

Analog Signal Chain Overview

July 2009

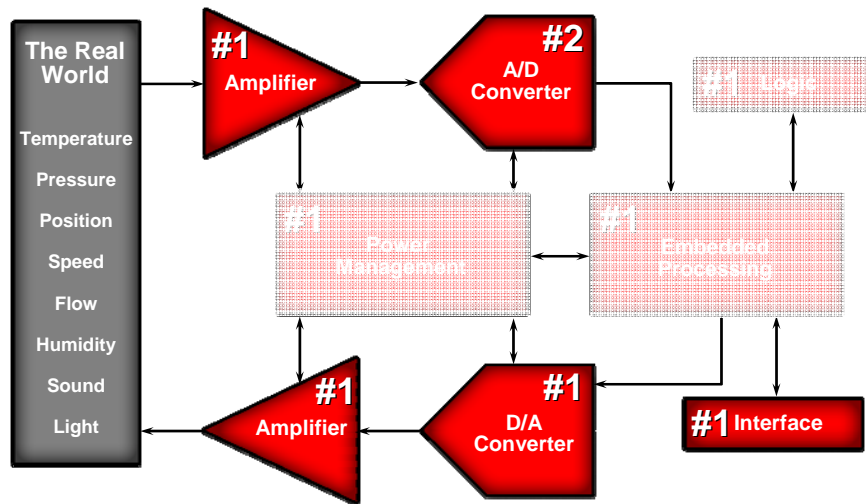


Agenda

- **Signal Chain Business and Technology**
- **Applications and Products**
- **Tools and Support**
- **Summary**



TI's Signal Chain Advantage



Source: Databeans, April 2008; Forward Concepts, February 2008



Signal Chain Spectrum




Signal Chain History



Texas Instruments

- Process Technology & Manufacturing
- Amplifiers & Data Converters



Burr-Brown

- High-performance Data Converters
- High-performance Amplifiers



Chipcon

- Low-Power RF ICs
- ZigBee®/IEEE 802.15.4



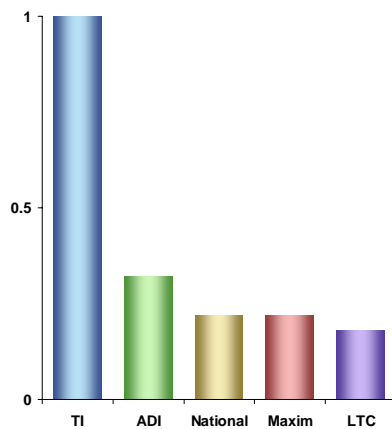
Graychip

- Digital Upconverters
- Digital Downconverters

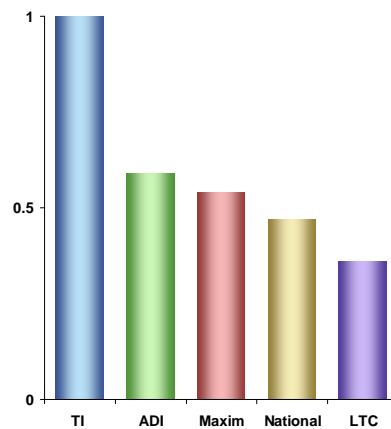


More Field Resources Enable Deeper and Broader Coverage

Relative # of Field Resources



Relative # of Analog FAEs



Source: TI estimates



Technology Roadmap Drives Product Innovation



High Speed High Precision High Density High Voltage

- ◆ Broadest, deepest analog process technology portfolio
- ◆ Process differentiation is sustainable competitive advantage
- ◆ New product development programs across four different process platforms
- ◆ Ongoing enhancements include high voltage extensions and process integration




BiCom3, BiCom3HV: High-Speed Bipolar SiGe Process

Features	Benefits
<ul style="list-style-type: none"> ◆ Silicon germanium (SiGe) <ul style="list-style-type: none"> ❖ Very fast transistors: 25GHz ❖ "Ideal" transistor characteristics 	<ul style="list-style-type: none"> ⇒ 30-50% lower power operation ⇒ Higher speeds
<ul style="list-style-type: none"> ◆ Silicon-on-Insulator (SOI) <ul style="list-style-type: none"> ❖ Dramatically reduced transistor size ❖ Low-voltage coefficient capacitance 	<ul style="list-style-type: none"> ⇒ Reduction in package size ⇒ Lower distortion from reduced parasitics
<ul style="list-style-type: none"> ◆ Metal-metal capacitor 	<ul style="list-style-type: none"> ⇒ Improved accuracy ⇒ Extremely low distortion
<ul style="list-style-type: none"> ◆ Precision thin-film resistors 	<ul style="list-style-type: none"> ⇒ High accuracy ⇒ Low temperature variation
<ul style="list-style-type: none"> ◆ Very low 1/f noise and transistor internal resistance 	<ul style="list-style-type: none"> ⇒ Improved Signal-to-Noise Ratio (SNR)
<ul style="list-style-type: none"> ◆ High-voltage extension <ul style="list-style-type: none"> ❖ 40V, 3GHz transistors 	<ul style="list-style-type: none"> ⇒ Higher voltage for industrial applications




