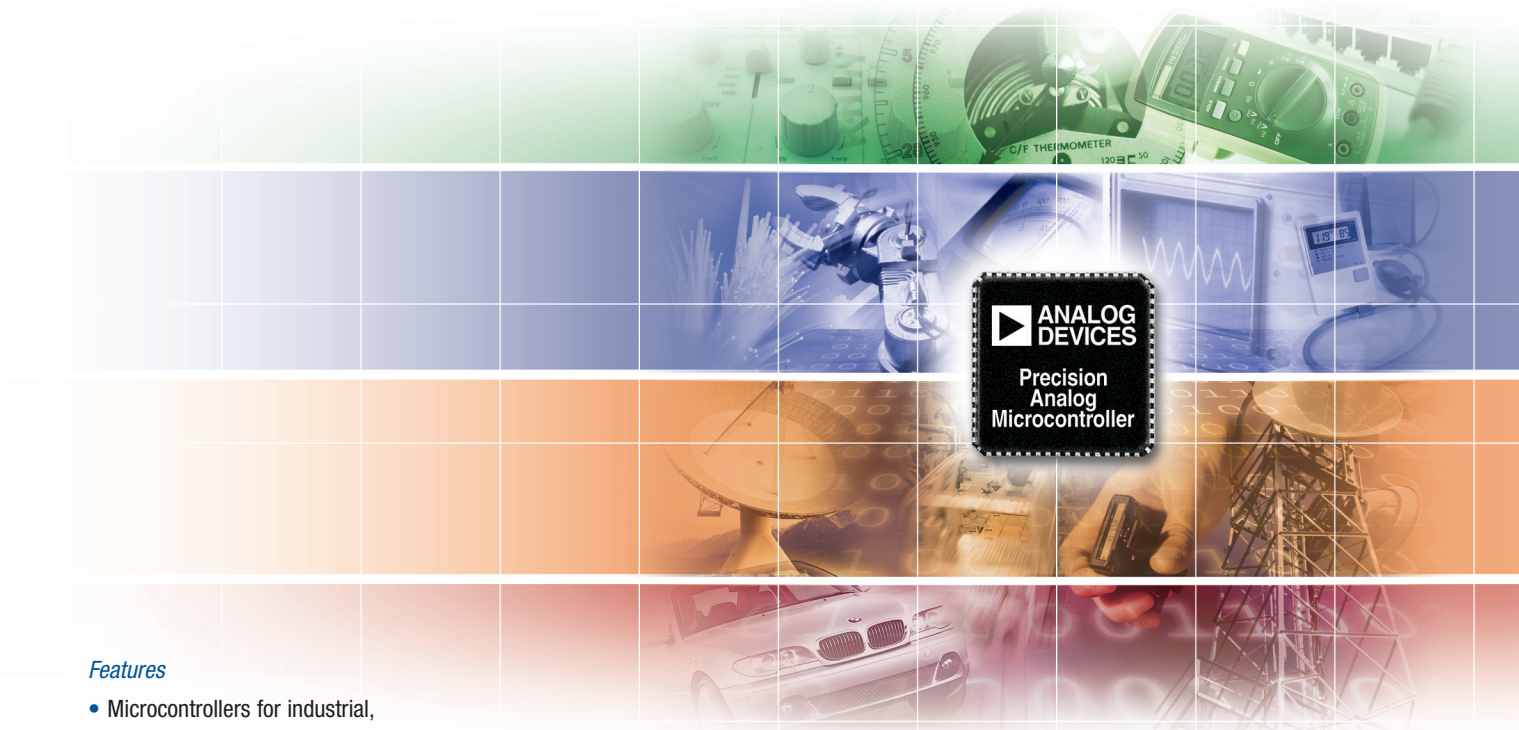# Precision Analog Microcontrollers

Features

- Microcontrollers for industrial, instrumentation, medical, communications, and automotive applications

- Leading edge mixed-signal integration with 12-, 16-, or 24-bit ADCs, multiple 12-bit DACs, reference and temperature sensor.

- ARM7TDMI Flash/EE and 24-bit analog-to-digital converters in 5 mm × 5 mm LFCSP

- 3-phase PWM, quadrature encoder, PLA, and up to 128 kB Flash/EE, plus 8 kB SRAM

- Fully integrated solution for automotive battery monitoring (ADuC703x series)

- 8052 MicroConverter series with Flash/EE and 12-bit to 24-bit analog I/O

- Complete suite of development tools

Precision Analog Microcontrollers—ARM7™ and 8051 Series

Analog Devices precision analog microcontrollers combine precision analog functions, such as high resolution ADCs and DACs, a voltage reference, and temperature sensor with an industry-standard microcontroller and flash memory. For example, the ADuC702x ARM7TDMI® family integrates 12-bit analog I/O with flash, SRAM, and a host of digital peripherals. These devices use a single 32-bit bus for instructions and data, integrate a JTAG test port for debug access, and operate up to 44 MHz. In addition to the 32-bit ARM® instruction set, the core supports an instruction set that is compressed into 16 bits (Thumb® mode). The on-chip precision analog I/O includes a multichannel 1 MSPS, 12-bit ADC, up to four 12-bit voltage-output DACs, a low drift band gap voltage reference, a temperature sensor, 3-phase PWM, a user-configurable PLA, and an uncommitted voltage comparator. All of this, and more, come in a variety of package footprints with the smallest being a tiny 5 mm × 5 mm, 32-lead chip scale package.

Getting more application specific, the ADuC7128/ADuC7129 extend the ADuC702x series to include a quadrature encoder and PWM for dc motor control applications. They also feature a 32-bit, 22 MHz DDS input followed by a high speed 10-bit DAC and a 100 Ω line driver, useful for transducer excitation.

The ADuC703x series, specifically for automotive battery monitoring, integrates up to three 16-bit ADCs to measure battery voltage, current, and temperature, the required high voltage I/O for direct battery interface, and an LIN transceiver to handle communications to the engine control unit.

The new ADuC706x series with the ARM7 core, dual and single 24-bit Σ-Δ ADCs, PGA, 14-bit DAC, and precision current sources are particularly suited to direct connection and signal processing in precision sensor and loop-powered applications.

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ANALOG
DEVICES

ARM7 Core Products with Precision 12-Bit Analog I/O (ADuC7019 to ADuC7028, ADuC7128, and ADuC7129)

Architectural Overview

The ARM7TDMI core is a 32-bit RISC machine. It uses a single 32-bit bus for instructions and data. The TDMI option provides four additional features: a secondary 16-bit Thumb (T) instruction set, debug (D) support, support for long multiples (M), and includes the embedded ICE (I) module containing the breakpoint and watchpoint registers, which allow code to be halted for debugging purposes.

Each ADuC7xxx device operates from an accurate ($\pm3\%$) on-chip oscillator and PLL generating an internal 41.7 MHz clock that is routed through a programmable clock divider from which the MCU operating frequency is generated. Alternatively, the parts can run from a master clock up to 44 MHz. Power consumption is 1 mA/MHz.

Either 126 kB, 62 kB, or 32 kB of nonvolatile Flash/EE and 8 kB of SRAM are provided on chip with both blocks mapped into a single linear array. ARM code can run directly from SRAM at 41.7 MHz/44 MHz (internal/external clock), given that the SRAM is configured as a 32-bit wide memory array. The 80-lead devices support external memory.

On-chip firmware supports in-circuit serial download via the UART or I²C® and JTAG serial interface ports while nonintrusive emulation is also supported via the JTAG interface.

