The FPAA Company

Field Programmable Analog Arrays

real time Analog programmability

Anadigm® FPAA Solutions Training

Class I

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**

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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.

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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

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Anadigm Technology Enables You (cont)

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

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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

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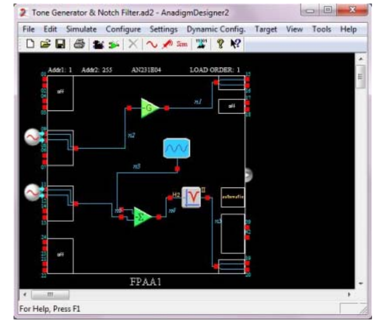
How We’re Making It Happen

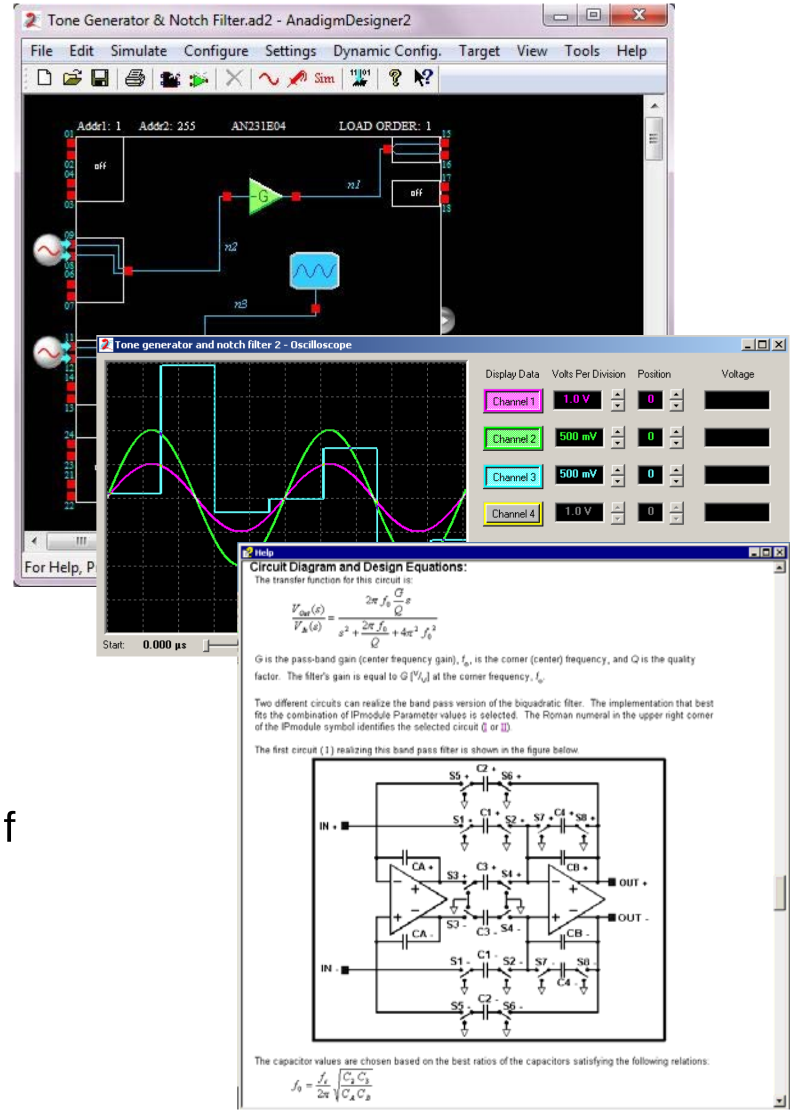
- **Anadigm® combines three powerful design trends from the digital world into the analog domain**
  - EDA tools and design modules for complete analog design automation remove the complexity from analog design
  - Specialized architecture for external processor control to allow for in-circuit programmability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



