

The logo features the word "anadigm" in a white, lowercase, sans-serif font. The letters "ana" are positioned on a dark blue rectangular background, while "digm" is on a white background. A thin dark blue border surrounds the entire text area.

anadigm

The FPAA Company
Field Programmable Analog Arrays
real time Analog programmability

Anadigm[®] FPAA Solutions Training

Class I

This is a smaller version of the Anadigm logo, consisting of the word "anadigm" in white lowercase letters on a dark blue background, with a small "TM" trademark symbol to the upper right.

anadigmTM

Take Control of Your Analog Destiny

- **Simplify Your Analog Design**
- **Gain the Flexibility to Adapt Your Design**
- **Add New Features and Capabilities to your Systems**
- **Improve the Manufacturability of Your Design**

Anadigm Technology Enables You

- **To shorten time to market by reducing analog design complexity**
 - Work at a higher level functional level instead of low level components
 - You can be testing analog hardware in a few days
- **To differentiate your products with dynamic re-configurability**
 - Design products that adapt to their environment (auto-ranging, auto-calibration, automatic gain control, etc)
 - Design products that change functionality sequentially over time (multiple operating modes)
 - Connect to multiple analog sensors and provide signal chains appropriate for each with one circuit.

Anadigm Technology Enables You (cont)

- **To future-proof designs**
 - Allows updates of analog functions in the field or on the production line
- **To attain cost savings in inventory control and field service**
 - Consolidation and standardization of board designs that can be utilized across multiple products
 - Reduce the cost and complexity of system calibration in production and in the field
- **To protect your IP of circuit designs.**
 - The configuration data cannot be reverse engineered back to the original circuit

Anadigm Technology Enables You (cont)

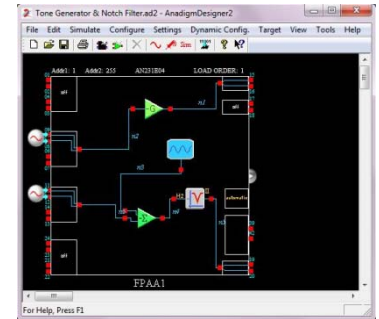
- **To implement high accuracy analog circuits in your products**
 - ❑ Achieves 0.1% functional accuracy
 - ❑ Chip to chip accuracy $\pm 0.1\%$
 - ❑ Drift free performance immune to process, temperature and aging

Software Control of Your Analog Design

- **Anadigm offers an advance in technology that is distinctive and valuable...**
- **The capability for pure analog signal processing under real-time software control**
 - In-circuit programmability with no interruption in system operation
 - Software control over Analog circuit parameters
 - Software control over Analog circuit configurations

How We're Making It Happen

- **Anadigm® combines three powerful design trends from the digital world into the analog domain**
 - EDA tools and design modules for complete analog design automation remove the complexity from analog design
 - Specialized architecture for external processor control to allow for in-circuit programmability and software control over analog circuit parameters
 - Reconfigurable CMOS silicon which allows instant creation of complex, high performance analog circuits





Development Tools

Anadigm Designer Overview

- **AnadigmDesigner® 2**
 - Easy-to-Use
 - Intuitive “drag-and-drop” user interface
 - Built-in signal generator, oscilloscope
 - Built-in, accurate discrete-time behavioral simulator
 - Extensive help documentation
 - Full version available free from Anadigm website (www.anadigm.com)
 - Supports the selection, configuration and interconnect of Configurable Analog Modules (CAM)

The screenshot displays the Anadigm Designer 2 software interface. The main window shows a circuit diagram titled "Tone Generator & Notch Filter.ad2" with components like AN231E04 and various signal paths. Below the circuit is an oscilloscope window titled "Tone generator and notch filter 2 - Oscilloscope" showing a signal waveform. A help window is open, displaying the transfer function for the circuit:

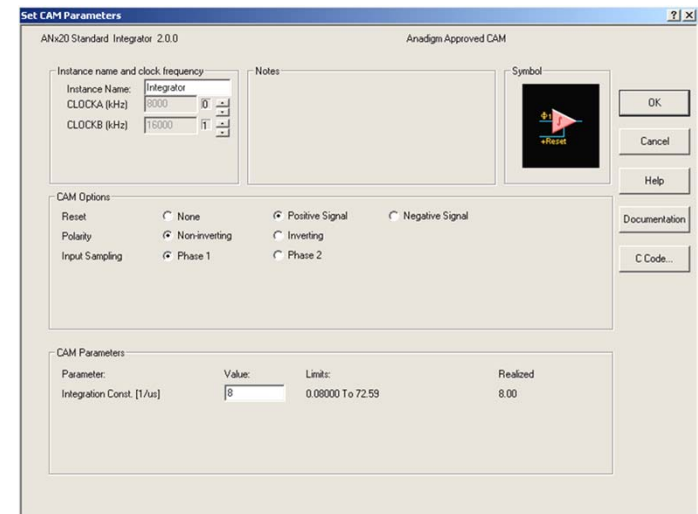
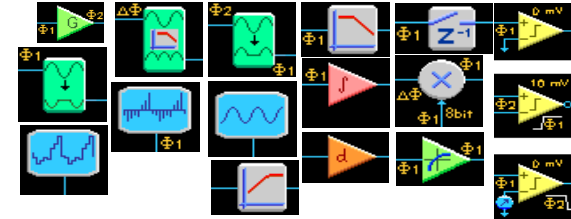
$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{2\pi f_c \frac{Q}{s}}{s^2 + \frac{2\pi f_c}{Q}s + 4\pi^2 f_c^2}$$

