YOUR SEMICONDUCTOR SOLUTIONS RESOURCE Volume 10, Issue 3

TEST AND INSTRUMENTATION ICs

Contents

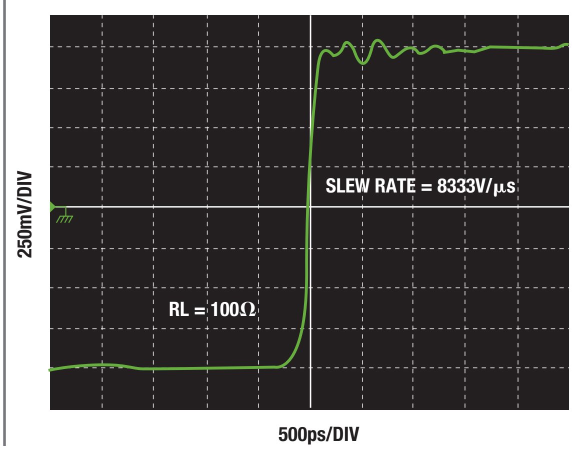
ADC Driver Provides Fast Slew Rates for Time Domain-Focused Instrumentation Applications

As electronic systems increase in frequency, speed, and bandwidth, new technical challenges arise that can limit system performance. The past few decades have seen an amazing expansion in the speed and frequency of electronic components, as well as many circuit innovations that have allowed users to improve their high frequency performance. However, not all applications are best addressed with a frequency domain focus. Often, time domain parameters wind up being the limiting constraint, especially in applications where transient analysis or pulse responses are the target measurement. This trend commonly appears in short acquisition time instrumentation, such as oscilloscopes, particle analyzers, and data acquisition systems where dc voltage level and high slew rates are of great importance and bandwidths extend to the gigahertz. Driving an analog-to-digital converter (ADC) to capture these high input slew rates can present a problem.

Solution

Designed specifically to drive 8-bit and 10-bit gigasample flash ADCs, the ADA4960 ultrawideband ADC driver/differential amplifier is a natural choice for these applications. The ADA4960 can drive signals from dc to 250 MHz with 70 dBc SFDR, to 500 MHz with 66 dBc SFDR, and to 1 GHz with 55 dBc SFDR. The device also offers excellent slew rates (differential slew rate = 8000 V/µs), as well as a low RTI noise of 3.6 nV/√Hz. The ADA4960 can support gain configurations from 6 dB to 18 dB, programmable with a single external gain setting resistor, which means that the nominal input impedance of 5 kΩ single-ended, 10 kΩ differential does not change with gain. These components are available as a single channel device in 16-lead, 3 mm × 3 mm LFCSP (ADA4960-1) and as a dual channel device in 24-lead, 4 mm × 4 mm LFCSP (ADA4960-2).

ADA4960 Slew Rate



Applications

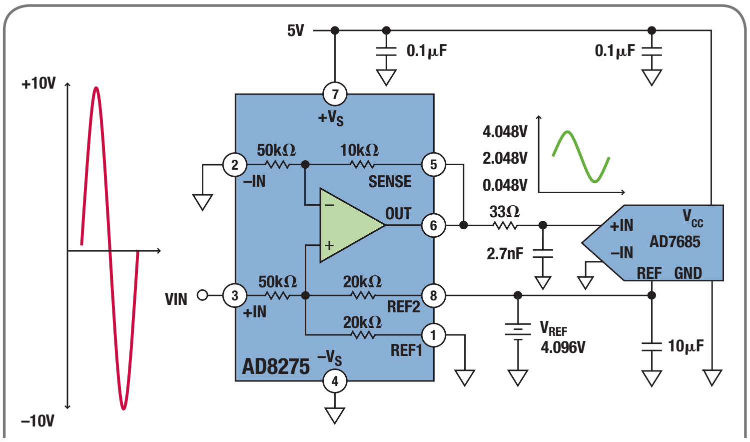
- Digital oscilloscope front ends
- Satellite communications equipment
- Broadband data acquisition
- Line drivers
- Defense and surveillance electronics

Level Translating 16-Bit ADC Driver Simplifies Signal Conditioning for High Voltage Designs

Driving higher than 16-bit successive approximation register (SAR) ADCs with up to 20 V p-p input signals in a small footprint is a challenge many designers face. Typical design challenges include achieving better than 16-bit and 18-bit converter noise performance, getting output signals to settle fast enough to meet requirements, using a single-supply part to interface to ±10 V industrial standard signals, operating over a –40°C to +85°C temperature range, and meeting tight cost and space requirements.