Key Features

- ARM7TDMI MCU core
- 16-/32-bit RISC architecture, 44 MHz operation
- Embedded JTAG for debug

Memory Organization

- 8 kB SRAM in 2k × 32 bits
- Up to 126 kB Flash/EE in 31k × 16 bits
- Retention: 20 years
- Endurance: >10k cycles
- In-system programming (ISP) via UART, I²C, or JTAG ports

Analog I/O

- Multichannel, 12-bit, 1 MHz ADC
- Multiple 12-bit V_{OUT} DACs
- 40 ppm/°C V_{REF}, 3°C temp sensor
- Uncommitted comparator

Additional Features

- 2 × GP timers
- Programmable logic array (PLA)
- UART, SPI, dual I²C, serial I/O
- Up to 40 GPIO pins
- Power supply monitor and power-on reset
- 3-phase PWM
- Specified for 3 V operation (5 V compatible I/O)
- Temperature range: −40°C to +125°C
- 6 mm × 6 mm and 9 mm × 9 mm LFCSP, 64-lead and 80-lead LQFP package options
- 1 mA/MHz current consumption
- Low cost QuickStart™ Development System support
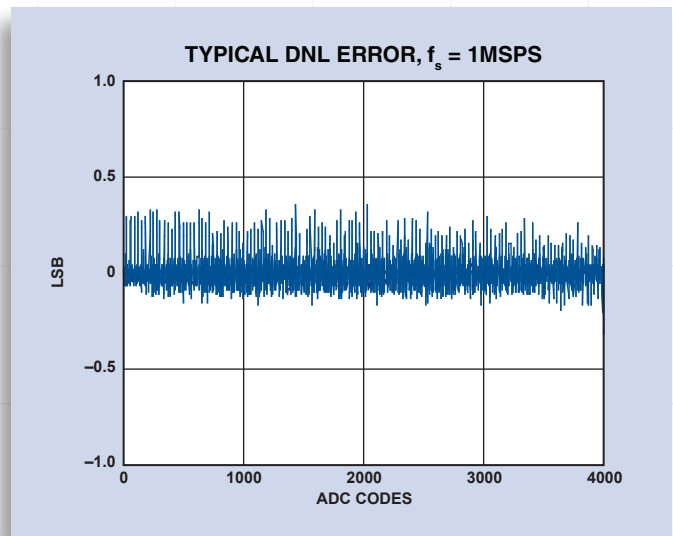
Differential nonlinearity plot of 12-bit ADC on ADuC7xxx device with core running at full speed.
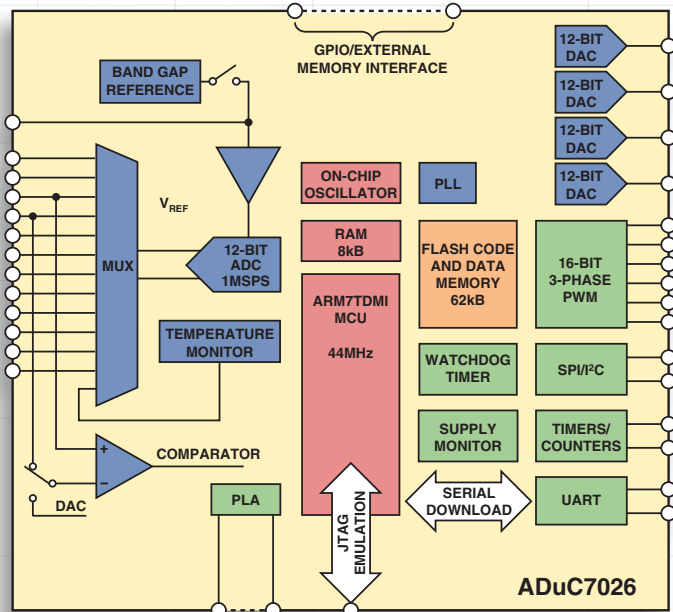
ADuC7xxx Series On-Chip Peripherals

High performance analog I/O and several other peripherals are included on chip. Some of them are examined here.
See the selection guide for a complete listing.

12-Bit ADC

- Key specs @ 1 MSPS
  - INL = ±0.6 LSB
  - Offset/gain = ±0.5 LSB
  - SNR = 69 dB
- Input ranges: 0 V to V_{REF} or ±V_{REF}
- Input modes: single, pseudo, and fully differential
- Trigger modes
  - External CONVST pin
  - Timer overflow
  - Software trigger
  - PLA trigger
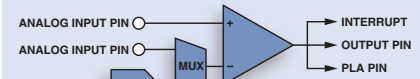 - Continuous
  - Up to 16 channels (ADuC7027)
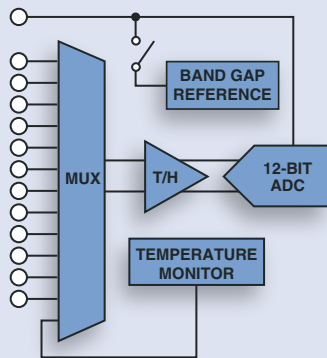
12-Bit Multichannel V_{OUT} DAC

- Monotonic to 12 bits
- Buffered/unbuffered outputs
- 10 μs settling time
- Output range of 0 V to V_{DD}
- 4 DACs on the ADuC7020/ADuC7026/ADuC7028
- 2 DACs on the ADuC7021/ADuC7024
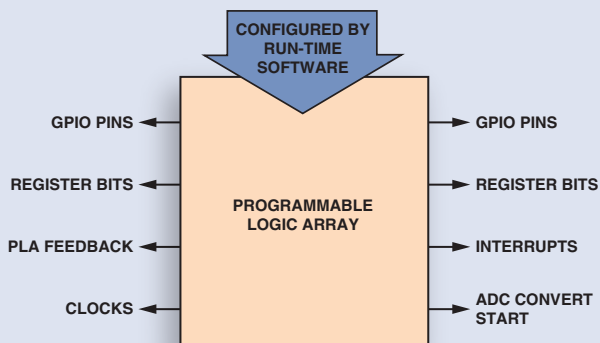- 3 DACs on the ADuC7019
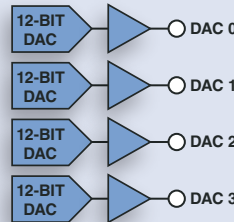
Voltage Comparator

The comparator can be configured to generate an interrupt if a voltage input exceeds a threshold level. The threshold voltage can be set via an external pin or by using one of the on-chip 12-bit DACs. The output of the comparator can also be routed both to the on-chip PLA and digital output pin, or to the on-chip interrupt controller. The comparator features 10 mV hysteresis and 1 μs response.

BAND GAP REFERENCE / MUX / T/H / 12-BIT ADC / TEMPERATURE MONITOR

12-BIT DAC → DAC 0
12-BIT DAC → DAC 1
12-BIT DAC → DAC 2
12-BIT DAC → DAC 3

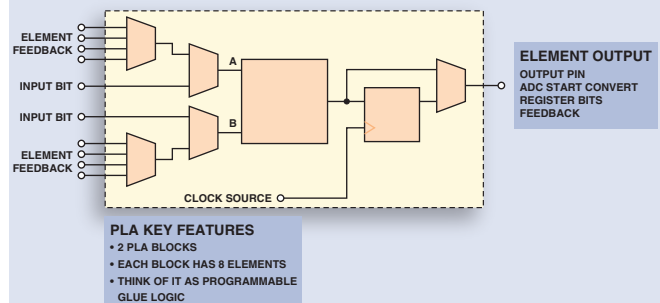ANALOG INPUT PIN / ANALOG INPUT PIN / DAC / MUX / INTERRUPT / OUTPUT PIN / PLA PIN

Programmable Logic Array (PLA)

The integrated PLA consists of two interconnected blocks of eight PLA elements for added flexibility. Each element can be configured to generate any logic output function based on two inputs, eliminating the need for external logic gates. The PLA is programmed with run-time code via the standard memory-mapped register (MMR) interface.