Development Tools

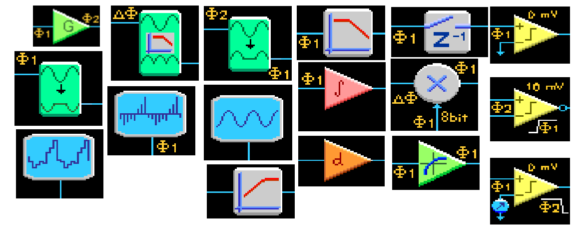
Anadigm Designer Overview

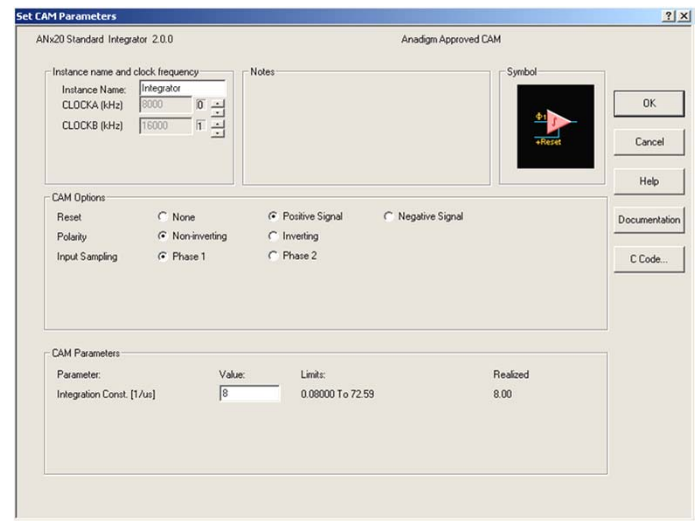
- **AnadigmDesigner® 2**
  - Easy-to-Use
  - Intuitive “drag-and-drop” user interface
  - Built-in signal generator, oscilloscope
  - Built-in, accurate discrete-time behavioral simulator
  - Extensive help documentation
  - Full version available free from Anadigm website (www.anadigm.com)
  - Supports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



Configurable Analog Modules (CAM)

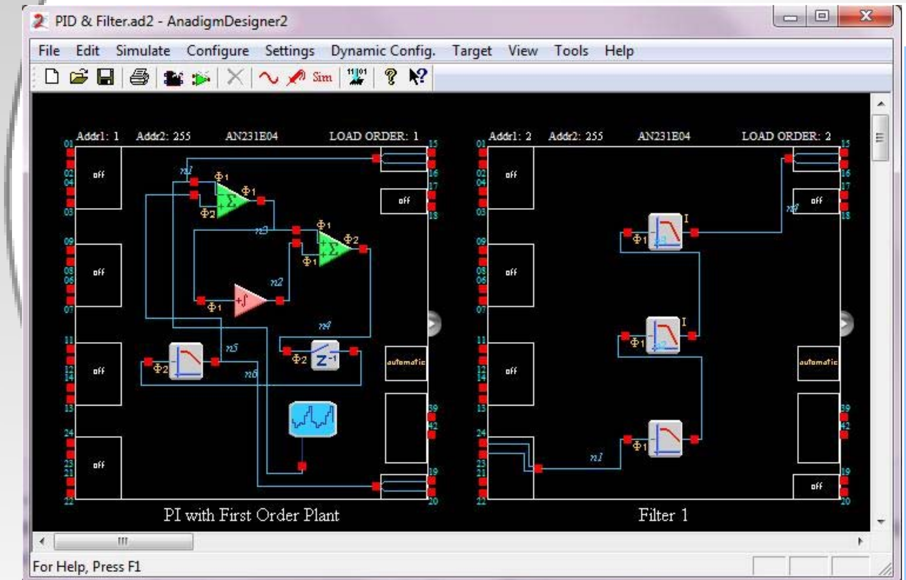
- **Circuit building blocks abstracted to a functional level**
- **Supports true design abstraction**
- **A complex circuit can be implemented simply by selecting, configuring, and wiring CAMs**
- **Each CAM has a user interface to set options and limits**
- **Each CAM has an accurate model for use in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





Typical CAM Options

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



- **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**

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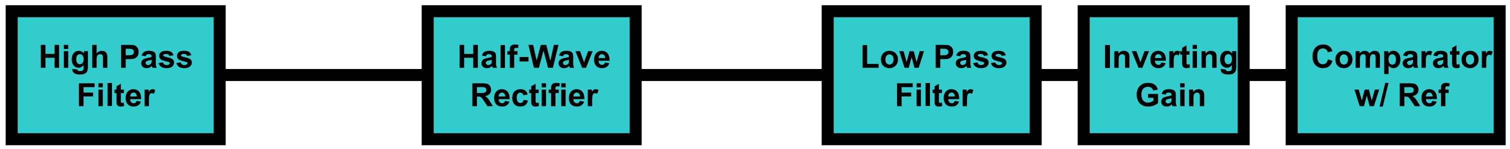
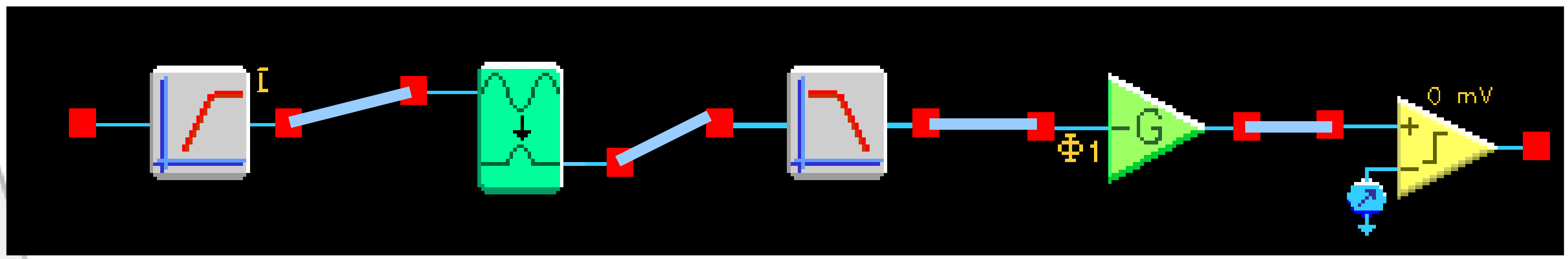
Customer CAMs