Solution

System designers now can use a single component to solve all these problems. The AD8275 ADC driver includes internal matched precision laser-trimmed resistors that achieve 0.02% gain error and 1 ppm/°C (max) gain drift. In addition to eliminating high voltage power supplies, the AD8275 eliminates discrete resistor dividers, driver amplifiers, and other signal conditioning circuitry previously required to drive SAR ADCs. By translating ±10 V signals to +4 V input levels, the 15 MHz AD8275 is especially suited for driving up to 250 kSPS 16-bit converters, including the AD7685 SAR ADC. The new difference amplifier can be configured to drive differential input converters, such as the AD7688 PulSAR® ADC, and can be used to drive lower sample rate 18-bit converters, including the AD7678 PulSAR ADC.



AD8275 Features

- Translates ±10 V to +4 V
- Drives 16-bit and 18-bit SAR ADCs
- Fast settling time: 450 ns to 0.001%
- THD + N: 106 dB

Applications

- Industrial and medical instrumentation
- Automated test equipment
- ADC driver
- Level translator
- Instrumentation amplifier building block

Current Output DACs Provide an Unmatched Combination of Speed, Accuracy, Low Power, and Integration in Time Domain Applications

In arbitrary waveform generation, instrumentation, and medical applications where positioning an analog signal to an exact value within the shortest interval is critical, the demand is for integrating more channels and functionality in the same board space. To achieve this higher level of integration and smaller package sizes, high speed current output DACs are tasked with not only delivering high accuracy and fast settling time specifications but also providing more functionality on lower power consumption.

Solution

To achieve fast digital-to-analog conversion, current output DACs are the solution of choice for mixed-signal board designers. This DAC architecture minimizes the output resistance, allowing faster settling time. Led by communications requirements, current DACs have achieved the required high update rates without compromising static accuracy.

The AD9726 is a true 16-bit accurate current output DAC with a maximum update rate of 400 MSPS, combining a single or double data rate LVDS data interface with a factory calibrated 20 mA differential current output for improved INL and DNL performance. The AD9726 operates from 2.5 V and 3.3 V power supplies.

The dual AD9117 features two 14-bit accurate current output DACs operating up to 125 MSPS update rate, integrating a double data rate CMOS digital interface with internally calibrated 20 mA differential current outputs. The AD9117 can operate with supplies between 1.8 V and 3.3 V.

AN-834 Application Note, *AD9786/AD9726 Calibration Engine.* For added flexibility, learn how to modify the AD9726 DAC's calibration engine. To access this note, visit *www.analog.com/AN-834*.

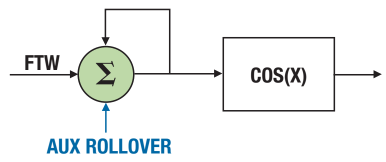
Precision Instrumentation Equipment Relies on Programmable Modulus DDS

Imagine a scenario in the lab where a precise 10 MHz signal is required to test your latest design. You dial your signal generator to 10 MHz, but hit 9.999999999 MHz. You then try to tick it over one more to hit your frequency exactly, but it jumps to 10.000000001 MHz. If you need to leave something running long term, that slight offset may eventually add up to a real problem. The inaccuracy is likely a result of the direct digital synthesis (DDS) technique being used to establish the signal being provided by the signal generator. The output frequency generated by a standard DDS device is only capable of binary division, as demonstrated in the equation $F_{OUT} = F_{REF}$ (FTW/2x), where F_{REF} is the reference frequency provided, frequency tuning word (FTW) is an integer value, and x is the bit width of the phase accumulator within the DDS. While extremely fine tuning can be achieved by increasing the size of the accumulator, nonbinary ratios cannot be implemented in the standard structure, so hitting exact frequencies is a challenge.