PLA FUNCTIONALITY

CONFIGURED BY RUN-TIME SOFTWARE

GPIO PINS ← PROGRAMMABLE LOGIC ARRAY → GPIO PINS
REGISTER BITS ← → REGISTER BITS
PLA FEEDBACK ← → INTERRUPTS
CLOCKS ← → ADC CONVERT START

SINGLE PLA ELEMENT

ELEMENT FEEDBACK / INPUT BIT / INPUT BIT / ELEMENT FEEDBACK / CLOCK SOURCE / A / B / ELEMENT OUTPUT (OUTPUT PIN, ADC START CONVERT, REGISTER BITS, FEEDBACK)

PLA KEY FEATURES
- 2 PLA BLOCKS
- EACH BLOCK HAS 8 ELEMENTS
- THINK OF IT AS PROGRAMMABLE GLUE LOGIC

ARM7 Series with Quadrature Encoder and H-Bridge PWM for Motor Control
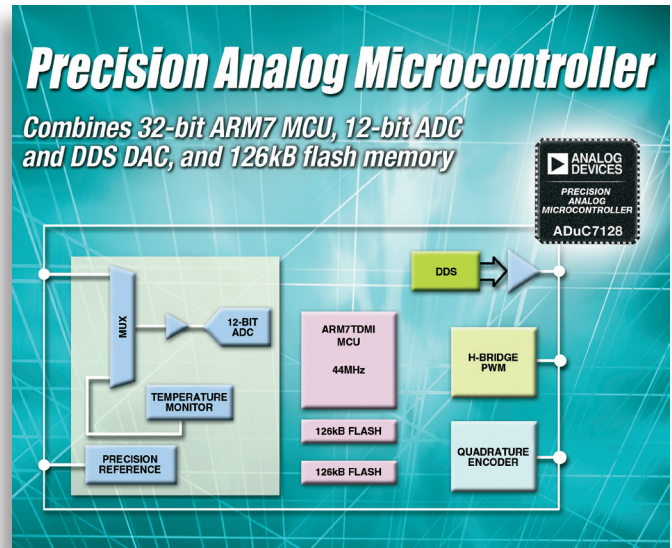
ADuC7128/ADuC7129

The ADuC7128/ADuC7129 combine an ARM7 microcontroller, 12-bit, 1 MSPS ADC, and a 10-bit DAC, along with a 16-bit PWM with H-bridge mode and quadrature encoder. There is a 32-bit, 22 MHz DDS input to the DAC, which also incorporates a 100 Ω line driver. This level of integration benefits designers of brushless dc (BLDC) and instrumentation systems, reducing external component count, while working in a familiar ARM7 environment.

Key Features

- ARM7 with 126 kB flash

- 10-bit DAC with 32-bit, 22 MHz DDS

- 16-bit PWM generator

- 10-channel, 12-bit, 1 MSPS ADC

- Quadrature encoder

- Temperature range: −40°C to +125°C

Additional Features

- Dual UART

- Differential line driver output

- 64-lead LFCSP package and 80-lead LQFP package
  (external memory)

Precision Analog Microcontroller
Combines 32-bit ARM7 MCU, 12-bit ADC and DDS DAC, and 126kB flash memory

DDS DAC Operation

- 32-bit DDS register

- 4096 point table

- 0.005 Hz resolution

- Minimum frequency: 0.005 Hz

- Maximum frequency limited by LPF

- THD: 51 dB typ
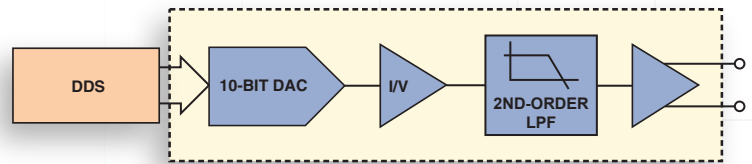
Application Focus: ADuC7128/ADuC7129 in H-Bridge Motor Control

The ADuC7128 integrates a 6-channel PWM interface. The PWM outputs can be configured to drive an H-bridge or can be used as standard PWM outputs. On power-up, the PWM outputs default to H-bridge mode. This ensures that the motor is turned off by default. In standard PWM mode, the outputs are arranged as three pairs of PWM pins. Users have control over the period of each pair of outputs and of the duty cycle of each individual output.
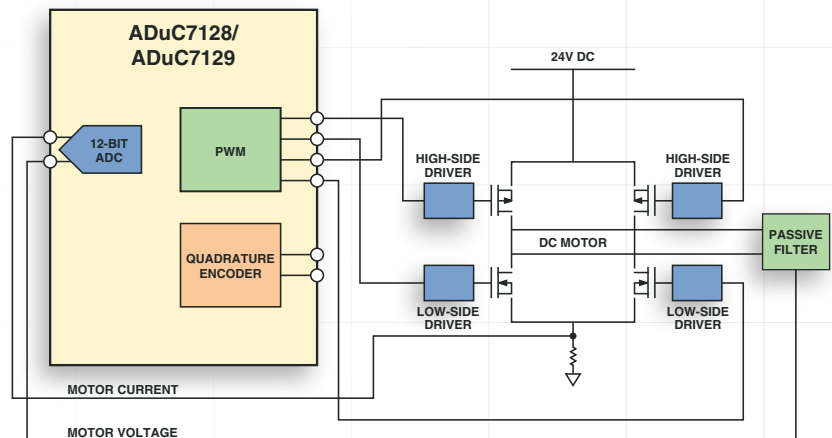
Integrated Battery Sensor for Automotive Battery Monitoring Includes High Voltage Physical Interface for LIN

ADuC703x Family

The ADuC703x family of automotive battery monitor solutions addresses a growing need to monitor and distribute power, and provide priority to critical functions such as engine startup. The ADuC703x family measures elementary physical variables such as battery voltage, current, and temperature to determine the battery's state-of-charge (SOC) and state-of-health (SOH). The vehicle's energy management system then uses this data to reserve sufficient battery energy for a guaranteed engine start and to tailor the charging cycles resulting in reduced fuel consumption.

The ADuC703x family integrates an on-chip PGA (programmable gain amplifier) for a wide range of battery current measurements and, similarly, attenuation for battery voltage measurement. Also on board are up to three 16-bit analog-to-digital converters (ADCs), an ARM7 microcontroller, a local interconnect network (LIN) transceiver, and embedded memory in a single package. The devices offer a cost-efficient and space-saving alternative to discrete solutions, which consists of a standalone processor, LIN transceiver, low dropout regulator (LDO), and analog front end (AFE). As a result, the component can be located between the battery terminal and the connector on the main power cable, giving a great saving in space and cost, while simplifying overall battery monitoring system design.