The help window also includes text explaining the parameters: G is the pass-band gain, f_c is the corner frequency, and Q is the quality factor. It also shows a circuit diagram for a band pass filter and the relation for capacitor values:

$$f_c = \frac{f_c}{2\pi} \sqrt{\frac{C_1 C_3}{C_2 C_4}}$$

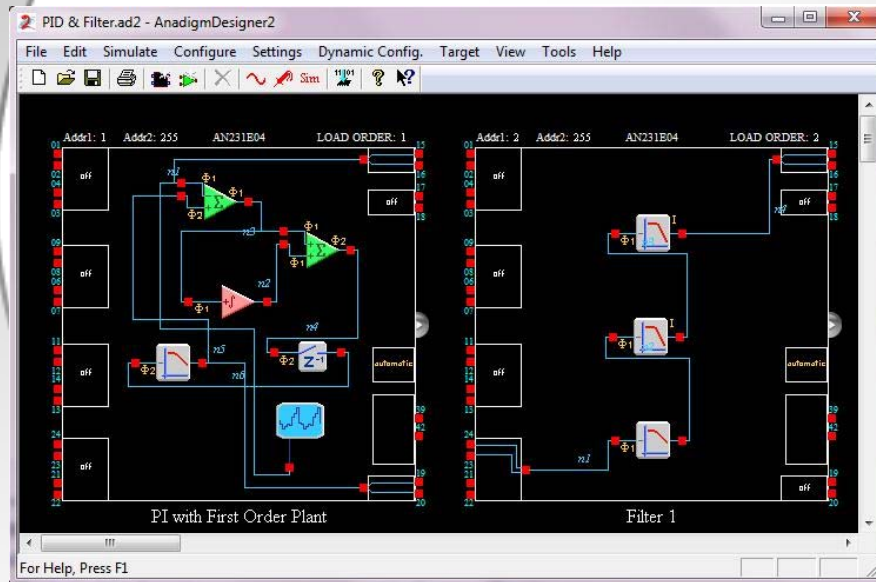
Configurable Analog Modules (CAM)

- **Circuit building blocks abstracted to a functional level**
- **Supports true design abstraction**
- **A complex circuit can be implemented simply by selecting, configuring, and wiring CAMs**
- **Each CAM has a user interface to set options and limits**
- **Each CAM has an accurate model for use in time-based simulator**



All CAM parameters are user definable and may be changed under software control with 0.1% functional accuracy

Typical CAM Options



- Differential Comparator
- Inverting Differentiator
- Divider
- Bilinear Filter
- Biquadratic Filter
- Half cycle gain stage
- Half Cycle Sum/Difference Stage
- DC Voltage Source
- Gain Stage with Output Voltage Limiting
- Gain Stage with Switchable Inputs

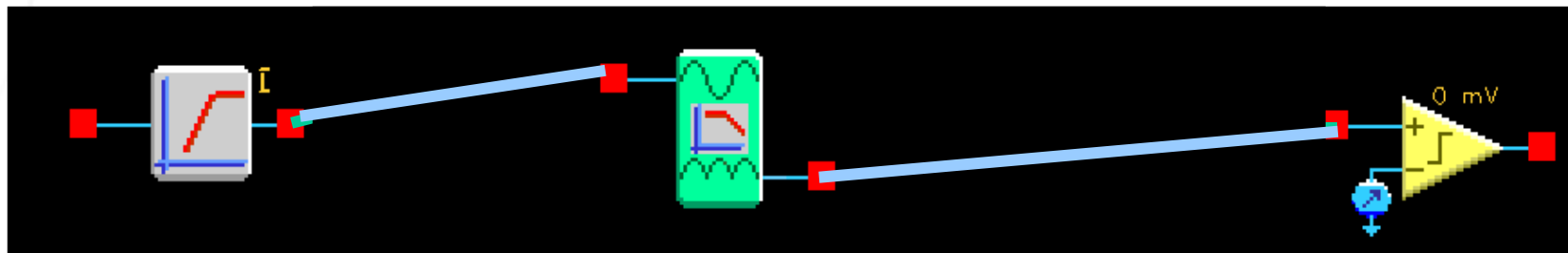
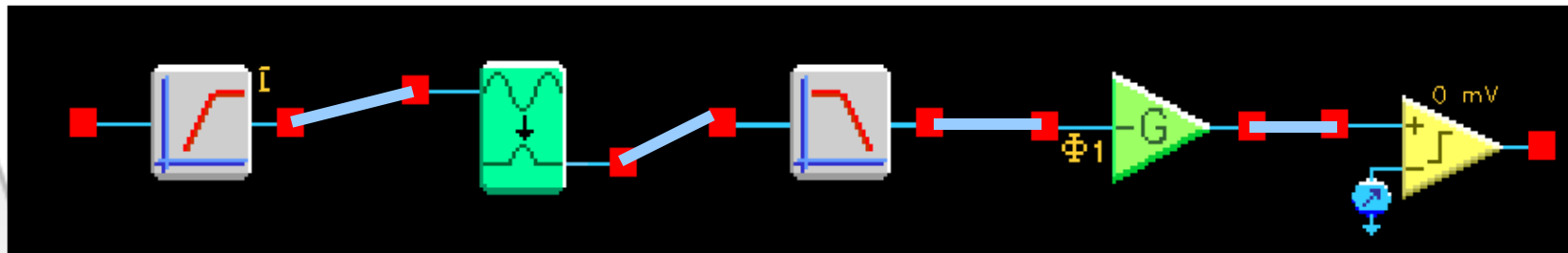
- Half Cycle Inverting Gain Stage (optional hold)
- Half Cycle Inverting Rectifier (optional hold)
- Half Cycle Rectifier
- Gain Stage with Polarity control
- Integrator
- Inverting Gain Stage
- Inverting Sum Stage
- Multiplier
- Rectifier with Low Pass Filter
- Sample and Hold
- Sinewave Oscillator
- Transimpedance Amplifier
- User-defined Voltage Transfer Function
- Arbitrary Periodic Waveform Generator
- Sum/Difference Stage with Low Pass filter
- Analog to Digital Converter (SAR)
- Voltage-controlled Variable Gain Stage
- Low Corner Frequency Bilinear Low-Pass Filter
- Sum/Difference Integrator
- Square Root