The AD9913 is the first device to implement the programmable modulus function. Most new DDS devices have an auxiliary accumulator on board, originally provided to make it easier to implement a phase or frequency sweep on the signal being generated. The AD9913 allows the user to set the rollover point for the auxiliary accumulator and adds an extra variable in the phase accumulator addition process, which is either 0 or 1 (as controlled by the auxiliary accumulator). Where Y is now any integer less than or equal to 2^{ATW} (ATW being the number of bits in the auxiliary accumulator):

$$F_{OUT} = \frac{FTW \times F_{REF}}{Y}$$

With programmable modulus DDS technology, it is easier to synthesize signals with more precise frequency control than ever before.



AN-953 Application Note, *DDS with a Programmable Modulus*. To access this note, visit *www.analog.com/AN-953*.

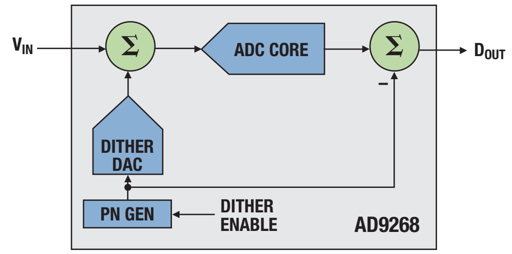
ADC with On-Chip Dither Simplifies System Design and Minimizes Impact on SNR Performance

Data acquisition and instrumentation applications that require excellent frequency domain performance with varying signal strength often use dither to improve spurious-free dynamic range (SFDR) with low level input signals. However, implementing dither at the board level requires additional components, increases processing overhead, and degrades the ADC SNR.

Solution

The AD9268 ADC simplifies data acquisition design by incorporating dither on chip. Dithering sums a small amount of noise with the analog input signal and digitally subtracts the noise from the data. This technique has been used at the board level for many years to minimize the effect of an ADC's differential nonlinearity (DNL). However, when dither is implemented outside of the ADC, the added noise consumes some of the ADC's input range and the signal of interest must be reduced to avoid saturating the ADC inputs.

The AD9268 includes optional dither that is enabled via the SPI port. When dither is enabled in the AD9268, the DNL tones are converted to white noise for small signal inputs. The largest benefit is seen with inputs from –6 dBFS to –30 dBFS. For instance, with a 70 MHz input signal amplitude 23 dB below full scale, the AD9268 SFDR without dither is 89 dBc, but with dither it improves to 106 dBc (operating at 125 MSPS). In most cases, dithering does not improve SFDR for large signal inputs because the SFDR is limited by the sampling network; but even with inputs close to full-scale, on-chip dither produces a whiter noise floor. Performance in oversampled systems is improved where the input BW is less than half the sample rate. By implementing dither inside the AD9268, a designer can take advantage of the full 2 V p-p input range and see improved SFDR when the input amplitude falls below –6 dBFS.



Applications

- Communications
- Diversity radio system
- I/Q demodulator circuits
- Broadband data applications.

The 16-bit AD9268 is a dual channel ADC available in 125 MSPS, 105 MSPS, and 80 MSPS versions. A single channel version, the AD9265, is also available. For 14-bit performance, the dual channel AD9258 and single channel AD9255 are available as well.

Test and Instrumentation Selection Guide

SAR ADCs

Part Number	Resolution (Bits)	Sampling Rate (kSPS)	Number of Channels	Power Dissipation (mW)	Package	Price ($U.S.)
AD7685	16	250	1	10	10-lead QFN	6.58
AD7986	18	2000	1	15	20-lead LFCSP	29.95

Σ-Δ ADCs

Part Number	Resolution (Bits)	Throughput Rate	Number of Channels	A_{IN} Range	Power Dissipation (mW)	Package	Price ($U.S.)
AD7780	24	16.7 SPS	1	$\pm(V_{REF}/gain)$	2.5	14-lead SOIC, 16-lead TSSOP	2.70
AD7781	20	16.7 SPS	1	$\pm(V_{REF}/gain)$	2	14-lead SOIC, 16-lead TSSOP	1.95
AD7190	24	4.8 kSPS	4	$\pm(V_{REF}/gain)$	36.7	24-lead TSSOP	5.90
AD7192	24	4.8 kSPS	4	$\pm(V_{REF}/gain)$	28	24-lead TSSOP	4.90