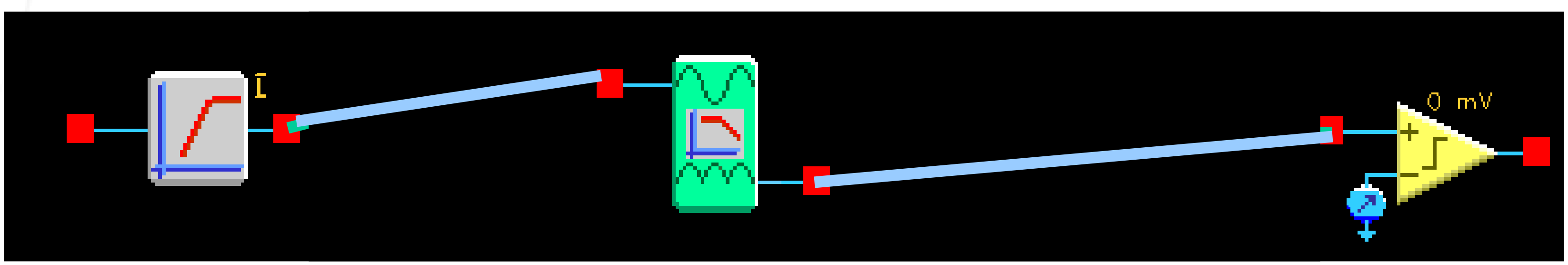
- Another library of CAMs
- Further level of customization for your products
- Integrate your special requirements
- Customer CAMs can be built to your needs.