HPA07, HPA07HV: High-Performance Analog CMOS Process

Features	Benefits
◆ 0.3 μm feature sizes	⇒ ◆ Higher speeds and accuracy ◆ Low CapEx requirements
◆ 5V isolated CMOS transistors	⇒ ◆ Improved Signal-to-Noise Ratio (SNR) ◆ Integration of analog and digital
◆ Metal-metal capacitor	⇒ ◆ 4x increase in accuracy ◆ 40% area reduction
◆ Precision thin-film resistors	⇒ ◆ Lower test costs ◆ 30% reduction in package size
◆ High-voltage extension ◆ 40V transistors	⇒ ◆ Higher voltage for industrial applications



C05: 0.18 μm Analog Enhanced CMOS

Features	Benefits
◆ 0.18 μm feature sizes	⇒ ◆ High Digital Density ◆ Reduced Analog Circuit Parasitics
◆ Low voltage digital logic libraries	⇒ ◆ Low Power Integrated Digital Processing
◆ Multiple voltage rating CMOS analog transistors (up to 6V)	⇒ ◆ Support for 5V and Li-ion battery connections ◆ Optimized transistor vs voltage
◆ Isolated CMOS transistors	⇒ ◆ Improved Signal-to-Noise Ratio (SNR) and Total Harmonic Distortion (THD)
◆ Integrated resistors and capacitors optimized for analog design	⇒ ◆ Small die size ◆ Lower total solution cost ◆ Reduced package size



LBC7: BiCMOS Advanced 0.25μm Low-Voltage Power Technology

Features

- ◆ 7V - 40V power transistors

- ◆ Low-Vt, 3.3V, 5V, & 7V Analog CMOS

- ◆ 0.35μm/0.25μm design rules

- ◆ Isolated CMOS

- ◆ Thick Cu power buss

Benefits

- ◆ Lowest Rdson in industry – area efficient
- ◆ Robust SOA – improved reliability
- ◆ Enables larger battery charger currents & lower heat dissipation.

- ◆ Low OFF and standby leakage.
- ◆ Optimized for portable & LV systems power

- ◆ Increased digital density
- ◆ High yield, low cost process.

- ◆ Improved Latch-up and noise immunity

- ◆ Smaller die size
- ◆ Optimized performance
- ◆ Reduced package size



Leadership Processes Drive Product Innovation

Lowest power amp drives highest accuracy conversion

THS452x Amp → ADC

ADSS268x
ADS8321
ADS1278

Medical, Audio

Highest accuracy digital-to-analog converter

DAC9881

Medical, Test Equipment

Fastest dual 14-bit ADC

ADS62P48 ADS62P49
ADS62P28 ADS62P29

210 250
Speed (MSPS)

