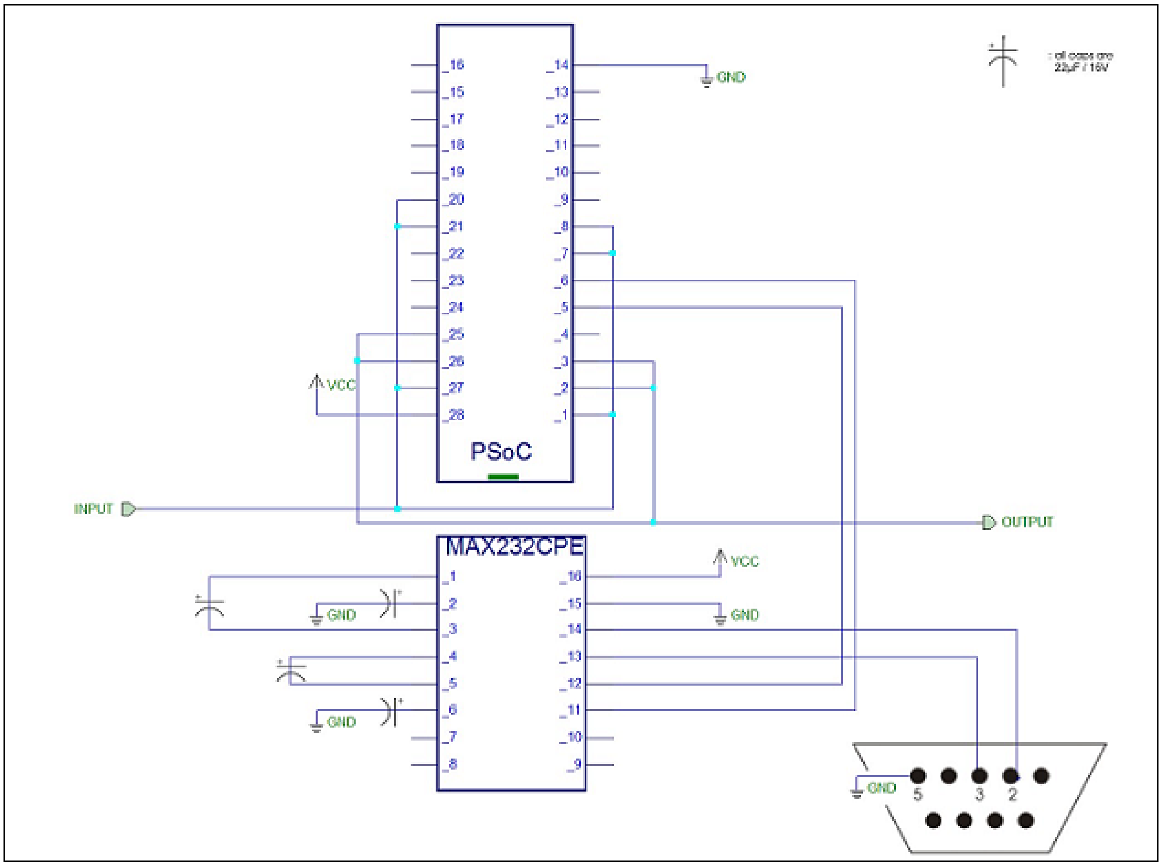

Figure 2

About the Author

Name: Melique Hoover, Joe McGee, Dimitrios Pantazis
Title: Student
Background: Electrical & Computer Engineering

Contact: jimpantazis@yahoo.com

Cypress MicroSystems, Inc.
2700 162nd Street SW, Building D
Lynnwood, WA 98037
Phone: 800.669.0557
Fax: 425.787.4641
http://www.cypress.com/ / http://www.cypress.com/aboutus/sales_locations.cfm / support@cypressmicro.com