Key Features
- ARM7TDMI MCU core
- Operates from 12 V battery supply
- Low power consumption
- 175 μA in low power mode
- Up to 10 mA at 10 MHz in regular mode

Memory Organization
- 6 kB SRAM
- 96 kB Flash/EE
- Retention: 20 years @ 85°C

Analog I/O
- 3 × 16-bit Σ-Δ ADC
- 5 ppm/°C V_{REF}
- ±2°C temperature sensor
- Digital comparator and integrator

Additional Features
- Programmable gain amplifier (PGA)
- PLL
- Precision oscillator (±1%)
- Timers (watchdog, wake-up, 2 × GP)
- Power supply monitor
- Power-on reset
- LIN (local interconnect network) transceiver
- Temperature range: −40°C to +125°C
- 7 mm × 7 mm, 48-lead LFCSP package

Integrated Automotive Battery Sensor Solution

- Fully integrated complete solution
- 3 × 16-bit ADCs measure battery V, I, and T
- High voltage attenuation
- 5ppm/°C reference and T 1% oscillator
- Small footprint, 7mm × 7mm, 48-lead LFCSP

For automotive battery performance management, the integration of leading-edge data converters and high voltage circuits with a high end, industry-standard MCU and flash memory has provided the automotive designer with a high performance, low cost, easy to use solution.
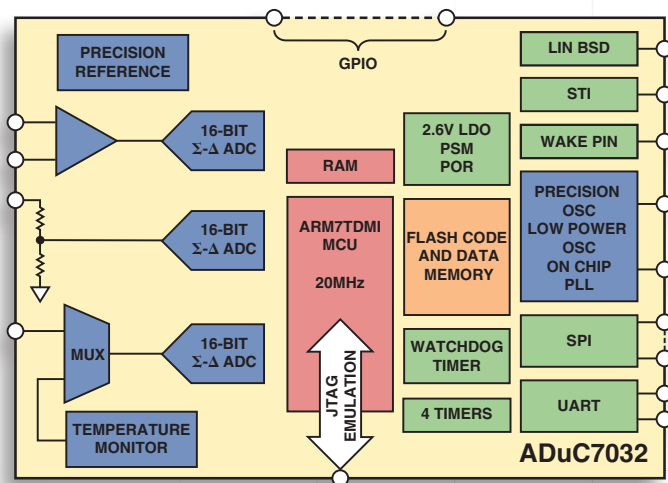
Part Number	ADCs	Flash (kB)	SRAM (kB)	Timers	Package	Price @ 1k ($U.S.)
ADuC7032	3	96	6	4	48-lead LQFP	7.55
ADuC7033	2	96	6	5	48-lead LFCSP, 48-lead LQFP	7.10
ADuC7034	2	32	4	5	48-lead LFCSP, 48-lead LQFP	6.73

Precision Analog Microcontroller (MicroConverter®) Products

Part Number	MCU, MIPS	Flash Code (Bytes)	Flash Data (Bytes)	RAM (Bytes)	External Memory Interface	Power Supply (V)	GPIOs[1]	Download/ Debug	ADCs	DACs	Temp Sensor Accuracy (°C)[2]
SAR 12-Bit Analog-to-Digital Precision Analog Microcontroller Products with ARM7 Core											
ADuC7019	ARM7, 44	62k	8k		None	2.7 to 3.6	14	JTAG + UART/I²C[6]	12-bit, 5-channel (2 differential), 1 MSPS	12-bit, triple	±3.0
ADuC7020	ARM7, 44	62k	8k		None	2.7 to 3.6	14	JTAG + UART/I²C[6]	12-bit, 5-channel (2 differential), 1 MSPS	12-bit, quad	±3.0
ADuC7021	ARM7, 44	62k, 32k	8k		None	2.7 to 3.6	13	JTAG + UART/I²C[6]	12-bit, 8-channel (4 differential), 1 MSPS	12-bit, dual	±3.0
ADuC7022	ARM7, 44	62k, 32k	8k		None	2.7 to 3.6	13	JTAG + UART/I²C[6]	12-bit, 10-channel (5 differential), 1 MSPS	None	±3.0
ADuC7024	ARM7, 44	62k	8k		None	2.7 to 3.6	30	JTAG + UART/I²C[6]	12-bit, 10-channel (5 differential), 1 MSPS	12-bit, dual	±3.0
ADuC7025	ARM7, 44	62k, 32k	8k		None	2.7 to 3.6	30	JTAG + UART/I²C[6]	12-bit, 12-channel (5 differential), 1 MSPS	None	±3.0
ADuC7026	ARM7, 44	62k	8k		Code and data	2.7 to 3.6	40	JTAG + UART/I²C[6]	12-bit, 12-channel (6 differential), 1 MSPS	12-bit, quad	±3.0
ADuC7027	ARM7, 44	62k	8k		Code and data	2.7 to 3.6	40	JTAG + UART/I²C[6]	12-bit, 16-channel (8 differential), 1 MSPS	None	±3.0
ADuC7028	ARM7, 44	62k	8k		None	2.7 to 3.6	30	JTAG + UART/I²C[6]	12-bit, 8-channel (4 differential), 1 MSPS	12-bit, quad	±3.0
SAR 12-Bit Analog-to-Digital Precision Analog Microcontroller Products with ARM7 Core and H-Bridge PWM											
ADuC7128	ARM7, 44	126k	8k		None	3.0 to 3.6	28	JTAG + UART/I²C[6]	12-bit, 10-channel (5 differential), 1 MSPS	10-bit DAC, PWM	±3.0
ADuC7129	ARM7, 44	126k	8k		Code and data	3.0 to 3.6	38	JTAG + UART/I²C[6]	12-bit, 10-channel (5 differential), 1 MSPS	10-bit DAC, PWM	±3.0
Multichannel 24-Bit Σ-Δ Analog-to-Digital Converters with ARM7 Core											
ADuC7060 *New*	ARM7, 10.24	32k	4k		No	2.5	16	JTAG, UART, I²C	Dual, 24-bit, 5-channel/ 8-channel, 8 kSPS	Single, 14-bit	±3.0
ADuC7061 *New*	ARM7, 10.24	32k	4k		No	2.5	8	JTAG, UART, I²C	Dual, 24-bit, 5-channel/ 8-channel, 8 kSPS	Single, 14-bit	±3.0
ADuC7062 *New*	ARM7, 10.24	32k	4k		No	2.5	8	JTAG, UART, I²C	Single, 24-bit, 5-channel, 8 kSPS	Single, 14-bit	±3.0
Σ-Δ (16-Bit Analog-to-Digital) Precision Analog Microcontroller Products with ARM7 Core for Automotive Battery Management											
ADuC7032	ARM7, 20	96k	6k		None	3 to 18	9	JTAG	3 × 16-bit Σ-Δ ADC	—	±2.0
ADuC7033	ARM7, 20	96k	6k		None	3 to 18	9	JTAG	2 × 16-bit Σ-Δ ADC	—	±2.0
ADuC7034	ARM7, 20	32k	4k		None	3 to 18	9	JTAG	2 × 16-bit Σ-Δ ADC	—	±2.0
Multichannel Σ-Δ (24-Bit and 16-Bit Analog-to-Digital) MicroConverter Products with 8052 Core											
ADuC845	8052, 12	62k, 32k, 8k	4k	2k + 256	Data only	2.7 to 3.6 4.75 to 5.25	32	Single pin or UART	24-bit, dual, 1.3 kSPS	12-bit, single	±1.5
ADuC847	8052, 12	62k, 32k, 8k	4k	2k + 256	Data only	2.7 to 3.6 4.75 to 5.25	32	Single pin or UART	24-bit, 1.3 kSPS	12-bit, single	None
ADuC848	8052, 12	62k, 32k, 8k	4k	2k + 256	Data only	2.7 to 3.6 4.75 to 5.25	32	Single pin or UART	16-bit, 1.3 kSPS	12-bit, single	None
Σ-Δ (24-Bit and 16-Bit Analog-to-Digital) MicroConverter Products with 8052 Core											
ADuC816	8052, 1.0	8k	640	256	Code and data	2.7 to 5.25	32	Single pin or UART	16-bit, dual, 105 kSPS	12-bit, single	±1.5
ADuC824	8052, 1.0	8k	640	256	Code and data	2.7 to 5.25	32	Single pin or UART	24-bit and 16-bit, 105 kSPS	12-bit, single	±1.5
ADuC834	8052, 1.0	62k	4k	2k + 256	Code and data	2.7 to 5.25	32	Single pin or UART	24-bit and 16-bit, 105 kSPS	12-bit, single	±1.5
ADuC836	8052, 1.0	62k	4k	2k + 256	Code and data	2.7 to 5.25	32	Single pin or UART	16-bit, dual, 105 kSPS	12-bit, single	±1.5
Successive Approximation 12-Bit Analog-to-Digital MicroConverter Products with 8052 Core											
ADuC812	8052, 1.3	8k	640	256	Code and data	2.7 to 5.5	32	Single pin or UART	12-bit, 8-channel, 200 kSPS	12-bit, dual	±3.0
ADuC814	8052, 1.3	8k	640	256	None	2.7 to 5.5	16	Single pin or UART	12-bit, 8-channel, 247 kSPS	12-bit, dual	±1.5
ADuC831	8052, 1.3	62k	4k	2k + 256	Code and data	2.7 to 5.5	32	Single pin or UART	12-bit, 8-channel, 200 kSPS	12-bit, dual	±1.5
ADuC832	8052, 1.3	62k	4k	2k + 256	Code and data	2.7 to 5.5	32	Single pin or UART	12-bit, 8-channel, 200 kSPS	12-bit, dual	±1.5
ADuC841	8052, 20	62k, 8k	4k	2k + 256	Data only	2.7 to 3.6 4.75 to 5.25	32	Single pin or UART	12-bit, 8-channel, 400 kSPS	12-bit, dual	±1.5
ADuC842	8052, 16	62k, 32k, 8k	4k	2k + 256	Data only	2.7 to 3.6 4.75 to 5.25	32	Single pin or UART	12-bit, 8-channel, 400 kSPS	12-bit, dual	±1.5
ADuC843	8052, 16	62k, 32k, 8k	4k	2k + 256	Data only	2.7 to 3.6 4.75 to 5.25	32	Single pin or UART	12-bit, 8-channel, 400 kSPS	None	±1.5