ADS62P49

Communications

TI's Class-G headphone amplifiers extend music playback time by 20%

DSP → DAC → Amp

TPA614A02/TPA6141A2

TPA614A02

Headphones, Media

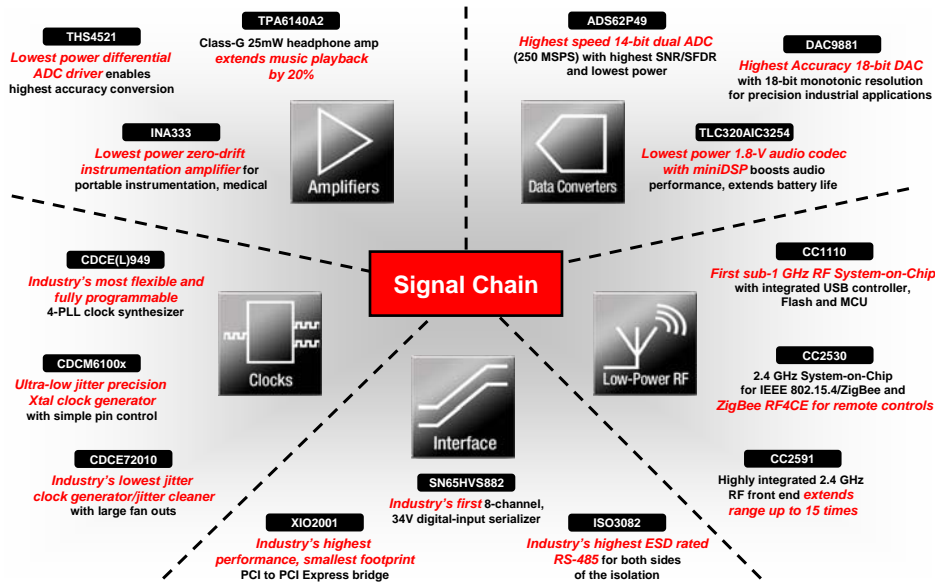


Industry Recognition

- **ADS5281 low-power, 12-bit octal ADCs**
 - *Electronic Design* Best ADC for Medical Applications (Tied w/National)
 - EDN China Innovation Award
- **ADS6149 wide-bandwidth, low-power, 12- and 14-bit ADCs**
 - *Electronic Design* Best Power/Performance Ratio for an RF ADC
- **AFE5805 analog front end for ultrasound**
 - *EDN Magazine's* Hot 100 new products of 2008
 - *Electronic Product Design* Europe e-Legacy Award
- **DAC5682Z 16-bit, 1GSPS DAC**
 - *Test & Measurement World* Best in Test Product Award (Finalist)
- **DAC9881 18-bit high-accuracy DAC**
 - EDN's 19th Annual Innovation Awards (2008) (Finalist: ADCs and DACs)
- **INA333 Low-power, zero-drift instrumentation amplifier**
 - *En-Genius.net* Product of the Year award
 - 2008 "Best" *Electronic Design* Winners for Best Continuous Improvement to Industry Standards for an Amplifier (Tied w/ADI)
- **SN65HVS882, 8-channel, digital-input serializer**
 - *Electronic Design* Best Industrial IC
 - *Embedded Control Europe* Reader Award Interface ICs "Silver"
- **TAS5414A/5424A automotive digital audio amplifier**
 - LSI of the Year 2008 (Japan), Finalist
- **Z-Accel CC2480 2.4-GHz ZigBee® network processor**
 - EDN's 19th Annual Innovation Awards (2008) (Finalist: ASSPs)



TI Signal Chain Portfolio at a glance...



Complete Signal Chain Portfolio

Precision Analog

- A/D Converters
- D/A Converters
- Op Amps
- Instrumentation Amps
- Differential Amps
- Log Amps
- Temperature Sensors
- Voltage References
- Shunt Monitors
- Comparators
- Touch Screen Control
- Gamma Buffers

Audio & Imaging

- Audio Amps
- Audio Converters
- Codecs
- Sample Rate Converters
- Mic Preamps
- Volume Controls
- Line Drivers
- Line Receivers
- CCD AFEs

Interface & Clocks

- RS-422/485
- Isolation, CAN
- Display, LVDS, Serdes
- USB, UART, RS232
- 1394, DVI, Switches
- PCIe, ESD, I²C
- Level Translation
- Line Circuits, Opto
- Clock Distribution
- Clock Generation
- Memory Clocks

High Speed

- A/D Converters
- D/A Converters
- Op Amps
- Mod/Demodulators
- Up/Down Converters
- Synthesizers
- Variable Gain Amps
- Video Muxes

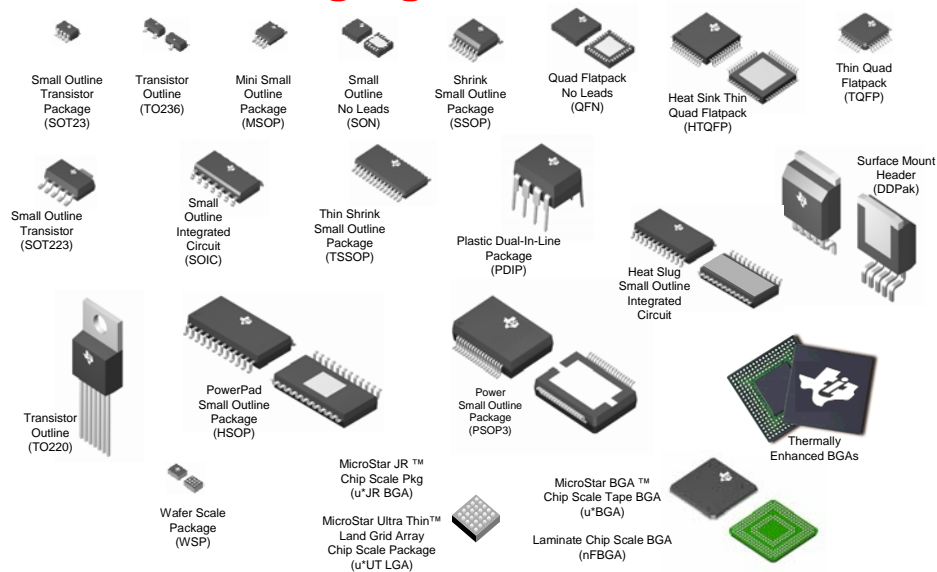
Low-Power RF

- System-on-Chip
- Transceivers
- Range Extenders
- ZigBee®
- Remote Control
- Wireless Audio