Customer CAMs

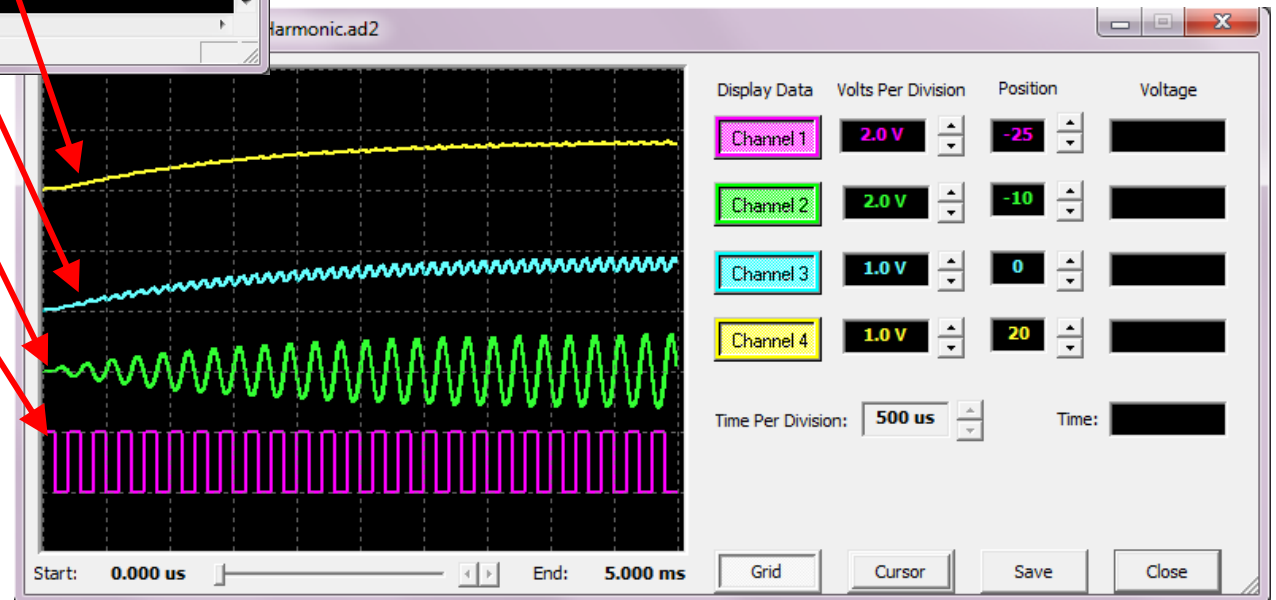
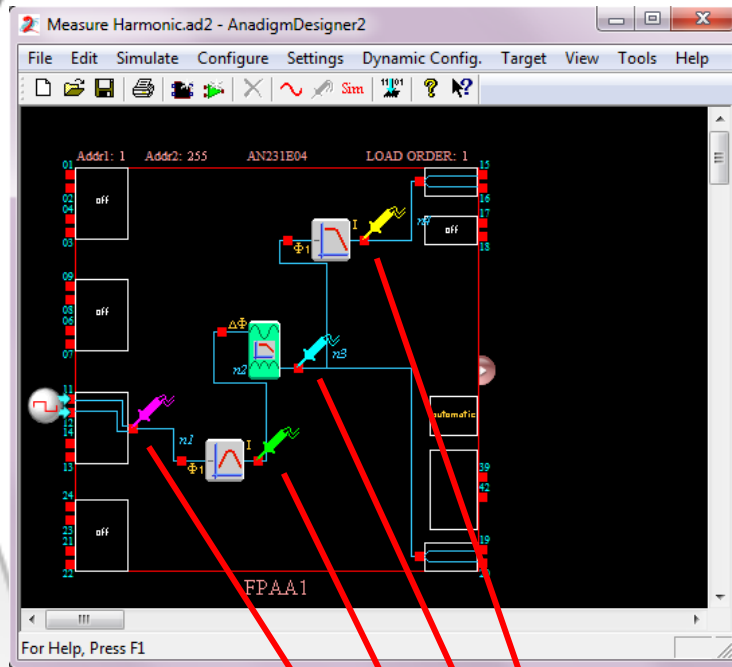
- **Another library of CAMs**
- **Further level of customization for your products**
- **Integrate your special requirements**
- **Customer CAMs can be built to your needs.**