[1] Pins that are also analog inputs are limited to digital input only, i.e., GPI, not GPIO. In the case of the ARM7 parts, all pins are full GPIO.

[2] Temperature sensor is calibrated on all Σ-Δ parts, while it is not calibrated on the successive approximation parts.

[3] **TIC:** time interval counter.

PWMs	Reference	Serial Ports	Clocking	Timers[3]	Other Peripherals[4]	Temperature Range[5] (°C)	Package	Price @ 1k ($U.S.)
See note 7	Internal 40 ppm or external	UART, SPI, 2 I²C ports	External, internal (3%), PLL (prog)	2 × 32-bit, 2 × 16-bit	PLA, comparator, PSM, POR	−40 to +125	6 mm × 6 mm, 40-lead LFCSP	6.34
See note 7	Internal 40 ppm or external	UART, SPI, 2 I²C ports	External, internal (3%), PLL (prog)	2 × 32-bit, 2 × 16-bit	PLA, comparator, PSM, POR	−40 to +125	6 mm × 6 mm, 40-lead CSP	6.80
See note 7	Internal 40 ppm or external	UART, SPI, 2 I²C ports	External, internal (3%), PLL (prog)	2 × 32-bit, 2 × 16-bit	PLA, comparator, PSM, POR	−40 to +125	6 mm × 6 mm, 40-lead CSP	4.32
See note 7	Internal 40 ppm or external	UART, SPI, 2 I²C ports	External, internal (3%), PLL (prog)	2 × 32-bit, 2 × 16-bit	PLA, comparator, PSM, POR	−40 to +125	6 mm × 6 mm, 40-lead CSP	3.98
3-phase, 16-bit	Internal 40 ppm or external	UART, SPI, 2 I²C ports	External, internal (3%), PLL (prog)	2 × 32-bit, 2 × 16-bit	PLA, comparator, PSM, POR	−40 to +125	9 mm × 9 mm, 64-lead LFCSP and 64-lead LQFP	7.00
3-phase, 16-bit	Internal 40 ppm or external	UART, SPI, 2 I²C ports	External, internal (3%), PLL (prog)	2 × 32-bit, 2 × 16-bit	PLA, comparator, PSM, POR	−40 to +125	9 mm × 9 mm, 64-lead LFCSP and 64-lead LQFP	5.24
3-phase, 16-bit	Internal 40 ppm or external	UART, SPI, 2 I²C ports	External, internal (3%), PLL (prog)	2 × 32-bit, 2 × 16-bit	PLA, comparator, PSM, POR	−40 to +125	80-lead LQFP	8.80
3-phase, 16-bit	Internal 40 ppm or external	UART, SPI, 2 I²C ports	External, internal (3%), PLL (prog)	2 × 32-bit, 2 × 16-bit	PLA, comparator, PSM, POR	−40 to +125	80-lead LQFP	6.42
3-phase, 16-bit	Internal 40 ppm or external	UART, SPI, 2 I²C ports	External, internal (3%), PLL (prog)	2 × 32-bit, 2 × 16-bit	PLA, comparator, PSM, POR	−40 to +125	6 mm × 6 mm, 64-ball BGA	6.80
6-channel, 16-bit	Internal 40 ppm or external	2 UARTs, SPI, 2 I²C ports	External, internal (2%), PLL (prog)	1 × 16-bit, 3 × 32-bit, 1 × 48-bit	PLA, comparator, PSM, POR	−40 to +125	9 mm × 9 mm, 64-lead LFCSP	6.95
6-channel, 16-bit	Internal 40 ppm or external	2 UARTs, SPI, 2 I²C ports	External, internal (2%), PLL (prog)	1 × 16-bit, 3 × 32-bit, 1 × 48-bit	PLA, comparator, PSM, POR	−40 to +125	9 mm × 9 mm, 64-lead LFCSP	7.74
6-channel	Internal ±10 ppm	UART, SPI, I²C	External, internal (3%), PLL (prog)	4 × timers	SPI/I²C/vectored interrupt controller	−40 to +125	48-lead LQFP, 48-lead LFCSP	4.90
2-channel	Internal ±10 ppm	UART, SPI, I²C	External, internal (3%), PLL (prog)	4 × timers	SPI/I²C/vectored interrupt controller	−40 to +125	5 mm × 5 mm, 32-lead LFCSP	3.95
2-channel	Internal ±10 ppm	UART, SPI, I²C	External, internal (3%), PLL (prog)	4 × timers	SPI/I²C/vectored interrupt controller	−40 to +125	5 mm × 5 mm, 32-lead LFCSP	3.40
—	Internal 5 ppm	LIN transceiver, SPI	Internal (1%), PLL (prog)	1 × 16-bit, 3 × 32-bit, 1 × 48-bit	Comparator, wake-up, WDT	−40 to +125	48-lead LQFP	7.55
—	Internal 5 ppm	LIN transceiver, SPI	Internal (1%), PLL (prog)	1 × 16-bit, 3 × 32-bit, 1 × 48-bit	Comparator, wake-up, WDT	−40 to +125	48-lead LFCSP, 48-lead LQFP	7.10
—	Internal 5 ppm	LIN transceiver, SPI	Internal (1%), PLL (prog)	1 × 16-bit, 3 × 32-bit, 1 × 48-bit	Comparator, wake-up, WDT	−40 to +125	48-lead LFCSP	6.73
Dual, 16-bit	Internal or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT, Isources, burnout	−40 to +125	56-lead LFCSP, 52-lead MQFP	8.95
Dual, 16-bit	Internal or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT, Isources, burnout	−40 to +125	56-lead LFCSP, 52-lead MQFP	5.85
Dual, 16-bit	Internal or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT, Isources, burnout	−40 to +125	56-lead LFCSP, 52-lead MQFP	4.98
None	Internal or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × TIC	PSM, WDT, Isources, burnout	−40 to +85	56-lead LFCSP, 52-lead MQFP	5.59
None	Internal or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × TIC	PSM, WDT, Isources, burnout	−40 to +85	56-lead LFCSP, 52-lead MQFP	6.07
Dual, 16-bit	Internal or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT, Isources, burnout	−40 to +125	56-lead LFCSP, 52-lead MQFP	12.32
Dual, 16-bit	Internal or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT, Isources, burnout	−40 to +125	56-lead LFCSP, 52-lead MQFP	9.85
None	Internal or external	UART, SPI, I²C	External	3 × 16-bit	PSM, WDT	−40 to +125	56-lead LFCSP, 52-lead MQFP	8.30
None	Internal or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × TIC	POR, PSM, WDT	−40 to +125	28-lead TSSOP	4.52
Dual, 16-bit	Internal or external	UART, SPI, I²C	External	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT	−40 to +125	56-lead LFCSP, 52-lead MQFP	8.76
Dual, 16-bit	Internal or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT	−40 to +125	56-lead LFCSP, 52-lead MQFP	8.76
Dual, 16-bit	Internal 20 ppm or external	UART, SPI, I²C	External	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT	−40 to +85	56-lead LFCSP, 52-lead MQFP	6.56
Dual, 16-bit	Internal 20 ppm or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT	−40 to +85	56-lead LFCSP, 52-lead MQFP	6.56
Dual, 16-bit	Internal 20 ppm or external	UART, SPI, I²C	Internal, PLL	3 × 16-bit, 1 × baud rate, 1 × TIC	POR, PSM, WDT	−40 to +85	56-lead LFCSP, 52-lead MQFP	5.15

