The dpASP Company
- delivering dynamically programmable
**Analog Signal Processing**

Dec, 2011
The Anadigm Mission

Anadigm’s mission is to provide the industry with dynamically programmable Analog Signal Processing that:

- Enabling features and capabilities not possible with fixed function analog at a much lower cost of ownership.
- Allows the customer to modify designs on demand - dynamically.
- Greatly simplify the analog design process while improving the customer’s time to revenue.
Company founded in January 2000 - spinout from Motorola as Analog (FPAA) dpASP fabless semiconductor company.

Over $35M invested - Key technology investments completed.

- Generated 25 core patents with 236 international filings
- Proven 2nd and 3rd generation silicon in Volume production
- 2nd generation of software released - AnadigmDesigner2

Broad and diverse customer base across many markets.

- Over 9,750 customers have licensed Anadigm’s design software
- +3800 customers have purchased our Development Kits
- ~200 customers in evaluation, design or production
History 1

- **Founded January 2000**
  - Venture backed technology spin-off from Motorola Semiconductor Products Group
  - FPAA Portfolio Acquired and Enhanced

- **Three rounds of funding from top tier investors – Total $35M**
  - 1st round Jan ’00 – raised $5.1M
  - 2nd round Feb ‘01 – raised $14.2M
  - VC Loan closed 2002 - $2.75M
  - 3rd round Oct ‘03 – raised $15M

- **1st and 2nd generation product - production**
  - 1st Generation 5.0volt product launched 2001, replaced and phase out 2003
  - 2nd Generation 5.0volt product Launched 2003 – continues today

- **Management Buyout Dec 2005**
  - Restructured and re-financed (to be profitable)
  - 3rd Gen 3.3volt product Launched 2006 - continues today
History 2

- **Management lead buyout and re-financing completed, 2006**
  - “New Anadigm” acquired full ownership of all Trademark, IP, Patents, Tooling, Manufacturing rights of Anadigm group of companies.
- First profit shown 2007.
- Consolidation of all activities to Mesa, AZ, USA. complete 2008.
- Consolidation of all subsidiary company’s. complete 2009, resulting in single entity “Anadigm Inc”.

- **Key manufacturing relationships** *(Fabless semiconductor Company Model).*
  - **Silicon wafers:**
    - Globalfoundries (formally Chartered Semi (Singapore) - 10 years)
  - **Assembly and Test:**
    - Unisem (formally AIT) Indonesia, 6 years
    - ISE(USA)- 5 years

- **Key Sales channel relationships.**
  - Nu Horizons – Worldwide Distributor - 6 years
Company Founded - spin out - Motorola:

- **2000**: 1st Gen FPAA launched
- **2001**: 2nd funding $14.1M
- **2002**: 2nd Gen product launched
- **2003**: 2nd funding $15M
- **2004**: Management lead Buyout
- **2005**: 3rd funding $15M
- **2006**: 3rd Gen product launched
- **2007**: Volume production ramp
- **2008**: Application Product launches
  - RM – RangeMaster
  - SM – SonicMaster
  - AF – AnadigmFilter

EDN Innovation of the Year 2003
- Analog Zone Product of the Year 2003

Volume production ramps:
- AN221E04
- AN231E03
- RM – RangeMaster
- SM – SonicMaster
- AF – AnadigmFilter

Company Overview - page 6
Anadigm dpASP Value Proposition - A

- **Product differentiation 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

- **Implementation of high accuracy analog circuits in your products.**
  - Achieves 0.1% functional accuracy
  - Chip to chip accuracy plus/minus 0.1%
  - Drift free performance immune to process, temperature, and aging
Anadigm dpASP Value Proposition - B

- To *simplify* the analog design process
- To *reduce the time* for analog design implementation from months to minutes
- To *enable* repurposing and real-time updating of analog functions within the system
- To *provide* the industry with an analog design platform similar to FPGA… more tightly coupled to the system processor
Graphical EDA tools
Extensions to real-time system software

“C-code”

Software
AnadigmDesigner™

Adaptive Software

(Dynamic) Re-Configuration

Top-down Analog design and implementation!