Think outside the box

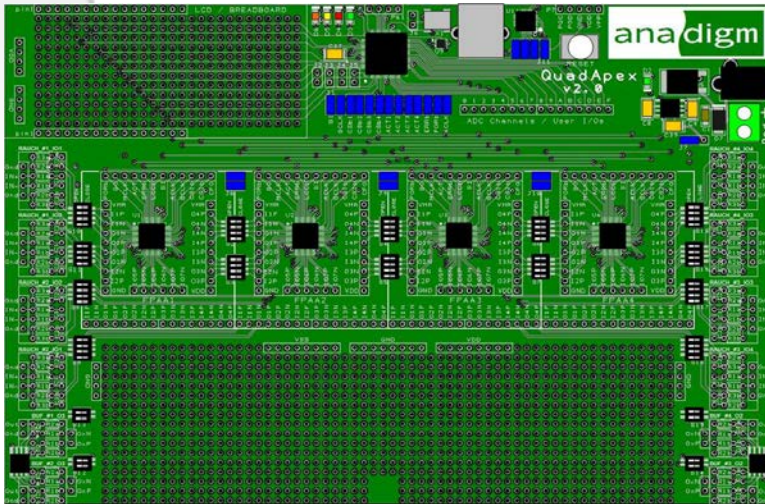
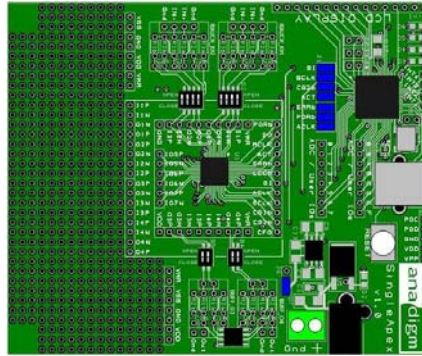
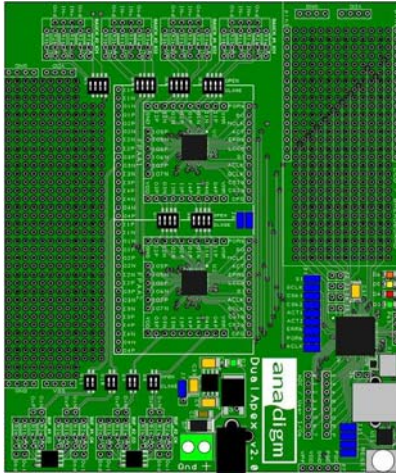
Mapping Functions to CAMs



Simulator



Anadigm Developers Kits



- Perfect hardware platform to get started with FPAA
- Evaluation board suitable for development and instant prototyping
- Three board sizes with 1,2 or 4 FPAA mounted on the PCB
- Part Numbers: AN231K04-SING1