Think outside the box

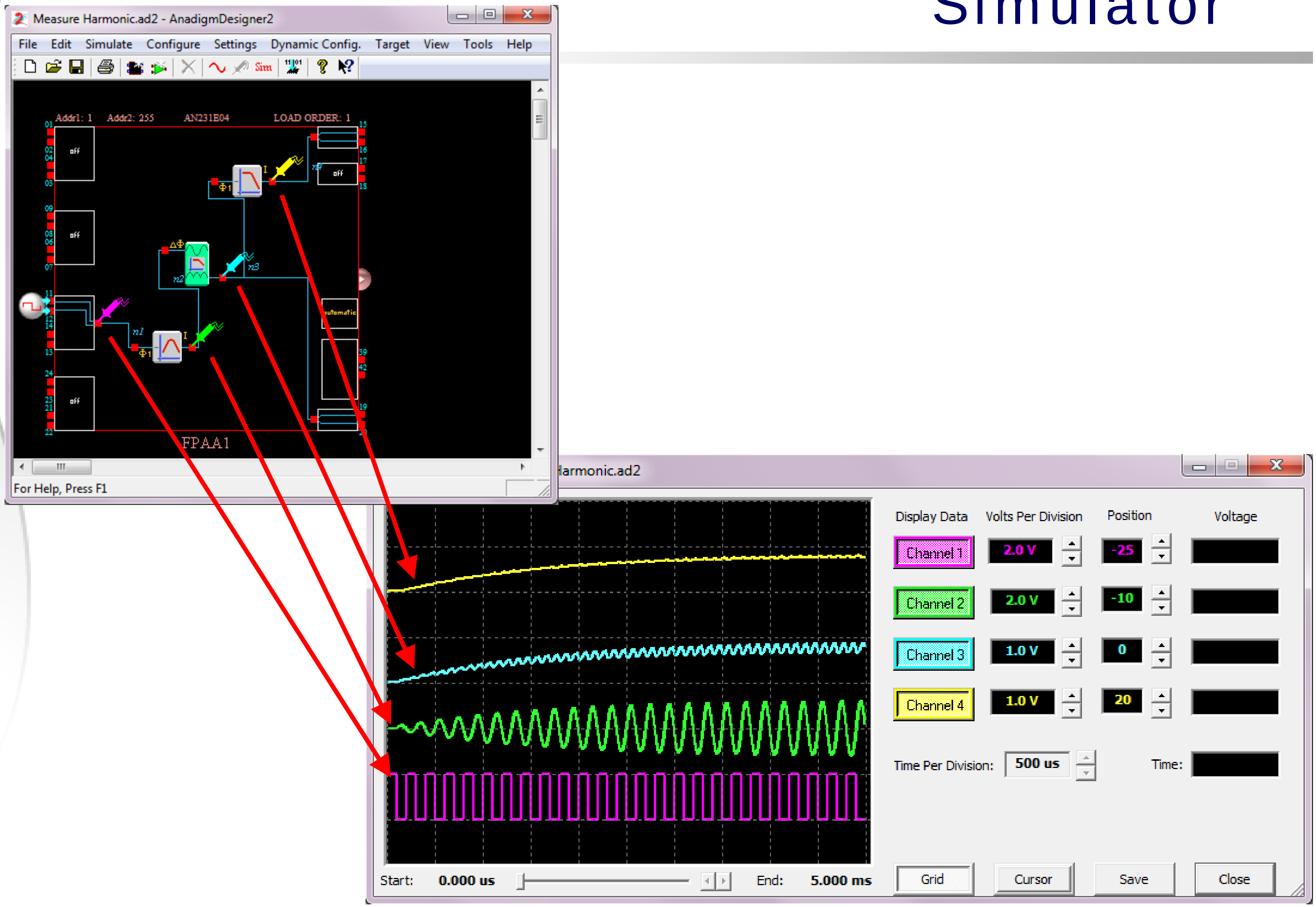
Mapping Functions to CAMs



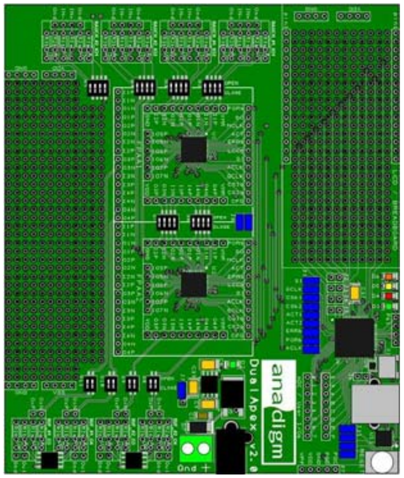


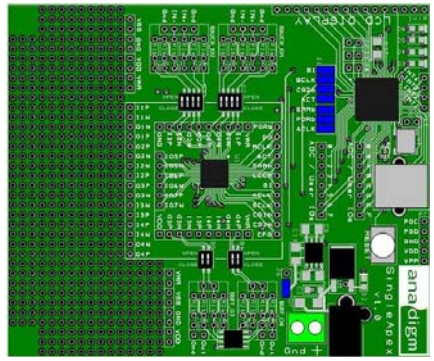


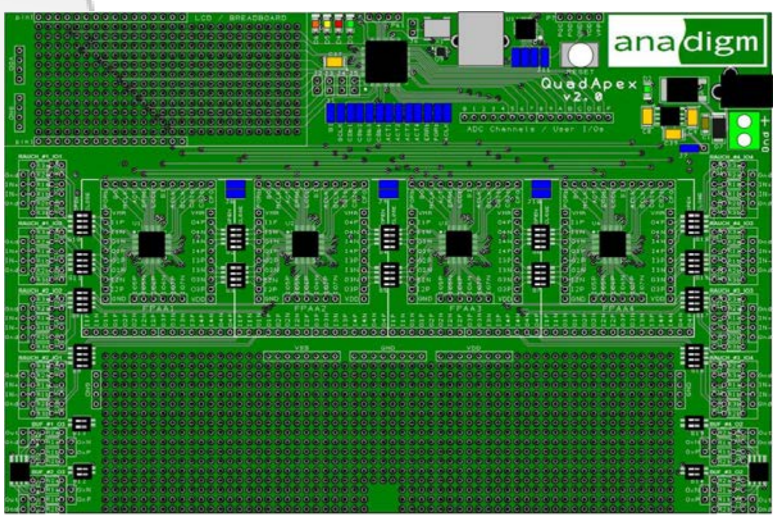
Simulator


Measure Harmonic.ad2 - AnadigmDesigner2
File Edit Simulate Configure Settings Dynamic Config. Target View Tools Help
Addr1: 1 Addr2: 255 AN231E04 LOAD ORDER: 1
FPAA1
For Help, Press F1
Display Data
Volts Per Division
Position
Voltage
Channel 1
2.0 V
-25
Channel 2
2.0 V
-10
Channel 3
1.0 V
0
Channel 4
1.0 V
20
Time Per Division:
500 us
Time:
Start:
0.000 us
End:
5.000 ms
Grid
Cursor
Save
Close