- More than 16,000 products – adding over 200/year
- 10-15 year typical product lifetime with no obsolescence



Broad Packaging Portfolio



Signal Chain Markets & Applications



Industrial

- Sensors
- Motor Control
- Test Equipment
- Blood Glucose Meter
- Personal Care



Communications

- Optical Networking
- Basestations
- Wireless Terminals
- Radar
- WiMax



Multimedia

- Portable Media Players
- Digital Video Recorders
- Media Gateways
- Digital Cameras
- PDAs



Computing

- Notebooks
- Servers
- Power Supplies
- LCD Monitors
- Disk Drives



Industrial Market



Industrial

- ◆ Sensors
- ◆ Motor Control
- ◆ Test Equipment
- ◆ Blood Glucose Meter
- ◆ Personal Care



Market Drivers

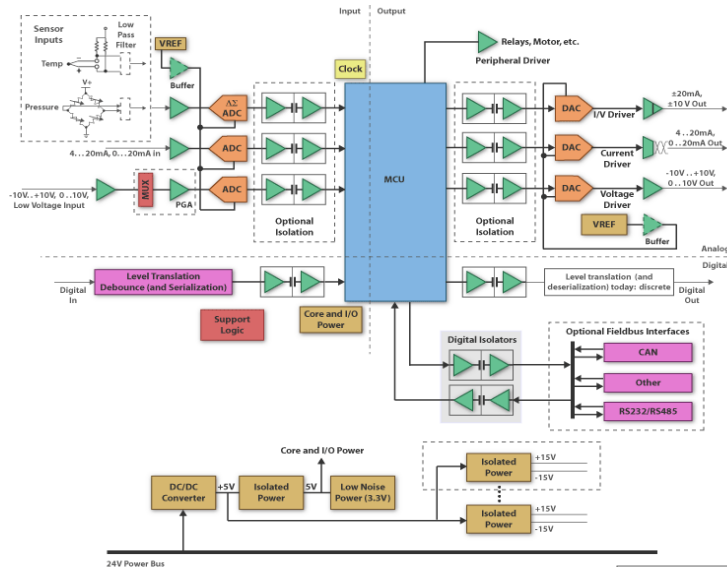
- ◆ Low Noise
- ◆ High Accuracy/Resolution
- ◆ Low Offset
- ◆ Low Drift
- ◆ Power
- ◆ Packaging

Key Product Innovations

- ADS1248 - 24-Bit Complete Temperature Measurement ADC
- ADS1675 - Industry's Widest Bandwidth 24-bit ADC
- DRV8402 - Industry's Highest Output Integrated Motor Driver
- DAC8568 - Industry's Highest Accuracy 8-Channel 16-bit DAC w/ref
- SN65HVS885 - Industry's first 5V industrial 8-channel serializer
- CC2530 - Industry's Most Complete 2.4GHz 802.15.4 RF SoC

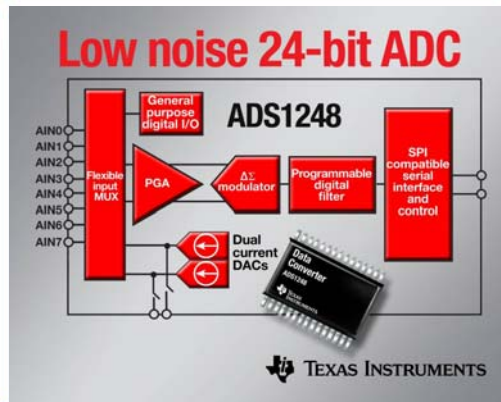


Programmable Logic Controller



TEXAS
INSTRUMENTS

ADS1248: 24-Bit Complete Temperature Measurement ADC



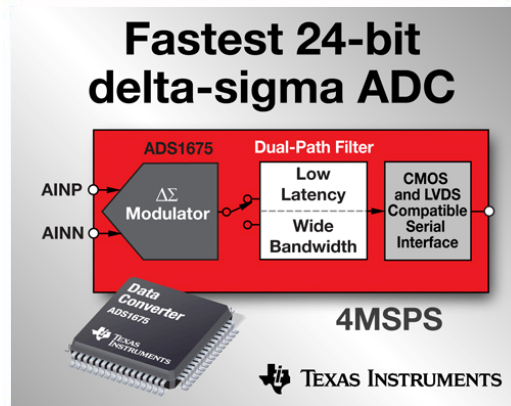
Supports:

- Temperature Measurement
- Industrial Process Control
- Flow/Pressure Measurement

- Integrated dual matched current sources and low noise (48nV) PGA up to 128 **provide complete solution reducing device count and simplifying design**
- 50/60Hz simultaneous noise rejection and low drift (4ppm/°C) reference **offers high integration without compromising performance**
- 2kSPS sample rate, 4 differential or 7 single-ended inputs, and +/-2.5V bipolar or 5V unipolar inputs **provide wide design flexibility**