High Speed ADCs

Part Number	Resolution (Bits)	Sampling Rate (MSPS)	Number of Channels	SNR Performance (dB)	SFDR Performance (dB)	Power Dissipation (mW)	Package	Price ($U.S.)
AD9268	16	125, 105, 80	2	78.2	88	788	64-lead LFCSP	136.00
AD9255	14	125, 105, 80	1	78.3	93	371	48-lead LFCSP	33.00

ADC Drivers

Part Number	–3dB BW (MHz)	Minimum Gain A_{CL} (dB)	Supply Voltage (V)	Supply Current (mA)	Slew Rate (V/µs)	Distortion, 2nd (dB)	Distortion, 3rd (dBc)	Package	Price ($U.S.)
ADA4960	3000	Adj 0 to 15	2.5	60	8000	–77	–67	16-lead LFCSP, 24-lead LFCSP	6.95
AD8275	15	0.2 (fixed)	3.3 to 15	1.9	25	–106 (THD + N)	–106 (THD + N)	8-lead MSOP	1.60

Instrumentation Amplifiers

Part Number	Description	Single/Dual Supply	Supply Voltage (V)	Supply Current	Bandwidth G = 10 Typ (kHz)	Minimum CMRR @ 60 Hz Min Gain (dB)	Minimum CMRR @ 60 Hz Max Gain (dB)	V_{NOISE} RTI, 1 Hz to 10 Hz (µV p-p)	Price ($U.S.)
AD8220	Rail-to-rail JFET	Single/dual	4.6 to 36	750 µA	800	78	94	0.8	2.32
AD8221	High performance	Dual	4.6 to 36	1 mA	562	80	130	0.25	2.01
AD8226	Wide supply rail-to-rail output	Single/dual	2.2 to 36	400 µA	160	80	105	0.4	1.40
AD8295	Precision	Dual	4.6 to 36	2.3 mA	750	80	130	0.25	2.59

Precision DACs

Part Number	Resolution (Bits)	Output	Settling Time (µs)	Number of Outputs	Data Input Format	Supply Voltage (V)	Package	Price ($U.S.)
AD5542A	16	Bipolar	1	1	3-wire serial	–2.7 to +5.5	16-lead LFCSP	6.00
AD5541A	16	Unipolar	1	1	3-wire serial	–2.7 to +5.5	16-lead LFCSP	6.00

Direct Digital Synthesizers

Part Number	Max Clock Rate (MSPS)	DAC Resolution (Bits)	Control Interface	Output SFDR	Supply Voltage (V)	Power Dissipation	Package	Price ($U.S.)
AD9913	250	10	Parallel or serial	>80 dB	1.8	<50 mW	32-lead LFCSP	9.77

RS-485 Transceivers

Part Number	V_{CC} (V)	Isolation (kV rms)	ESD (kV)	True Fail-Safe	Data Rate	Duplex	Nodes	Package	Price ($U.S.)
ADM2587E	5 or 3.3	2.5	15	Yes	500 kbps	Half or full	256	20-lead wide-body SOIC	5.50
ADM2582E	5 or 3.3	2.5	15	Yes	16 Mbps	Half or full	256	20-lead wide-body SOIC	6.50

Blackfin® Processors

	ADSP-BF504 ADSP-BF504F ADSP-BF506	ADSP-BF512	ADSP-BF514 ADSP-BF516 ADSP-BF518	ADSP-BF522 ADSP-BF524 ADSP-BF526	ADSP-BF523 ADSP-BF525 ADSP-BF527	ADSP-BF531 ADSP-BF532	ADSP-BF533	ADSP-BF534 ADSP-BF535 ADSP-BF536	ADSP-BF537	ADSP-BF538 ADSP-BF539	ADSP-BF547 ADSP-BF548 ADSP-BF549	ADSP-BF561
LowestBOM cost	•	•		•	•	•						
Baseline connectivity	•	•		•	•	•	•					•
System connectivity (USB, Ethernet, or CAN)	•		•	•	•			•	•	•	•	
Low standby	•	•	•	•								
Lockbox® security		•	•	•	•						•	
System integration (flash, mixed signal)	•	•	•	•	•					•		
600 MHz or greater					•		•		•		•	•