Assembled & verified by s/w

‘Plug & Use’ analog circuit blocks, Market segment-specific libraries

Rich Library of Configurable Analog Modules (CAMs)

dpASP product families
Anadigm Designer Overview

- **AnadigmDesigner2™**
  - Easy-to-Use PC based S/W
  - Intuitive “drag-and-drop” user interface
  - Built-in signal generator, oscilloscope
  - Built-in, accurate discrete-time behavioral simulator
  - Extensive help documentation
  - Trial version available free at [http://www.anadigm.com](http://www.anadigm.com)
Configurable Analog Modules (CAM)

- Circuit building blocks abstracted to a functional level
- A complex circuit can be implemented 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
- Custom CAMs can also be built to your specifications
Mapping Functions to CAMs

High Pass Filter → Half-Wave Rectifier → Low Pass Filter → Inverting Gain → Comparator w/ Ref

High Pass Filter → Rectifier/Filter with Gain → Comparator w/ Ref
Anadigm Developers Kit

- Perfect hardware platform to get started with dpASPs
- Development board suitable for development and prototyping
- Part Number: AN221K04-DVLP2 AN231K04-DVLP3
- Priced at $199
dpASP- dynamically programmable
Analog Signal Processing
Dynamic Programmability with dpASP’s

- Potential uses for dynamic re-configuration.
  - Reconfigure the device to match multiple system states
  - Auto calibrate the system at power-up
  - Automatically adjust system to incoming signal characteristics

- Anadigm’s dpASP allows you to change the active configuration while device is operational (dynamic re-configuration).

- Versions of the dpASP are available in static-programmable configuration allowing for programming only on power up - targeting lower cost applications.
**Dynamic Programmability**

**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
Silicon Product Offering
dpASP Product Roadmap

Vortex (2nd Generation)
Product definition was Engineering driven and initially targeted at broad Industrial applications
5V, .6u CMOS

Apex (3rd Generation)
Product definition was market driven and targeted at Audio and lower cost 3V applications 3.3V, .35u CMOS

Application Specific Products
RangeMaster1 based on Vortex 5v dpASP announced July 2005
RangeMaster2 based on Apex 3.3v dpASP announced January 2006
RangeMaster3 and RangeMaster5, 2nd half 2006

More Specific Products
SonicMaster1 based on Apex 3.3v dpASP announced Dec 2006
SonicMaster2 based on Apex 3.3v dpASP announced Mar 2007
SonicMaster3, WooferWidget, Q2/2008

More Specific Products
AnadigmFilter based on Apex 3.3v dpASP announced Q4/2007

APEX SE (4 Generation)
Lower cost and performance sensor apps 3.3V, .35u CMOS

5th Generation
High performance
Product definition
Anadigm Vortex (5volt) 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

- SPI configuration interface enables software control

- SRAM based configuration for real time state changes and seamless control over analog parameters

- Six I/O cells – with built in anti-aliasing and smoothing filters

- Look Up Table for arbitrary waveform generation

- Pre-built library modules
AnadigmApex (3.3volt) Architecture

• 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

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
dpASP Applications
Typical dpASP 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 adjustments to range of operation

- **Closed loop control systems**
  - Proportional-Integral-Derivative controllers implemented within minutes
  - Low latency control
Some Application Areas

- RFID
- SENSORS
- AUDIO
- INDUSTRIAL
- COMMS

Dynamic programming

- Anadigm product is well suited for application that have “real world” interface requirements
- Re-purposing provides the flexibility to use a single product for many applications
- Dynamic operation provides a very flexible method of changing parameters and coefficients in-circuit, in operation
Other dpASP Application Areas

- **Audio**
  - Subwoofers
  - Effects
  - Speaker Crossovers
  - Synthesizers

- **RFID for**
  - Access Control
  - Security
  - Asset Management

- **Coin / Currency Validation**
  - Coin Validation
  - Currency Validation
  - Combo Devices

- **Ultrasonics**
  - Various Medical Apps
  - Sonar Ranging

- **LVDT Control**
  - Various Industrial Apps
RFID - Applications

RFID Systems

- Many RFID systems that can use different frequencies and protocols:
  - Class 0
  - EPC Global Gen 1 & 2
  - ISO18000-6
  - ISO14443 Type A or B
  - ISO15693
  - HF (13.5MHz) & UHF (~900MHz)

- Tags may employ any of these systems, but reader has to be able to read ALL

- Select the right frequency…
  - Control of frequency/filter settings for multiple tag types

- …and setting correct sensitivity
  - Algorithmic control of gain/sensitivity for distance/position
RFID Readers