TEXAS
INSTRUMENTS

ADS1675: Industry's Widest Bandwidth 24-bit ADC



- 4MHz wide bandwidth mode and 4MSPS sample rate device is **4x BW and 60% faster than nearest competitor**
- 2.65uS convert time **3 times faster than nearest competitor**
- Low latency mode **enables multi channel systems** through mux capability
- 575mW **40% lower power consumption than nearest competitor**

Supports:

- Vibration Analysis
- Precision Test and Instrumentation
- Advanced Sonar
- Image Stabilization



DRV8402: Industry's Highest Output (24A) Integrated Motor Driver



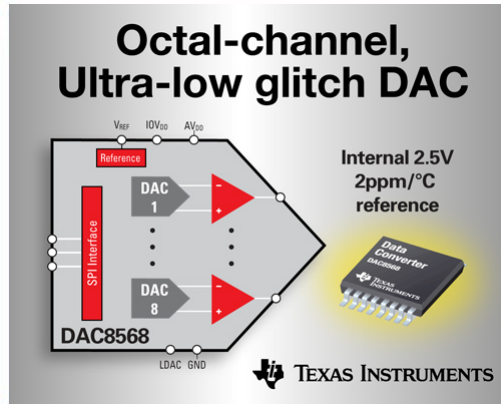
- Only integrated solution that can drive 500W continuous in a single package **reduces board space and maximizes performance**
- High efficiency (up to 96%) architecture **reduces system cooling costs**
- Integrated protection features (programmable current limit, two stage thermal protection) **reduces design complexity and improves reliability**
- DKD-36pin package **maximizes power dissipation** through use of exposed heat slug allowing optimized heat sinks

Supports:

- Brush DC, Stepper, and Brushless Motors
- Robotics
- Actuators and Pumps
- TEC Driver



DAC8568: Industry's Highest Accuracy 8-Channel 16-bit DAC w/Internal Reference



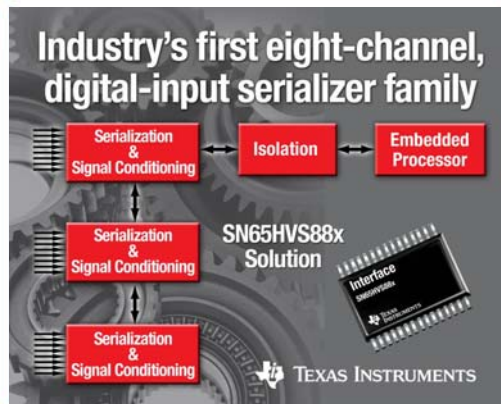
- Integration of 8 D/A channels and 2.5V reference **reduces device count by almost 90% and saves board space**
- $\pm 12\text{LSB}$ INL 25% better and low drift (2ppm) reference 10X better than nearest competitor **providing higher accuracy solution**
- Lowest output glitch energy of 0.15nV-Sec **reduces transients and lowers THD when generating waveforms**

Supports:

- Industrial Process Control
- Closed-Loop Servo-Control
- Optical Networking



SN65HVS88X: Industry's 1st Industrial 8-Channel, Digital-Input 0-34V Serializer



Industry's most compact
serializer – **saves 60% more
board space than
competition**

Lowest system power
dissipation – **saves 50%-
80% power in typical
industrial applications**

Ability to cascade devices
up to 160 inputs and 6.4mm
x 9.7mm package offers
highest level of integration

5Vs option with
SN65HVS885 offers **superior
design flexibility in low
voltage applications**

Supports:

- Sensors for Industrial Automation
- Programmable Logic Controllers
- Motion Control Systems



CC2530: Industry's Most Complete 2.4GHz 802.15.4 RF System-on-Chip

2.4 GHz System-on-Chip for IEEE 802.15.4, ZigBee® & RF4CE



TEXAS INSTRUMENTS

- 256K on chip flash 2X nearest competitor **enabling diverse network protocol support (Zigbee Pro, RF4CE, SimpliciiTI)**
- 400m+ line of sight range 2x over previous generation **lowering system cost**
- Current draw 25% lower than nearest competitor **increasing longevity for battery operated systems**
- Excellent selectivity and blocking performance **allows TI to be 8 times closer to interferer improving network performance and saving install costs**

Supports:

- Home and Commercial Building Automation
- Industrial Monitoring and Control
- Asset Tracking
- Sensor Networks



Communications Market



Communications

- ◆ Optical Networking
- ◆ Basestations
- ◆ Wireless Terminals
- ◆ Radar
- ◆ WiMax