Isolation

Part Number	Number of Channels	Data Rate (Mbps)	Isolated Output Power (mW)	Supply Voltage (V)	Current (mA)	Package	Price ($U.S.)
ADuM5401	4	25	500	3.3 or 5	100	16-lead SOIC	5.06

MEMS

Part Number	Range (*g*)	Sensitivity (mV/*g*)	Axis	Typical Bandwidth (kHz)	Supply Voltage (V)	Supply Current (mA)	Package	Price ($U.S.)
ADXL103	±1.7	1000	Single	5.5	3 to 6	0.7	8-lead ceramic leadless chip carrier	8.19
ADXL203	±1.7	1000	Dual	5.5	3 to 6	0.7	8-lead ceramic leadless chip carrier	8.19

DC-to-DC Converters

Part Number	V_{IN} Range	V_{OUT} Preset Options	V_{OUT} Adjust Options	I_{OUT} Max (mA)	Switching Frequency (MHz)	Supply Current (µA)	Package	Price ($U.S.)
ADP2503	2.3 to 5.5	2.8 to 5.0	Fixed	600	2.5	38	10-lead LFCSP	1.30

Supervisory

Part Number	Reset Threshold Summary	Minimum Reset Timeout (ms)	Reset Output Stage	Manual Reset	Package	Price ($U.S.)
ADM6316	26 options, 2.5 V to 5 V	1	Active high, push-pull/open-drain, active low/active low, push-pull	Yes	5-lead SOT-23	0.51
ADM809	2.93 V or 4.63 V	30	Active high, push-pull/active low, push-pull	No	3-lead SC70, 3-lead SOT-23	0.69

Circuits from the Lab: Tested Circuit Designs Provide Faster Time to Market and Lower Risks

Circuits from the Lab™

As design engineers look to build systems from the ground up, they often rely on various calculators, simulation models, software, and other design tools to aid in the selection, evaluation, and implementation of components.

Circuits from the Lab™ by Analog Devices is a new design assistance resource that provides engineers with tested circuit solutions for many common applications. Circuits from the Lab pairs at least two complementary components, such as an ADC and amplifier, to present a circuit optimized for a targeted application. Each circuit has been built and tested in the lab and can be easily integrated into designs, resulting in reduced design risk and faster time to market.

Featured Circuits from the Lab

CN-0123 Circuit Note, *Automated Calibration Technique Reduces the AD5360 16-Channel, 16-Bit DAC Offset Voltage to Less Than 1 mV*

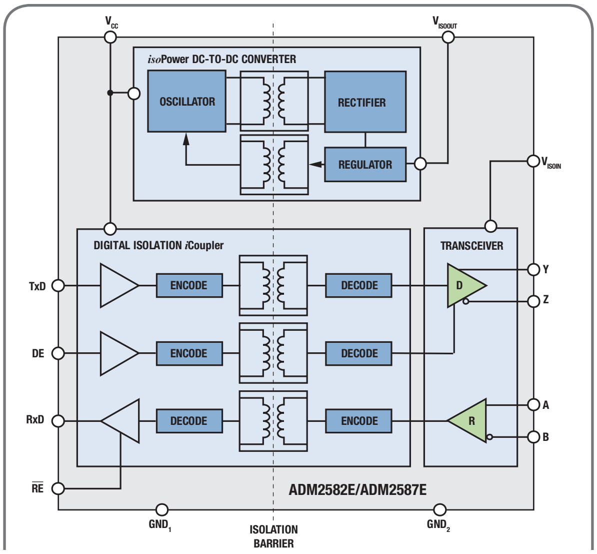
This circuit provides a method of calibrating that removes an unknown offset error. When using high precision, high resolution DACs in industrial process control and instrumentation applications, low offset is often a critical specification. The circuit uses built-in features of the AD5360 16-channel, 16-bit digital-to-analog converter, in conjunction with the AD790 comparator and the AD8597 operational amplifier, to determine if the DAC output voltages are above or below a ground reference signal. With the amount of offset known, the user can adjust the codes sent to the DAC to null out the offset. For access to this circuit note, visit *www.analog.com/CN-0123*.