AN231K04-DUAL2

AN231K04-QUAD4





Static Configurability and Dynamic Re-configurability

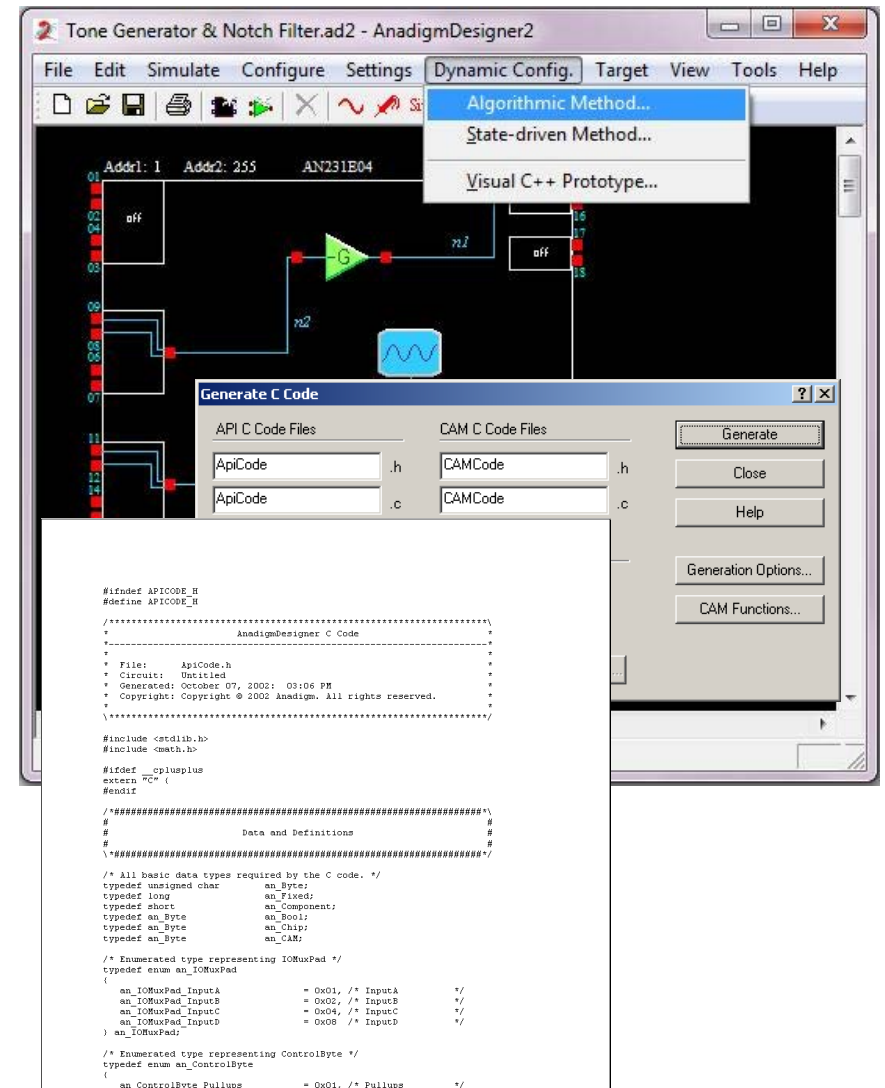
Static and Dynamic Devices

- **All FPAA parts need configuration information loaded when the device first powers up (static configuration)**
- **Some devices have an additional feature to allow you to change the active configuration while device is operational (dynamic re-configuration)**
- **Potential uses for dynamic re-**
 - Reconfigure the device to match multiple system states
 - Auto calibrate the system at power-up
 - Automatically adjust system to incoming signal characteristics
- **Apex devices that support dynamic re-configuration (AN231E04)**

How Does Dynamic Reconfiguration Work?

System Update via C-code

- Circuit description available in C-code
- System software can change functionality by making a function call
- Allows the MCU to update the system functionality dynamically



The screenshot shows the AnadigmDesigner2 interface for a project named 'Tone Generator & Notch Filter.ad2'. The main window displays a circuit diagram with components like 'off', 'AN231E04', and a green gain block 'G'. A 'Dynamic Config.' menu is open, showing options: 'Algorithmic Method...', 'State-driven Method...', and 'Visual C++ Prototype...'. A 'Generate C Code' dialog box is open in the foreground, with the following fields:

API C Code Files		CAM C Code Files	
ApiCode	.h	CAMCode	.h
ApiCode	.c	CAMCode	.c

Buttons in the dialog include 'Generate', 'Close', 'Help', 'Generation Options...', and 'CAM Functions...'. Below the dialog, a snippet of C code is shown:

```
#ifndef APICODE_H
#define APICODE_H

/*-----
 * AnadigmDesigner2 C Code
 *-----
 * File:      ApiCode.h
 * Circuit:   Untitled
 * Generated: October 07, 2002 03:06 PM
 * Copyright: Copyright © 2002 Anadigm. All rights reserved.
 *-----
 */

#include <stdlib.h>
#include <math.h>

#ifdef __cplusplus
extern "C" {
#endif

/*-----
 * All basic data types required by the C code. */
typedef unsigned char    an_Byte;
typedef long             an_Fixed;
typedef short           an_Component;
typedef an_Byte         an_Bool;
typedef an_Byte         an_Chip;
typedef an_Byte         an_CAM;

/* Enumerated type representing IOmuxPad */
typedef enum an_IOmuxPad
{
    an_IOmuxPad_InputA    = 0x01, /* InputA */
    an_IOmuxPad_InputB    = 0x02, /* InputB */
    an_IOmuxPad_InputC    = 0x04, /* InputC */
    an_IOmuxPad_InputD    = 0x08, /* InputD */
} an_IOmuxPad;

/* Enumerated type representing ControlByte */
typedef enum an_ControlByte
{
    an_ControlByte_Pullups    = 0x01, /* Pullups */

```



FPAA Applications

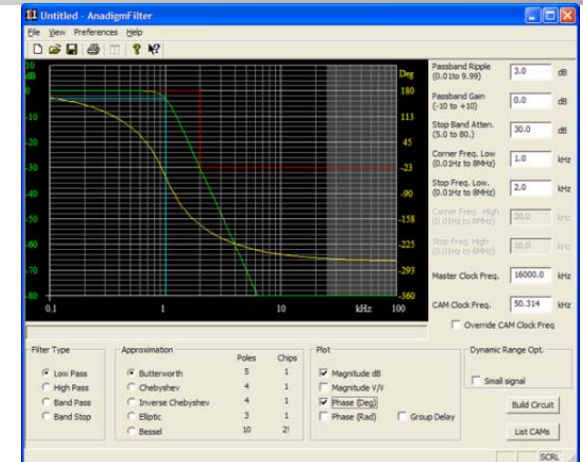
Typical FPAA Applications

- **Complex analog filtering circuits**

- Guaranteed and repeatable filter implementation
- Implemented filter is drift-free and immune to aging or component variations
- Make tunable (adaptable) filters within minutes