[4] **PSM:** power supply monitor; **WDT:** watchdog timer; **POR:** power-on reset; **Isources:** current sources; **burnout:** sensor burnout capability; **PLA:** programmable logic array.
[5] 125°C applies to the MQFP package only.
[6] UART/I²C download only.
[7] Can be used through PLA.

Application Focus: Electrocardiogram Using ADuC7021

An electrocardiogram (ECG) is the recording of the electrical activity on the body surface generated by the heart. This electrical activity is collected by skin electrodes placed on predetermined parts of the body. A low cost implementation of an ECG monitor is shown in the schematic here, and for the main signal processing, the ADuC7021 MicroConverter device is chosen. This part features the necessary high performance analog peripherals, a fast ARM7 core, integrated 62 kB flash for code, and several other useful peripherals. The ADC converts the analog signal from the differential amplifier to a digital signal. The software, resident in the ADuC7021 flash, then processes the digitized signal to produce the final ECG trace. Because of the flash-based code memory on the ADuC7021, this customization can be done after manufacture or even as the individual patient's needs change.

For more information, see complete technical article at *www.analog.com/library/analogdialogue/archives/37-11/ecg.pdf.*
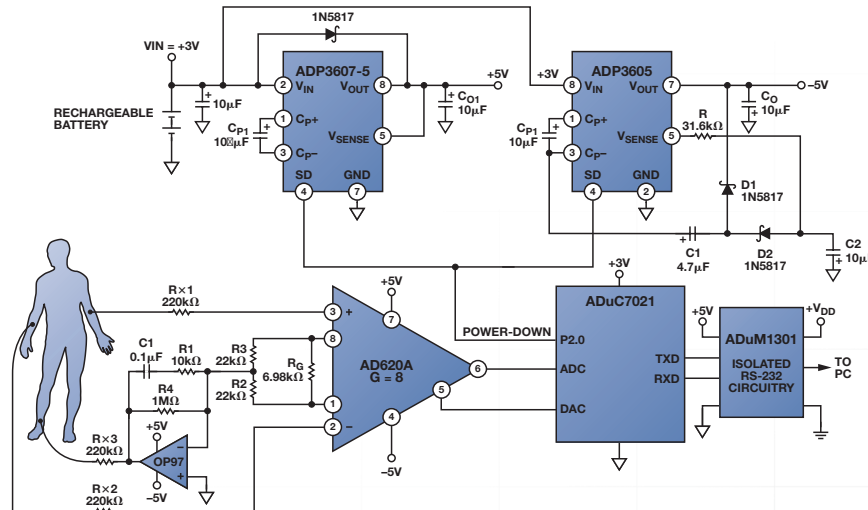

Application Focus: Pulse Oximeter Uses ADuC7024

Beyond heart rate, blood pressure, respiratory rate, and temperature—pulse oximetry is considered to be the "fifth vital sign" of health status. A pulse oximeter is a medical device that provides a noninvasive measure of the amount of oxygen in a patient's arterial blood.

A typical oximetry sensor has a pair of light-emitting diodes (one red with 660 nm wavelength, one infrared with 940 nm wavelength) facing a photodiode through a translucent part of the patient's body, usually a fingertip or an earlobe. The percentage of blood oxygen is calculated based on the absorption rate from each wavelength of light after it passes through the patient's body.

The precision analog microcontroller family of products from Analog Devices includes the key analog building blocks required for high end oximetry designs. The ADuC7024, used here, includes a high performance, high speed, multichannel, 12-bit, 1 MSPS ADC and two DACs. The MicroConverter device also includes a 32-bit ARM7TDMI core. Running at 41.8 MHz, it provides a very powerful computational platform for digital signal processing algorithms to detect arterial blood pulsations, while allowing plenty of CPU performance for additional functions, such as control of the graphics LCD display. The ADuC7024 MicroConverter device features 30 general-purpose I/Os (GPIOs), required for interfacing with the LCD. With fewer I/Os, the same level of performance can be achieved by using the ADuC7021, available in a space-saving 6 mm × 6 mm LFCSP package.

For more information, see complete technical article at *www.analog.com/library/analogdialogue/archives/41-01/pulse_oximeter.html.*
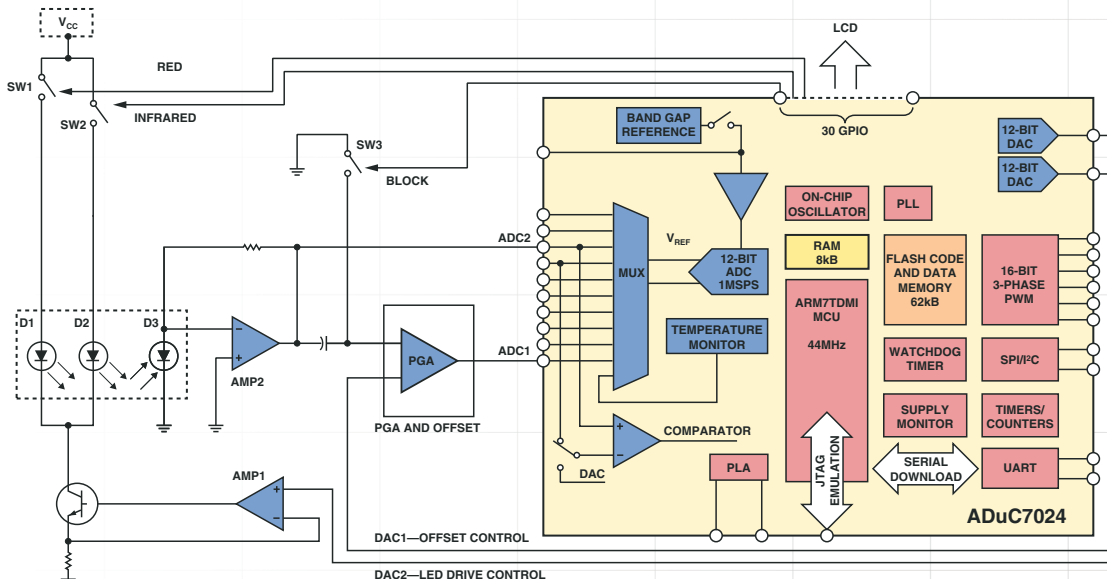
Transceiver Module with SFP and XFP Chipset and Reference Design

Analog Devices' chipsets and reference designs work together seamlessly and enable designers to develop best-in-class optical transceivers with minimal time and effort. XFP is rapidly becoming the leading standard for optical transceiver modules that connect to 10 Gbps ports, such as those used in Ethernet, Fibre Channel, and SONET/SDH protocol applications.