Market Drivers

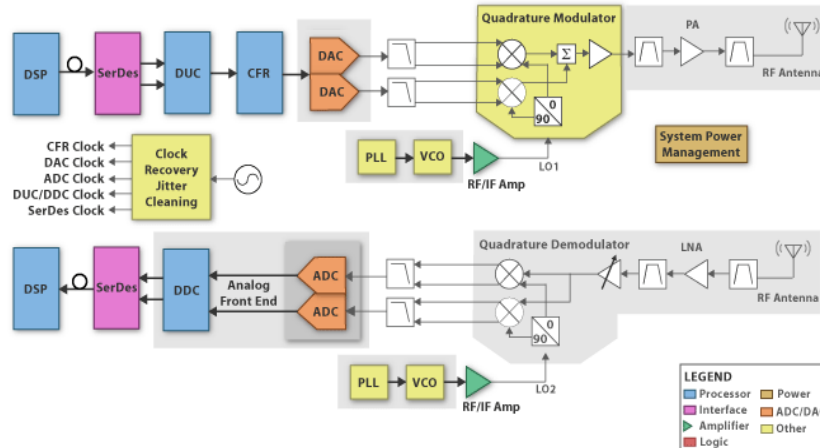
- ◆ Speed
- ◆ Resolution
- ◆ Bandwidth
- ◆ Gain
- ◆ Power
- ◆ Integration

Key Product Innovations

- THS452x – Lowest Power High Speed Fully Differential Amplifiers
- ADS62P49 – Industry's Fastest Dual 14-bit, 250MSPS ADC
- CDCM61001/2/4 – Pin Programmable Xtal Clock Generator Family
- SN65EL11 – 5.0V PECL/ECL 1:2 Fanout Buffer

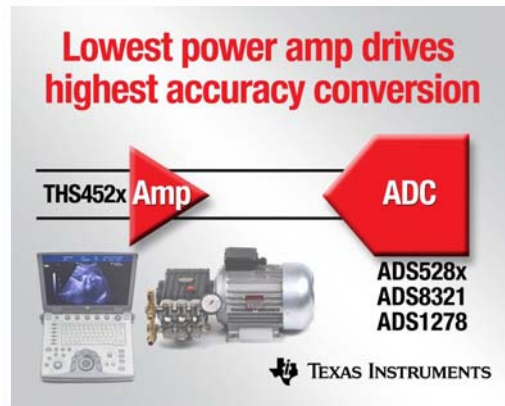


Wireless Communications



TEXAS
INSTRUMENTS

THS4521/2/4: Lowest Power High Speed Fully Differential Amplifier Family



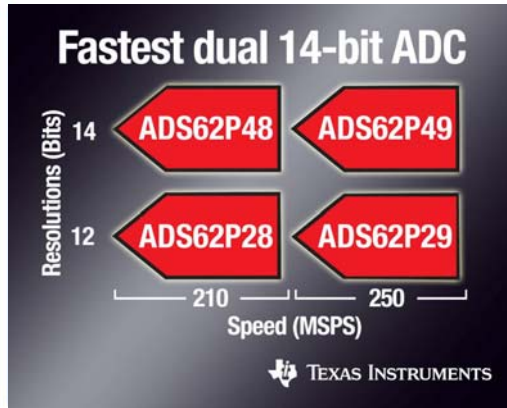
Supports:

- +3V and +5V Differential ADC Driver
- Portable Instrumentation
- Portable Medical
- Test and Measurement

- Ultra low supply current (1.14mA/ch) **consumes less than half the current** compared to the closest competitor
- 145 MHz bandwidth and 490 V/us slew rate **provide > 30% increased performance at low power**
- Input voltage noise of 4.6nV/rtHz **half the nearest competitor provides 50% increased dynamic range**
- Negative rail input and output Common-Mode control **allows easy DC coupling to ADC**
- Multi-channel options **save space and provide flexible solution for driving multi channel converters**

TEXAS
INSTRUMENTS

ADS62P49: Industry's Fastest Dual 14-bit, 250MSPS ADC



- Highest performance SNR and SFDR (73dB and 85dB @ 100MHz IF) **provides greater receiver sensitivity**
- Lowest power dual 14-bit 250MSPS (625mW/ch) **reduces thermal footprint**
- Small 9x9mm form factor and pin-compatible 12 and 14-bit sample rate options in same family (65-250MSPS) **save board space and improve design flexibility**

Supports:

- Wireless Communications
- Radar and Guidance Systems
- Test, Measurement, and Instrumentation