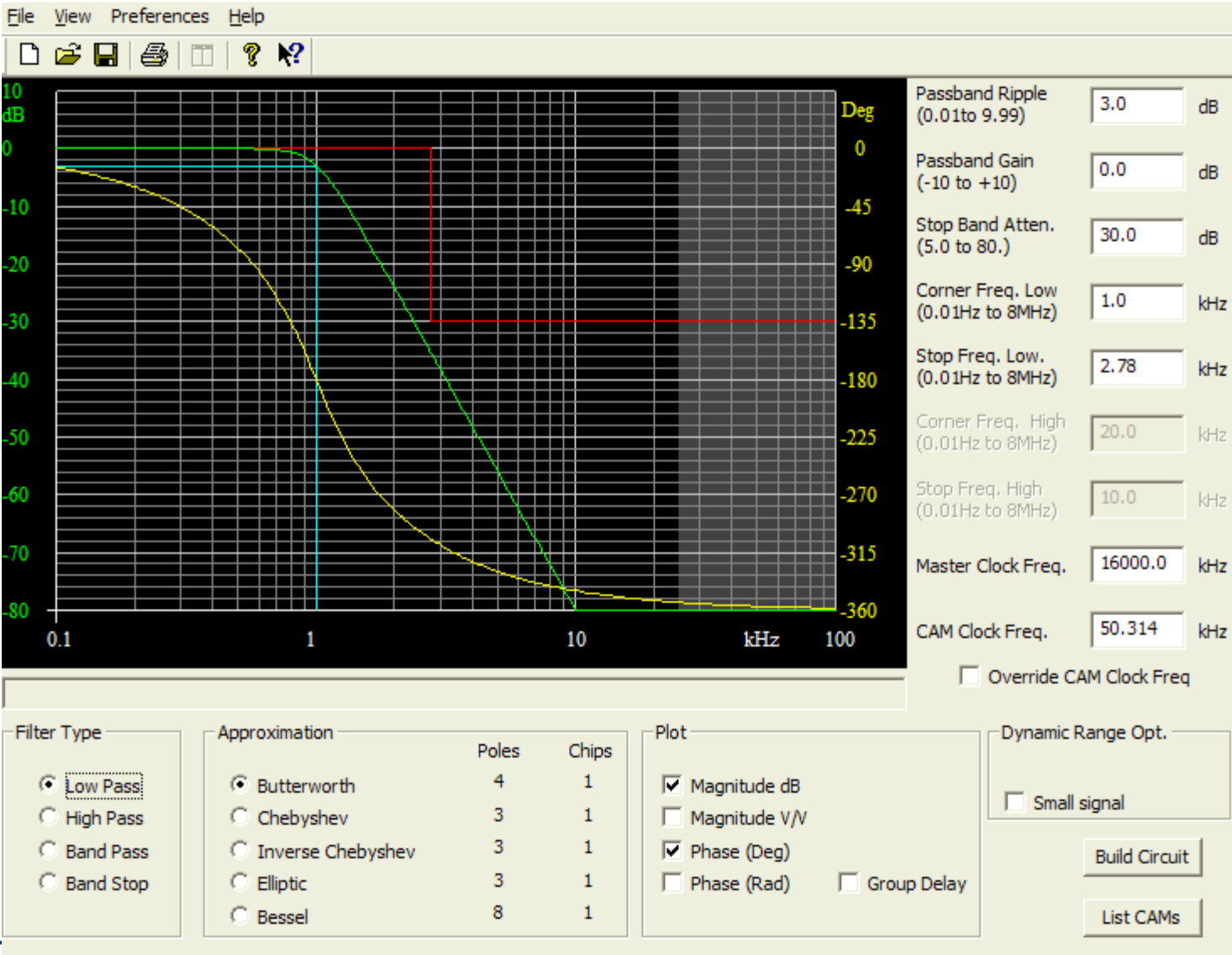
- **Sensor signal conditioning**

- Gain, offset correction, linearization, etc.
- Stable and adaptable sensor stimulus
- Correct / adjust for aging, drift, manufacturing variability, etc.
- Improve accuracy, performance and control by providing real time adjustments to range of operation



AnadigmFilter™

EDA Tools-AnadigmFilter



EDA Tools-AnadigmFilter - It builds the circuit for you!

The screenshot displays the AnadigmDesigner2 interface. On the left, a circuit diagram for a filter is shown, labeled 'Filter0'. It features a central AN231E04 component with various pins connected to other components, including several 'off' blocks and a 'automatic' block. The diagram includes a grid of pins numbered 01 to 24 on the left and 15 to 20 on the right. The top of the window shows a menu bar with 'File', 'Edit', 'Simulate', 'Configure', 'Settings', 'Dynamic Config.', 'Target', 'View', 'Tools', and 'Help'. Below the menu is a toolbar with icons for file operations, simulation, and help.