For more information, visit *www.analog.com/xfp_ref_design* and *www.analog.com/sfp_ref_design*.

The chipset consists of

- TIA:
  - ADN2821, 11.1 Gbps, 3.3 V, low noise, high gain transimpedance amplifier
- LDD:
  - ADN2525, 10 Gbps active back-match, differential laser diode driver
  - ADN2530, 10 Gbps active back-termination VCSE driver
- XFP signal conditioner:
  - ADN2926/ADN2927, standalone transmit and receive functions in a 4 mm $\times$ 4 mm LFCSP
  - ADN2928, XFP single chip transceiver IC
- Microcontroller:
  - ADuC7020, precision analog microcontroller: 44 MIPS ARM7 flash MCU, 5-channel, 1 MSPS, 12-bit ADC, quad 12-bit DAC, two I²C ports, in 6 mm $\times$ 6 mm, 40-lead LFCSP
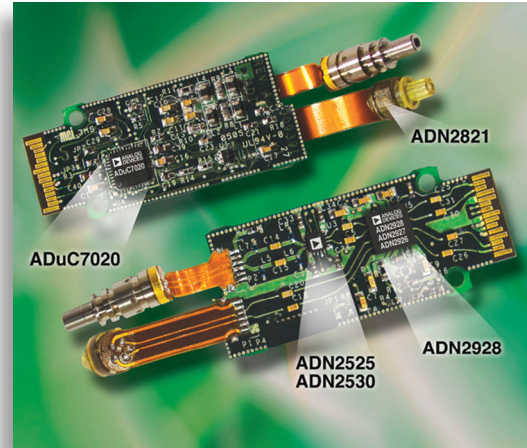
Energy Measurement IC Integrates ADE Core with 8052 Core

The ADE51xx and ADE55xx energy meter SoC (system on a chip) families provide a cost-effective solution for meter manufacturers by integrating ADI's proven energy measurement core with the 8052 microprocessor, on-chip flash memory, LCD driver, real-time clock (RTC), and intelligent battery management. The ADE51xx and ADE55xx families have unique battery management features that consume less than 1.5 μA of current in battery mode while keeping critical system components active. Based on ADI's field-proven ADE energy measurement core that is designed into more than 225 million energy meters worldwide, these highly integrated SoC devices provide a high performance, cost-effective, and low risk solution.

For more information, visit *www.analog.com/energymeter.*

Features

- 4-quadrant high precision energy measurement
- Battery operation down to 2.4 V power supply
- Power fail/battery management with no external component needed
- 104-segment LCD driver
- Low power RTC—1.5 μA typical
- RTC compensation accurate to 2 ppm
- Digital temperature measurement

Benefits

- Single chip solution
- No external battery switching circuitry required
- LCD display maintained in battery mode
- Extended battery life with low voltage operation
- Integrated LCD contrast adjustment

Part Number	Antitamper	W + VA + RMS	VAR	di/dt	RTC	UART	Flash (kB)	RAM (Bytes)
ADE7569	No	Yes	Yes	Yes	Partial	1	8 or 16	512
ADE7566	No	Yes	No	No	Partial	1	8 or 16	512
ADE7169	Yes	Yes	Yes	Yes	Partial	1	8 or 16	512
ADE7166	Yes	Yes	No	No	Partial	1	8 or 16	512
ADE5569	No	Yes	Yes	Yes	Full	2	62	2048
ADE5566	No	Yes	No	No	Full	2	62	2048
ADE5169	Yes	Yes	Yes	Yes	Full	2	62	2048
ADE5166	Yes	Yes	No	No	Full	2	62	2048

QuickStart Development Tools for ADuC7xxx Series

All ADuC7xxx series precision analog microcontroller products are supported by a comprehensive suite of software development tools that are shipped with supporting hardware. The ADuC7xxx series low cost QuickStart Development System includes a suite of software development tools by Keil Software and IAR Systems. The hardware includes a power supply, cables, an evaluation board, and an RDI-compliant JTAG emulator. The QuickStart Development System is priced at $249 (with emulator) and at $75 (without emulator) and is available directly from Analog Devices.

All you need to get started:

- Evaluation board
- ADI mIDAS-Link JTAG emulator
- Power supply
- Serial download cable
- Keil μVision3 IDE (16k limit)

- IAR Systems WorkBench for ARM (32k limit)
- Serial downloader
- PLA tool

*Components of the ADuC7xxx Series QuickStart Development System.*

Development System	Part on Eval Product	Board Type/ Description	Products Supported	Emulator	Order Part Number	Description
MiniKit ($30)	ADuC7020	Mini board	ADuC7020 only	No	EVAL-ADUC7020MKZ	Prototyping system
QuickStart Kit ($75)	ADuC7020	Evaluation board	ADuC7019, ADuC7020, ADuC7021, ADuC7022	No	EVAL-ADUC7020QSZ	Evaluation/upgrade system
QuickStart Kit ($75)	ADuC7024	Evaluation board	ADuC7024, ADuC7025	No	EVAL-ADUC7024QSZ	Evaluation/upgrade system
QuickStart Kit ($75)	ADuC7026	Evaluation board	ADuC7026, ADuC7027	No	EVAL-ADUC7026QSZ	Evaluation/upgrade system
QuickStart Plus Kit ($249)	ADuC7128	Evaluation board	ADuC7128	Yes	EVAL-ADUC7128QSPZ	Full development system
QuickStart Plus Kit ($249)	ADuC7129	Evaluation board	ADuC7129	Yes	EVAL-ADUC7129QSPZ	Full development system
QuickStart Plus Kit ($249)	ADuC7033	Evaluation board	ADuC7033, ADuC7034	Yes	EVAL-ADUC7033QSPZ	Full development system
QuickStart Plus Kit ($249)	ADuC7032	Evaluation board	ADuC7032	Yes	EVAL-ADUC7032QSPZ	Full development system
QuickStart Plus Kit ($249)	ADuC7026	Evaluation board	ADuC7019, ADuC702x	Yes	EVAL-ADUC7026QSPZ	Full development system
QuickStart Plus Kit ($249)	ADuC7060	Evaluation board	ADuC7060, ADuC7061, ADu7062	Yes	EVAL-ADUC7060QSPZ	Full development system

MiniKit—ADuC7020

For a rapid start with the ARM7TDMI-based precision analog microcontroller, Analog Devices is offering a very low cost evaluation kit, the ADuC7020 MiniKit. This is a small adapter board with the form factor of a standard 40-lead DIL-socket. It is powered directly from a 9 V battery block and can be connected to a PC with the included serial download cable. In addition to the evaluation software package, it comes with a comprehensive installation and getting-started presentation on CD, to enable the user to debug code in the on-chip flash memory. This low budget evaluation tool enables the user to experience the quality of the high performance 12-bit analog front end (12-bit/1 MSPS ADC and 12-bit voltage output DAC) in combination with the powerful processing capabilities of the 32-/16-bit ARM7TDMI core and the integrated real-time-programmable logic array (PLA).