Anadigm Developers Kits







- Perfect hardware platform to get started with FPAAs
- 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)**

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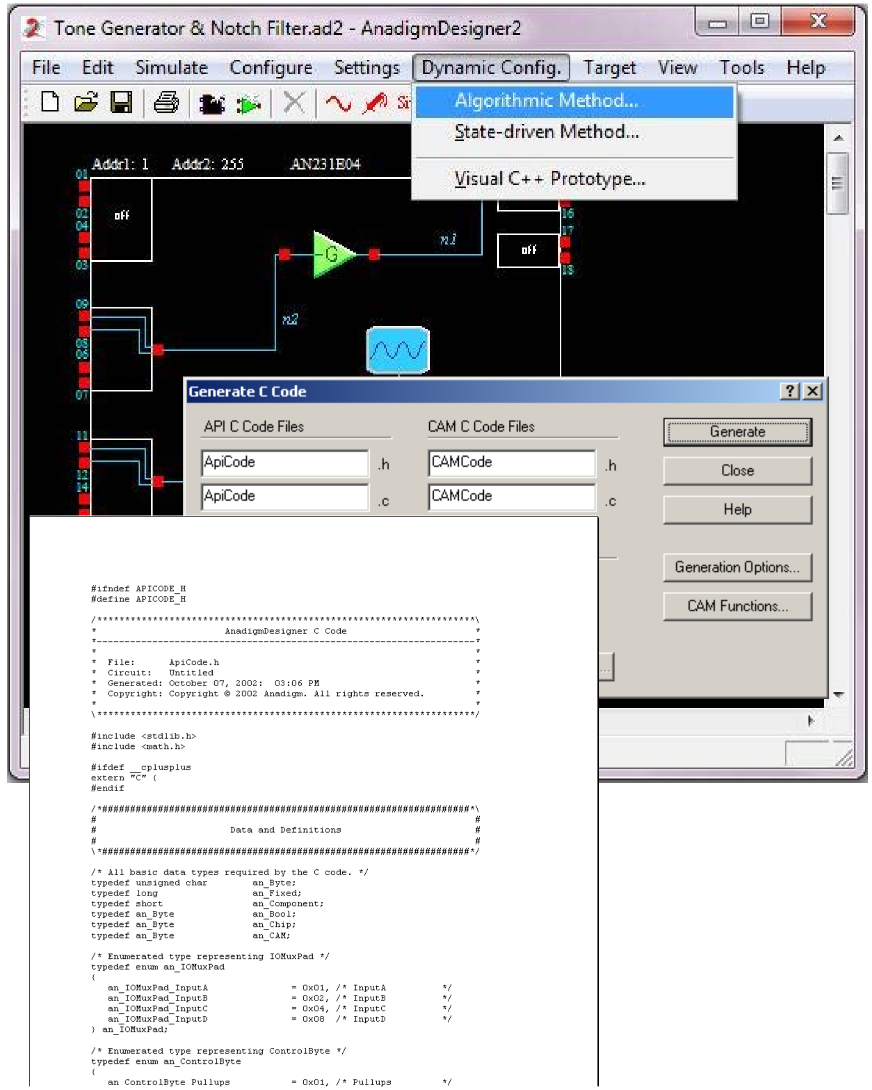
How Does Dynamic Reconfiguration Work?