On the right side of the window, a configuration panel for the filter is visible. It includes a plot area showing the filter's response. The plot has a logarithmic frequency axis from 10 kHz to 100 kHz and a linear phase axis from 0 to -360 degrees. A green line represents the phase response, and a yellow line represents the magnitude response. A red box highlights a region of the plot between 10 kHz and 100 kHz, with a horizontal line at -135 degrees.

Below the plot, there is a table with the following data:

	Poles	Chips
th	4	1
v	3	1
hebyshev	3	1
	3	1
	8	1

Below the table, there are checkboxes for 'Plot' options: 'Magnitude dB' (checked), 'Magnitude V/V' (unchecked), 'Phase (Deg)' (checked), 'Phase (Rad)' (unchecked), and 'Group Delay' (unchecked). There is also a 'Dynamic Range Opt.' section with a 'Small signal' checkbox (unchecked).

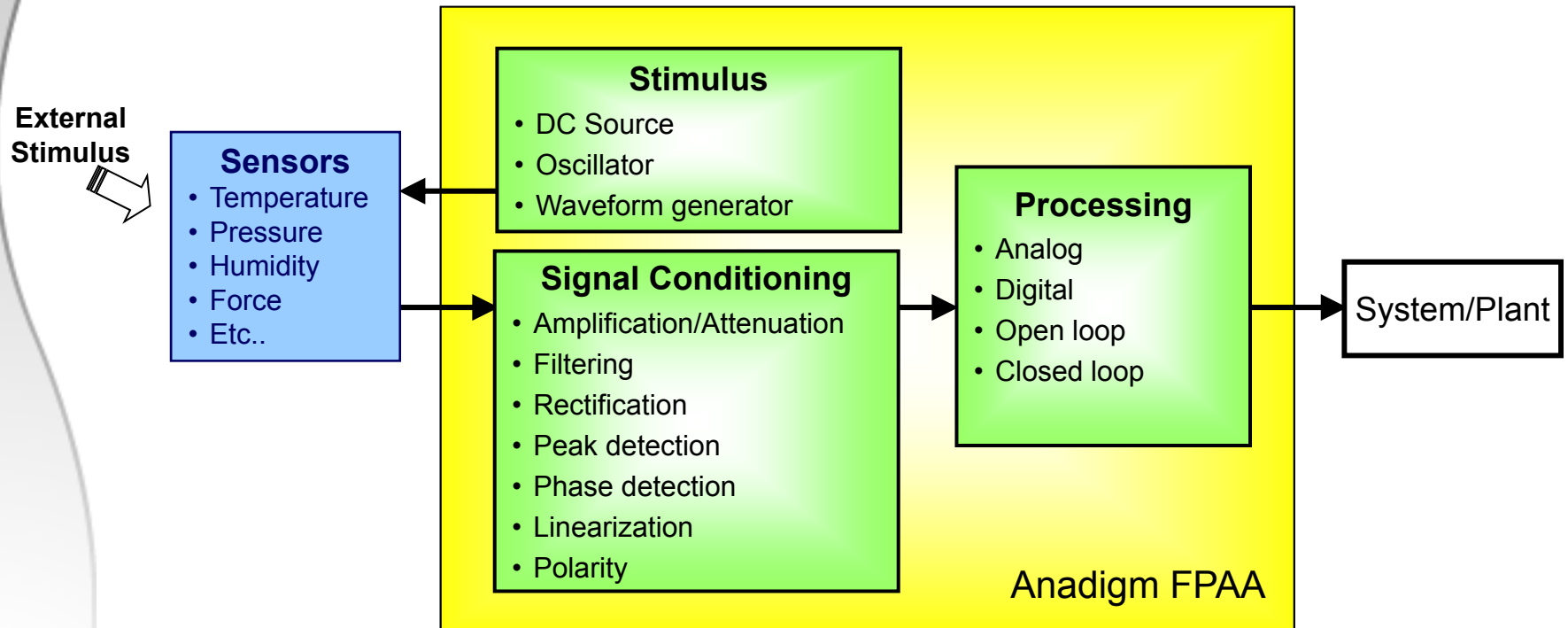
At the bottom right of the configuration panel, there are two buttons: 'Build Circuit' and 'List CAMs'. An arrow points to the 'Build Circuit' button.

On the right side of the configuration panel, there are several input fields for filter parameters:

- Passband Ripple (0.01 to 9.99): 3.0 dB
- Passband Gain (-10 to +10): 0.0 dB
- Stop Band Atten. (5.0 to 80.): 30.0 dB
- Corner Freq. Low (0.01Hz to 8MHz): 1.0 kHz
- Stop Freq. Low. (0.01Hz to 8MHz): 2.78 kHz
- Corner Freq. High (0.01Hz to 8MHz): 20.0 kHz
- Stop Freq. High (0.01Hz to 8MHz): 10.0 kHz
- Master Clock Freq.: 16000.0 kHz
- CAM Clock Freq.: 50.314 kHz

There is also an 'Override CAM Clock Freq' checkbox (unchecked).