- Support all RFID frequencies and protocols
- User can dynamically select from pre-defined sub-carrier frequencies with optimized read range
- Create a universal reader that can read different tag types
- Ability to handle interference filtering
- Simple interface with host controller
- Minimal external components
- I & Q filtering increases performance of reader over single channel readers
Audio Applications

Crossover, Equalization & Effects

- Real time user control over speaker crossover corner frequencies
- Maintain “pure analog sound quality” – no digital artifacts
- Guaranteed 1% phase matching for speaker pairs – noticeable audio difference
- Intelligent audio – customizable compressor and levels, speaker optimization for room acoustics
- Guitar effects – unlimited number of effects: Phaser, Overdrive, Wah
- On-line updates in S/W plug-ins
Audio Example

Sub-Woofer Application

- To address:
  - Low frequency loss
  - Cabinet resonance
  - Room resonance
  - Interference at listening position
  - Location and reflection
  - System cross over matching
  - Dynamic level compression
  - Speaker output for tone generation
  - Microphone input for feedback
  - Remote control for microcontroller inputs
Sensor Applications

Stimulation and conditioning

- Sensors need electrical stimulation:
  - Voltage/Current
  - DC/AC

- Sensor output requires conditioning
  - Filtering
  - Amplification/attenuation
  - Rectification
  - DC offset removal

- Noisy environment require differential input
  - Common mode rejection
  - Modulated sensor stimulation and synchronous demodulation (lock-in detect)

- Sensor linearization
  - Using LUT and transfer functions
An LVDT requires an AC input (primary) and provides two AC outputs (secondary) in proportion to the movement of a core.

Core movement can be large or small, with only millivolt changes in output:
- 0.05mV/V/0.001” for long stroke
- 10mV/V/0.001” for short stroke

Signal conditioning requires:
- Filtering
- Rectification
- Band-limiting

Then a calculation:
- \((\frac{VA+VB}{V_{prim}})\)
- Calculate the ratio of the difference and the sum of secondary voltages \((\frac{VA-B}{VA+VB})\)
Industrial Applications

- Real world measurements via sensors:
  - Movement
  - Pressure
  - Temperature
  - Moisture
- Open loop and closed loop control (PID)
  - Proportional
  - Integral
  - Differential

Measurement & Control

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Thermistor

Thermocouple

Strain Gauge

PID control loops
Industrial - Example

The theory on Synchronous demodulation for electromagnetic coin recognition – complex and costly implementation. A coin passes through the core of a transformer, effectively damping the sinusoidal signal that is applied to the windings. Need to capture amplitude and phase to match against valid coin.

This is a simple implementation in dpASP.

Currency Validation

- Used in many vending machines
- Different techniques to determine valid currency:
  - Weight
  - Sound
  - Light
  - Electromagnetic
- Coins require different validation method than notes
- Sometimes a mix of techniques is used
- Outdoor use - wide temperature range
- Using repurposing and dynamic reconfiguration, one dpASP device can perform all tasks under microcontroller control.
Communications Applications

- The dpASP device can be used to create simple transmit and receive circuits in a modem.
- By using repurposing and dynamic programming, a single device can gather data from a sensor, reconfigure as a transmitter and send the data. The reconfigure to a receiver and await response.
**Communications - Example**

**Transmitter (Laser)**
- Laser driver
- Modulation Bias V/I conv
- TEC Laser
- Laser Monitor diode
- Laser Power stage
- TEC Power stage

**Receiver (Diode)**
- Laser Power stage
- TEC Laser
- Laser Monitor diode
- TEC Power stage

**dpASP Device**
- Multiple adaptive control loops
- Signal conditioning

**Input Sensors** (Temp, wave, power, Bias, etc.)

**Microcontroller**

**Laser/Diode control in DWDM**
- Optical transmission systems are sensitive to variations in analog parameters
  - Temperature
  - Power levels, bias points
- Transmitter and receiver modules require sophisticated adaptive control
- Laser and diode (PIN or APD) elements need constant control of power and operating points for performance, efficiency and longevity (aging)
- Laser manufacturing tolerances as such that regular recalibration is required
The dpASP 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
The Anadigm dpASP Difference

- Add New Features and Capabilities to your Systems - that can run dynamically.
- Gain the Flexibility to Adapt Your Design.
- Simplify Your Analog Design.
- Improve the Manufacturability of Your Design.

Anadigm… “the dynamically programmable Analog Signal Processor”