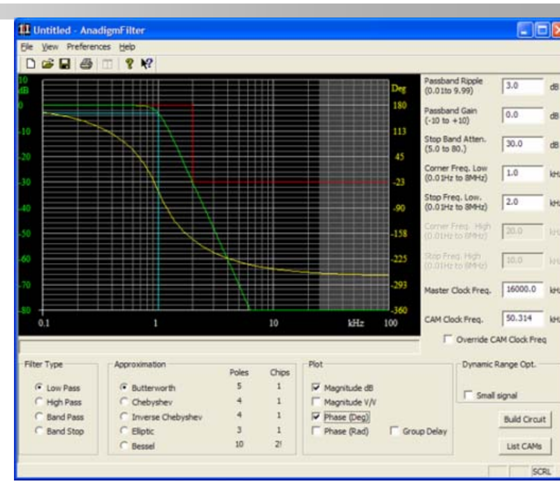
System Update via C-code

- 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



FPAA Applications

Typical FPAA Applications

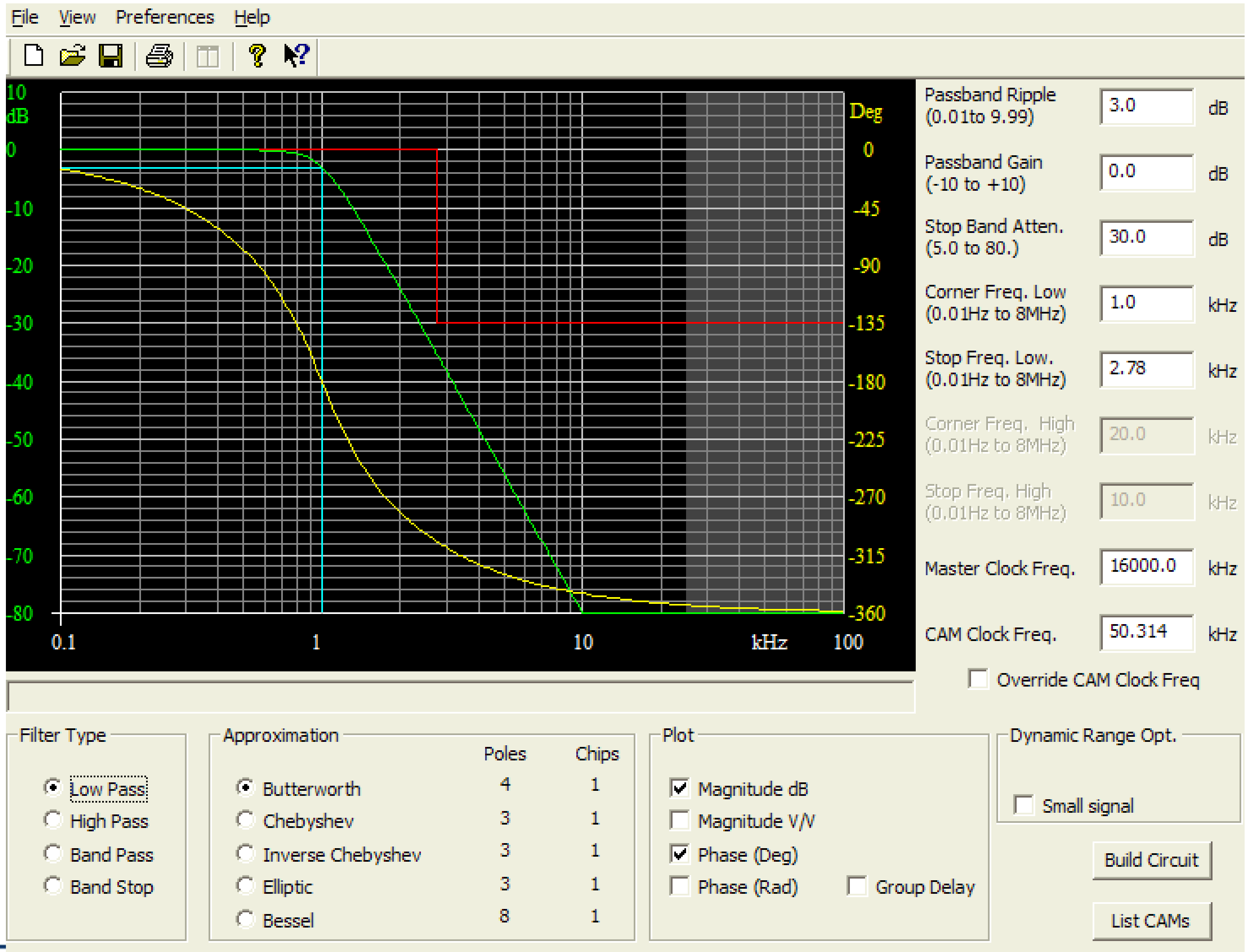


AnadigmFilter™

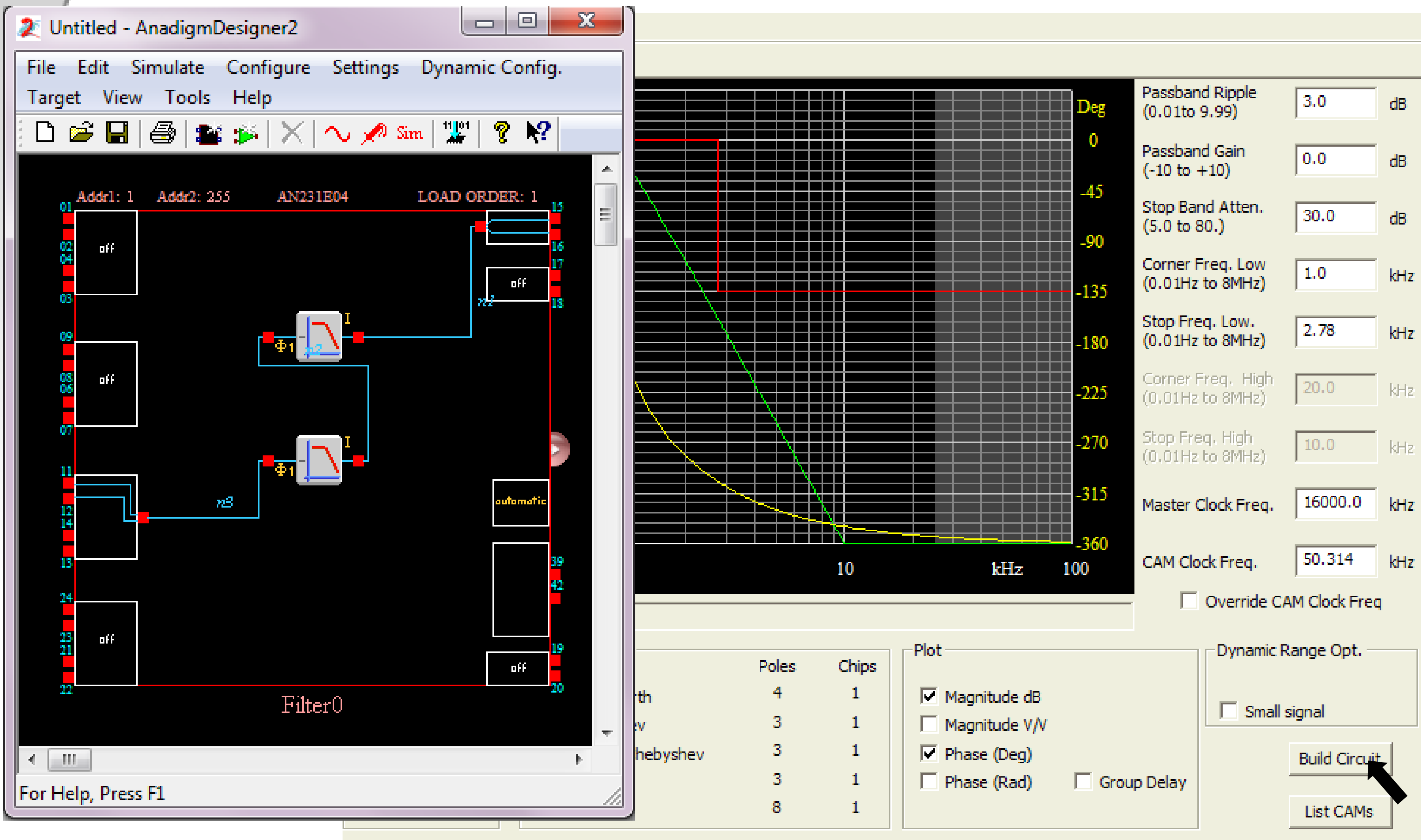
- **Complex analog filtering circuits**
  - Guaranteed and repeatable filter implementation