Sensor Signal Conditioning – Overview



The FPAA helps meet the following system challenges:

- Sourcing stable references and stimulus
- Multiple sensors with differing signal conditioning needs
- Real time adjustments to range of operation
- Methods of calibration and maintenance
- Correct / adjust for aging, drift, manufacturing variability, etc.
- Manufacturing considerations for multiple boards



Summary

Take Control of Your Analog Destiny

- **Simplify Your Analog Design**
 - Reduce design time
 - Save engineering costs
- **Gain the Flexibility to Adapt Your Design**
 - Easily address unknown/unforeseen design issues
 - Quickly modify circuits when specifications change
 - A board spin can be replaced with a software change
 - And this flexibility can extend all the way to your customer's site
 - One PCB can serve many products

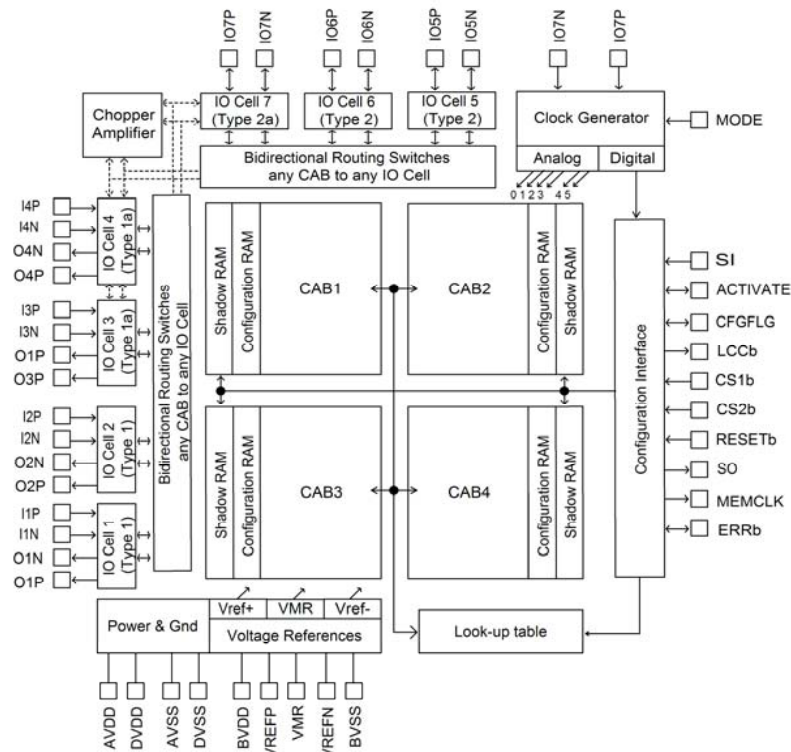
Take Control of Your Analog Destiny

- **Add New Features and Capabilities to your Systems**
 - Change your analog feature-set while your system runs
 - Add new capabilities you could only dream of in the past
- **Improve the Manufacturability of Your Design**
 - Automated system calibration and testing on production line
 - High integration – BOM reduction
 - Removes need for high tolerance components



Backup Materials

AnadigmApex (3.3volt) Architecture



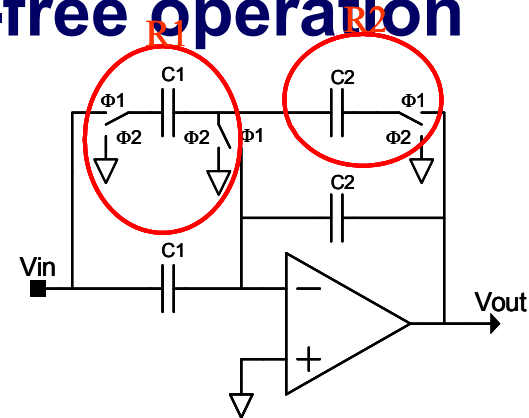
Four Configurable Analog Blocks (CABs) controlled by a switch capacitor architecture each containing:

- 2 differential 50MHz op-amps
- 1 differential comparator
- 1 SAR based ADC
- 8 programmable capacitors

- OpAmps contain an Input offset voltage “auto-nulling” feature. (I/O and core OpAmps)
- SPI configuration interface enables software control
- dualSRAM based configuration for real time state changes and seamless control over analog parameters
- Four type1 “featured” I/O cells, each can be independantly powered down or configured as
 - single-ended or differential
 - an independent differential gain stage
 - differential input filter
 - input or output sample and hold
 - a bypass wire or digital output
- Three (type2) simple differential I/O cells.
- One chopper stabilized gain stage ($G \leq 60\text{dB}$), available to use with Type1 or type2 I/O cells
- Two logic/control signal outputs
- Clock management providing 6 non-overlapping internal clocks, two with variable phase delay
- Look Up Table for arbitrary waveform generation
- Rich pre-built (CAM) library

Switched Capacitors Precise Operation

- **Capacitor ratios deliver accurate circuit parameters**
 - Achieves 0.1% functional accuracy
 - Chip to chip accuracy $\pm 0.1\%$
- **Capacitor ratios deliver drift-free operation**
 - Immune to:
 - Process
 - Temperature
 - Aging



$$\frac{V_{out}}{V_{in}} = \frac{-R_2}{R_1} = \frac{-1/f_c C_2}{1/f_c C_1} = \frac{-C_1}{C_2}$$