Signal and Power Isolated RS-485 Transceivers Provide Integrated Solution for Robust Communications

The harsh real-world environment can expose equipment to large common-mode transient voltages caused, for example, by large motors starting and/or differences in ground potentials due to the long distances between equipment in or between buildings. Protection is needed for industrial communications ports in networked instruments against these types of transient threats.

Solution

The ADM2587E/ADM2582E transceivers are the first surface-mount RS-485/RS-422 transceivers to feature full isolation of both the data and power lines, incorporating well known *i*Coupler® and *iso*Power® isolation technologies from ADI. With a 2.5 kV isolation rating, the new RS-485/RS-422 transceivers comply with industry-standard isolation regulations, including UL 1577 and DIN VDE 0884-10, ensuring they will meet the robustness levels required in applications such as industrial PCs, self-service kiosks, environmental analysis, and water treatment facilities.



ADM2587E/ADM2582E Features

- Isolated RS-485/RS-422 transceiver, configurable as half or full duplex
- *iso*Power integrated isolated dc-to-dc converter
- ±15 kV ESD protection on RS-485 input/output pins
- Data rate: 16 Mbps/500 kbps
- 5 V or 3.3 V operation
- 256 nodes on bus
- True fail-safe receiver inputs
- High common-mode transient immunity: >25 kV/μs
- Safety and regulatory approvals (pending)
- UL recognition: 2500 V rms for 1 minute per UL 1577
- VDE certificates of conformity

Applications

- Chemical analysis, such as networked spectrum analyzers
- Environmental analysis, such as water quality analysis and treatment
- Industrial PCs and printers
- ATM, POS, self-service kiosks
- Industrial networked instrumentation
- Large form factor weigh scales

18-Bit, 2 MSPS High Performance ADC Dissipates Only 15 mW to Solve Heat Dissipation in Dense Data Acquisition System Designs

Designers of high channel count, high precision data acquisition systems inevitably face the challenges of minimizing both power consumption and design footprint. Achieving maximum system throughput under these circumstances required either multiplexed high speed resolution ADCs, which generate more heat, or multiple low speed resolution ADCs, taking up extra board space.

Solution

With power dissipation levels nearly 15× lower than the competition and a smaller footprint, the AD7986 eliminates the need for such trade-offs. The AD7986 is an 18-bit, 2 MSPS ADC that offers an industry-leading combination of 97 dB SNR performance and only 15 mW power consumption in a 20-lead QFN package. Now high channel density and high resolution can be achieved without compromising heat or size, allowing designers to get more out of their designs.

AD7986 Features

- 18-bit resolution with no missing codes
- Throughput: 2 MSPS (TURBO = high), 1.5 MSPS (TURBO = low)
- Low power dissipation: 15 mW with external V_{REF}, 26 mW with internal V_{REF}
- SNR: 97 dB with external V_{REF}

Applications

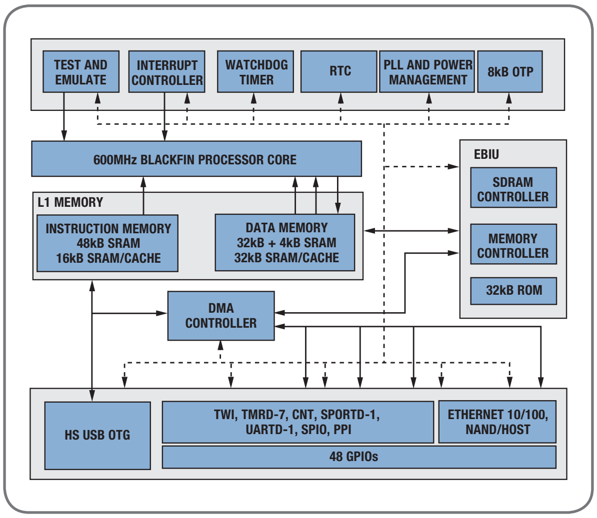
- Battery-powered equipment
- Process control systems
- Medical instruments
- Seismic data acquisition system

Enhanced System Level Connectivity in Instrumentation Applications

As the user requirement for instruments to interface with networks and other devices including computers becomes more prevalent, so does the requirement for the embedded processors inside the instruments to support system level connectivity.