CDCM61001/2/4: Pin Programmable Xtal Clock Generator Family



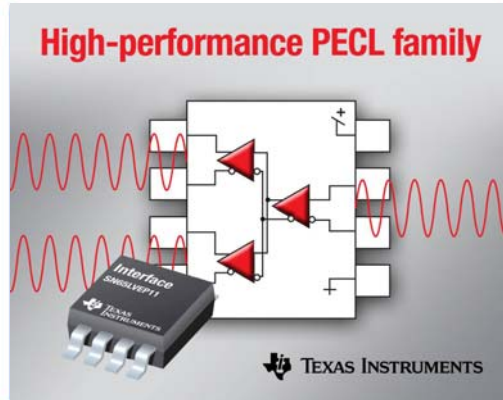
- Crystal/LVCMOS input frequencies of 25MHz, 25.5625MHz, and 24.8832MHz **eliminate need for costly oscillator alternatives – greatly reducing cost**
- 40% lower jitter (480fs) and nearly 3X VCXO frequency range (2 GHz) vs. nearest competitor **significantly improves system performance**
- Highly integrated solution and 25% smaller package (5x5mm QFN) **reduces device count, simplifies design, and saves boards space**

Supports:

- Datacom/Telecom
- Routers/Switches
- Wireless Infrastructure
- Networking



SN65EL11: 5.0V PECL/ECL 1:2 Fanout Buffer



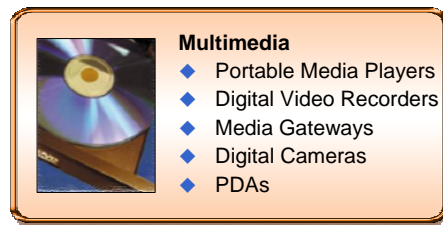
- Family of pin compatible fanout, buffer and translation devices to compete with On Semi and Micrel **offer improved performance and lower price**
- Replaces ON MC10, MC100 and Micrel SY10, SY100
Ex: MC100EL16 → SN65EL16
- Up to 33% speed improvement (2GHz) vs. nearest competitor **provides higher data throughput**

Supports:

- Data and Clock Transmission Over Backplane
- Signal Level Conversion
- Communications/Basestations



Multimedia Market



Market Drivers

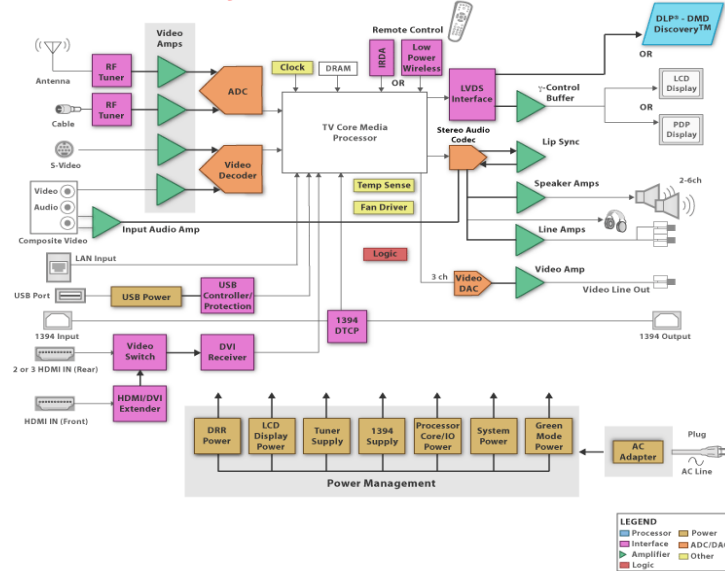
- ◆ Power
- ◆ Size
- ◆ Integration
- ◆ Cost

Key Product Innovations

- TAS5630/1 – Industry's First 600W class-D amp w/integrated feedback
- TLV320AIC3254 – Lowest power audio codec with integrated miniDSP
- TPA6140A2 – Class-G headphone amp with I2C volume control



Multimedia System



TEXAS
INSTRUMENTS

TAS5630/1: First 600W Class-D Amp with Integrated Feedback



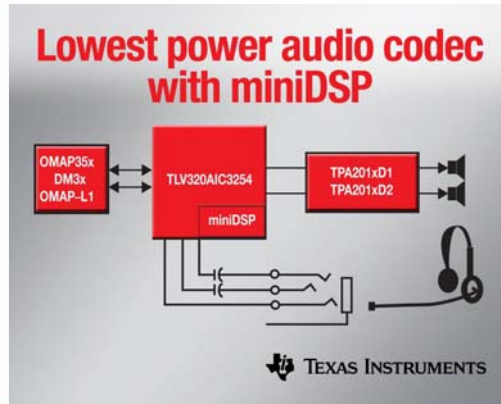
Supports:

- AV/DVD Receivers
- Home Theater in a Box
- Active Speakers

- Closed loop architecture offers superior PSRR & THD **reducing power supply noise and lowering system cost**
- Ability to accept analog (DAC) or PWM (modulator) inputs and provide mono, stereo, and quad configurations **enables flexible designs**
- Integrated under voltage, over temp, clipping, short circuit, and over current protection circuits **safeguard expensive speaker systems**

TEXAS
INSTRUMENTS

TLV320AIC3254: Lowest Power Audio Codec with Integrated miniDSP



Supports:

- Cell Phones
- Portable Media Players
- Portable Navigation Devices
- Headsets

- **PowerTune™** Technology allows user to control power vs. SNR to optimize power consumption
- **Embedded miniDSP** can run advanced audio processing algorithms **offloading host**
- **Integrated stereo headphone driver** **reduces device count and simplifies design**
- **Integrated LDOs** allow **single-supply operation** **lowering system cost**



TPA6140A2: Class-G DirectPath™ Headphone Amp with I²C Volume Control




Supports:

- Mobile/Smart Phones
- Portable Media/MP3 Players

- **Class-G architecture** saves power and **extends battery life up to 20% for MP3 playback**
- **DirectPath™ technology** **reduces board space by eliminating need for large output capacitors**
- **No turn-on or turn-off pop** **provides noiseless activation**
- **32 step, -60dB to +4dB gain range** **provides built in volume control with no external resistors**



Computing Market



Computing

- ◆ Notebooks
- ◆ Servers
- ◆ Power Supplies
- ◆ LCD Monitors
- ◆ Disk Drives

Market Drivers

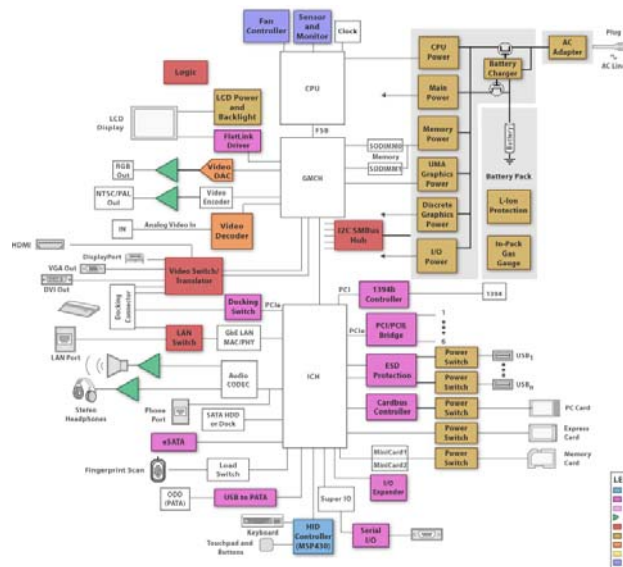
- ◆ Integration
- ◆ Cost
- ◆ Power
- ◆ Size
- ◆ Efficiency

Key Product Innovations

- TMP112 – Industry's Lowest Power High Accuracy Temp Sensor
- XIO2001 – Industry's Smallest PCI Express to PCI Bridge



Notebook PC



TMP112: Industry's Lowest Power High Accuracy (1°C) Digital Temp Sensor



- 10uA quiescent current **over 90% lower than next nearest competitor** increasing battery life
- 1°C accuracy over extend temp range (-40°C to 125°C) **nearly double nearest competitor and improves the accuracy of temperature monitoring and feedback systems**
- SOT563 package **68% smaller than nearest competitor's packaged device reducing board space and system cost**

Supports: • Computers – Servers, Desktop, Notebook
• Thermostat Controls
• Power Supplies – Thermal Management

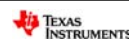


XIO2001: Industry's Smallest PCI Express to PCI Bridge



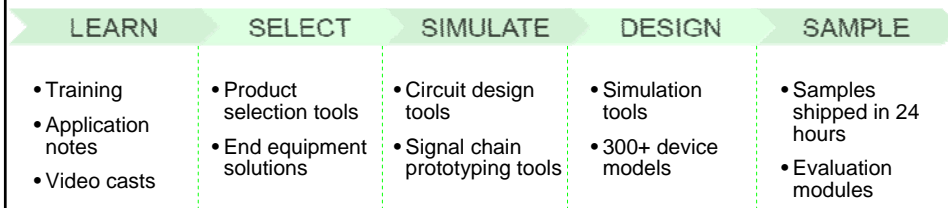
- Performance tuning application with Pre-Fetcher agent **allows for unique optimization to customer design**
- Industry's smallest 7x7 BGA package option **preserves customer board space**
- Compliance to PCI Express Base Spec 2.0 **provides seamless integration to latest and greatest I/O technologies**

Supports: • Desktop / Notebook Motherboards
• PC Add-in Cards
• Surveillance Camera Capture Card / DVRs



Signal Chain Tools & Support

- Common design cycle across all customers
- TI's Analog eLAB™ accelerates the process with online training and tools



Signal Chain Summary

More digital means more analog

Depth and breadth across portfolio

Innovative products and technologies

Applications and market expertise

Largest technical sales force

Tools and support to simplify design process



Have a safe trip home...

*Provide specific workshop feedback to:
Eric Wilbur
ericw@ti.com
Texas Instruments Technical Training*