  - Implemented filter is drift-free and immune to aging or component variations
  - Make tunable (adaptable) filters within minutes

- **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

EDA Tools-AnadigmFilter



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



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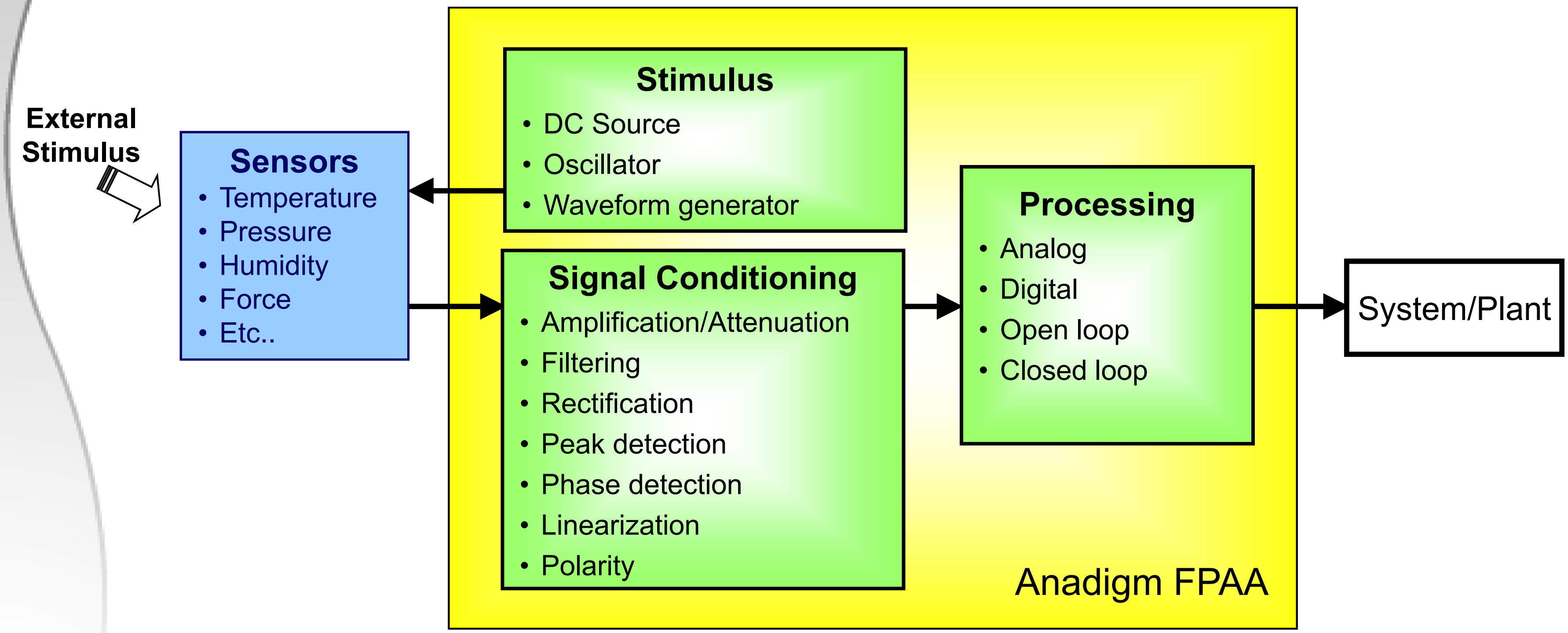
Sensor Signal Conditioning – Overview