Solution

Two of the most ubiquitous means of system level connectivity are Ethernet and universal serial bus (USB). Ethernet offers the ability to connect to IP-based packet switched networks. USB provides the ability for devices such as electronic instruments for measurement, analysis, and data acquisition to interface to each other, to computers, and even to power supplies. Both Ethernet and USB are not only widely accepted but offer plug and play connectivity. Typically, Ethernet is used in instrumentation to enable access to network resources (printers, network storage devices), remote control, and message notification. USB offers a low cost, high bandwidth, plug and play interface to other devices (flash memories, human interface devices, other instruments) and computers.



The ADSP-BF524/ADSP-BF526 and ADSP-BF525/ADSP-BF527 offer both USB 2.0 HS connectivity and 10/100 Ethernet connectivity. The ADSP-BF524 and ADSP-BF526 with 400 MHz core clock speeds offer USB and USB/Ethernet connectivity, respectively, for lower power applications, while the ADSP-BF525 and ADSP-BF527 with 600 MHz core clock speeds offer USB and USB/Ethernet connectivity, respectively, for high performance applications. Included as part of the ADSP-BF52x embedded processors are software stacks for Ethernet/IP, as well as USB. It is also important to note that the ADSP-BF52x family, as members of the Blackfin® portfolio of embedded processors, have both true digital signal processing capabilities, as well as the ability to perform system level controller functions such as network stack processing, LCD interface, human interface device processing (keypad, capacitive touch screen), bulk memory storage, and other functions.

Features

- Up to 600 MHz Blackfin processor
- USB 2.0 high speed on-the-go (OTG) with integrated PHY
- IEEE 802.3-compliant 10/100 Ethernet MAC
- Code security with Lockbox Secure Technology one-time-programmable (OTP) memory

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Integrated Signal Conditioning Simplifies Design and Saves Power in Weigh Scale Applications

Accurate weigh scales rely on high performance analog signal processing to precisely digitize low level signals. As weigh scales become smaller, lower power, and less expensive, this design challenge gets more difficult to solve.

Solution

The Σ-Δ ADCs from ADI solve these problems at varying performance and price points. Σ-Δ ADCs are traditionally used to accurately process very small real-world signals from sensors measuring parameters like temperature, weight, pressure, and flow. Featuring high resolution with low offset and drift, the Σ-Δ ADC fulfills the requirements for weigh scales.

The AD7190 Σ-Δ ADC features an advanced on-chip PGA with ultralow noise and drift from dc to 4.8 kHz. This PGA enables the AD7190 to achieve only 8.5 nV rms noise with gain at 128 and 4.7 Hz update rate. This performance translates to 20.5 bits of noise-free resolution with an input signal of only ±40 mV.

For systems that require lower power consumption, while maintaining accuracy, the AD7192 is a pin and functionally compatible option. Where the AD7190 consumes 6 mA of current, the AD7192 only uses 4.35 mA. The noise is only 11 nV rms with gain at 128 and 4.7 Hz update rate.

For battery-powered weigh scales, the AD7780 and AD7781 Σ-Δ ADCs offer the lowest power consumption in their class. The AD7780 and AD7781 include an on-chip clock oscillator and consume only 330 μA. These ADCs also have a power-down mode that allows the user to switch off the power to the bridge sensor and power down the ADC when not converting, thus increasing the battery life of the product.

Finally, for systems that need to optimize integration, the ADuC7061 is a low power precision analog microcontroller with dual Σ-Δ ADCs, Flash/EE memory, and an ARM7 microcontroller. The ADuC7061 incorporates many of the features of standalone Σ-Δ ADCs, such as a power-down mode that will switch off power to the bridge sensor and an on-chip clock oscillator.

Circuits from the Lab™

ADI engineers offer multiple tested circuit solutions for designing a precision weigh scale system. For access to these circuit notes, visit *www.analog.com/circuits* and view the News section.

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