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

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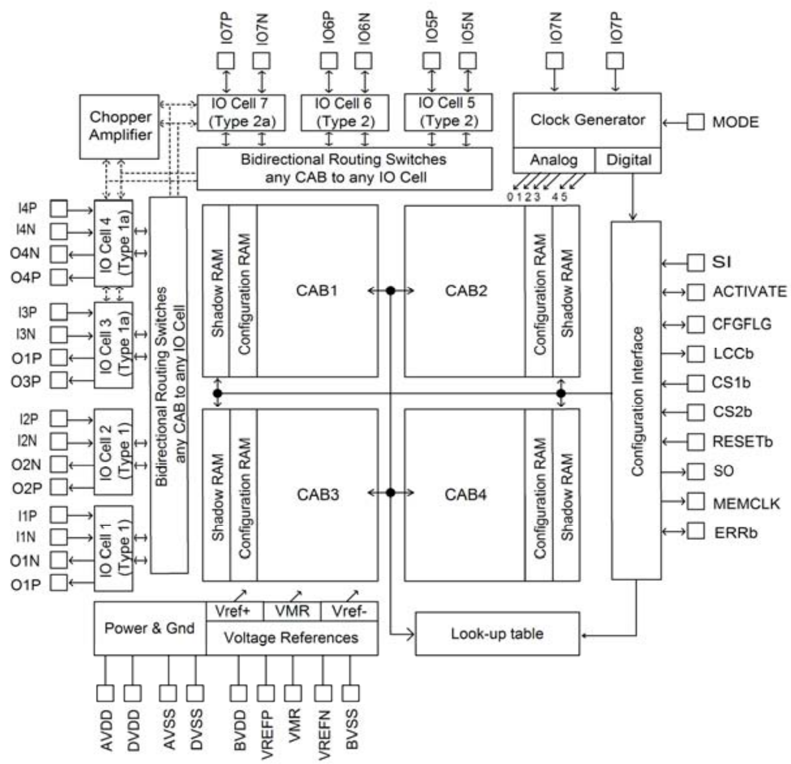
Take Control of Your Analog Destiny

- **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 <= 60dB), 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**

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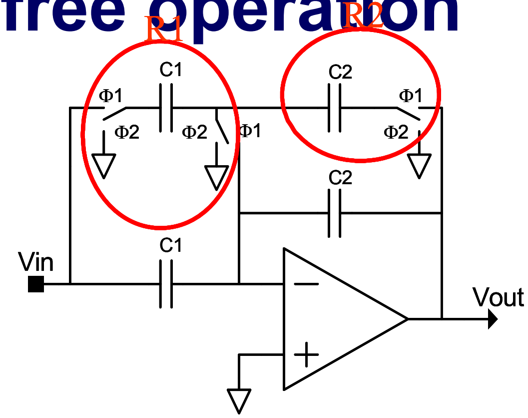
Switched Capacitors
Precise Operation

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



$$\frac{Vout}{Vin} = \frac{-R2}{R1} = \frac{-1/f_cC2}{1/f_cC1} = \frac{-C1}{C2}$$