The MiniKit consists of

- Mini board
- Power supply cable
- Serial download cable
- Keil μVision3 IDE (16k limited)
  - Compiler/simulator/debugger

- IAR Workbench IDE (32k limited)
  - Compiler/simulator/debugger
- Serial downloader
- PLA tool
- Example code
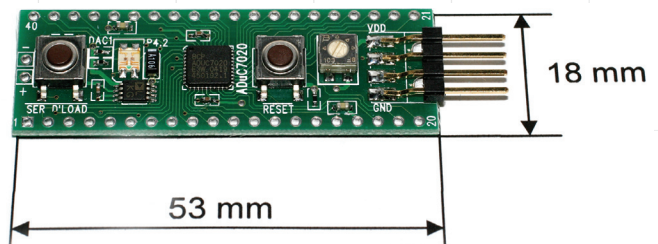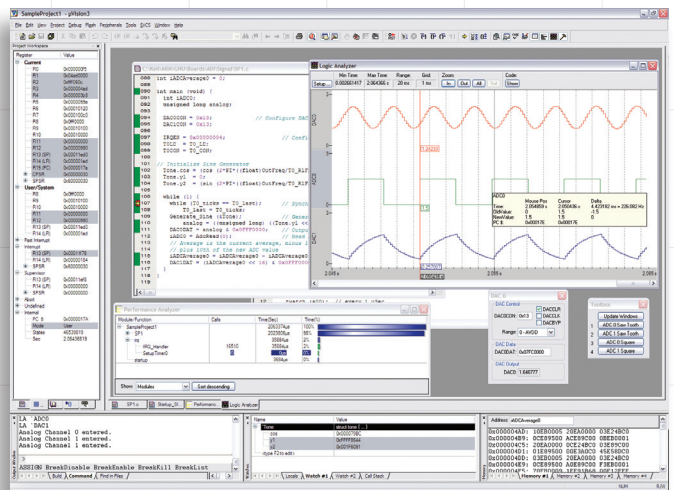
ADuC8xx Series: 8052-Based MicroConverter Products

The ADuC8xx series was the first to integrate true 12-bit to 24-bit analog precision, in-circuit reprogrammable Flash/EE memory, and an on-chip 8052 core. Applications include industrial control, precision instrumentation, and communications infrastructure. Options with high resolution Σ-Δ ADCs, such as ADuC845, ADuC847, and ADuC848, are particularly suitable for applications that call for precise measurement of low frequency signals with a wide dynamic range. Examples include intelligent sensor calibration and conditioning, smart transmitters, weigh scales, temperature and pressure transducers, 4 mA to 20 mA control loops, patient monitoring equipment, and portable test-and-measurement gear.

Precision Analog

- 12-bit to 24-bit ADC resolution
- Sample rates to 400 kSPS
- Flexible ADC input multiplexing
- Programmable gain differential inputs
- Self-calibration
- On-chip 2.5 V band gap reference
- Single or dual, 12-bit rail-to-rail DAC

Integrated Programmable Peripherals

- 8052 MCU core (up to 20 MIPS)
- Flash code memory (up to 62k)
- Flash data memory (up to 4k)
- RAM (up to 2k)
- Flexible SPI, I²C, and UART serial ports
- High speed baud rate generator
- Multiple PWM outputs
- Watchdog timer
- Power supply monitor
- Robust internal POR

Essential Embedded Tools

- Serial port downloader/debugger
- Single pin emulator
- Code lockout security feature

Additional Features

- TSSOP, MQFP, and CSP packages
- Extended temperature range to 125°C
- Pin-compatible upgrade paths
- 3 V and 5 V operation
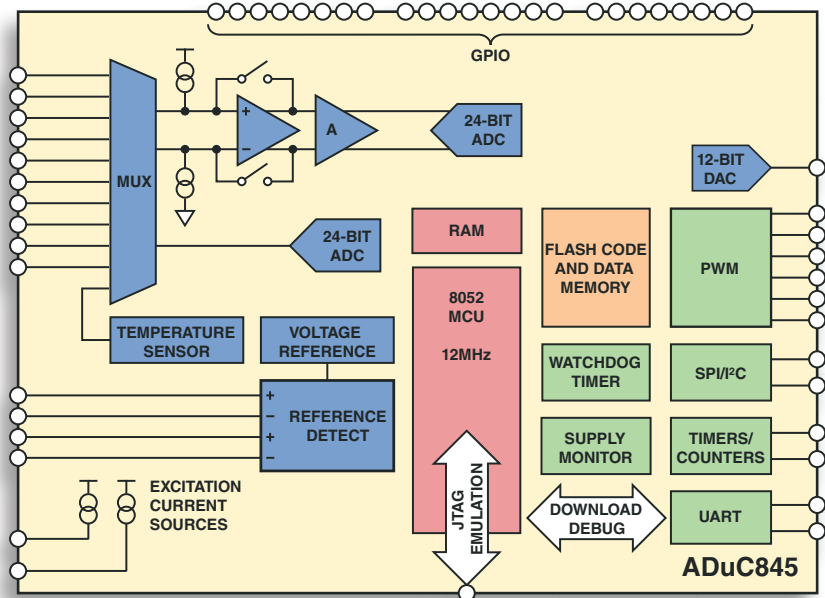
The ADuC845 features two 24-bit Σ-Δ analog-to-digital converters (ADCs) with 10 single-ended or five fully differential channels on a single chip. This is integrated with a fast, programmable, 8-bit, single-cycle, 8052 flash MCU.

QuickStart Development Tools ADuC8xx Series

The "entry level" QuickStart Development System allows designers to rapidly evaluate MicroConverter performance and functionality, and then begin a prototype development. The system provides all of the tools needed, including software tools, development board, integrated serial download/debug cable, and power supply. It fully supports assembly level code development via a serial port debug path and provides designers with access to a demonstration project of the C-level development environment available in QuickStart Plus.

A small, nonintrusive, single-pin emulator POD and the accompanying Aspire™ Integrated Development Environment (IDE) are supplied directly by Accutron Ltd. and can be ordered via the company's website.

Components of the ADuC8xx Series QuickStart Plus Development Tools

Development System	Support Product	Board	Emulator	Cables/Power Supply	Software
QuickStart Kit ($75)	ADuC8xx series	Evaluation board	No	Download/debug cable and power supply	IDE (assembly only)
μSpear™ ($299)	ADuC8xx series	No	Yes	Serial cable	IDE (C + assembly), Keil compiler (trial version)

Precision Analog Microcontroller with Unequalled Data Acquisition and Processing Performance for Industrial and Instrumentation Applications

ADuC706x Family

The ADuC706x family of ARM7 microcontrollers with best-in-class data conversion performance is ideal for industrial systems engineers designing smart sensing, factory automation, and instrumentation equipment.

ADuC7060 incorporates two 24-bit Σ-Δ ADCs and a host of analog peripherals with ARM7 core to create a solution for precision sensing applications. The integration of a 32-bit RISC MCU, flash memory, and high resolution data converters in a small footprint, combined with low power operation eliminates the complexity, cost, and performance degradation issues associated with discrete mixed-signal solutions.

Designed to support 4 mA to 20 mA loop-powered applications and precision instrumentation, the 24-bit Σ-Δ ADC provides the resolution required by high performance industrial and instrumentation equipment, while keeping the noise low at just 60 nV. This performance combined with an ARM7 provides a single chip solution that can handle all data acquisition, processing, and communications functions at the sensor node.

In addition to the 5-channel, 24-bit Σ-Δ ADC with PGA and the ARM7 core with eight interrupt priority levels, the ADuC706x products integrate 32 kB flash memory and 4 kB SRAM, a 14-bit DAC, multiplexers, buffers, an auxiliary 8-channel, 24-bit ADC for cold junction compensation in thermocouple applications, and SPI, UART, and I²C ports. Operating current is just 2.6 mA with all peripherals activated.

Key Features

- ARM7TDMI MCU core
- Low power consumption
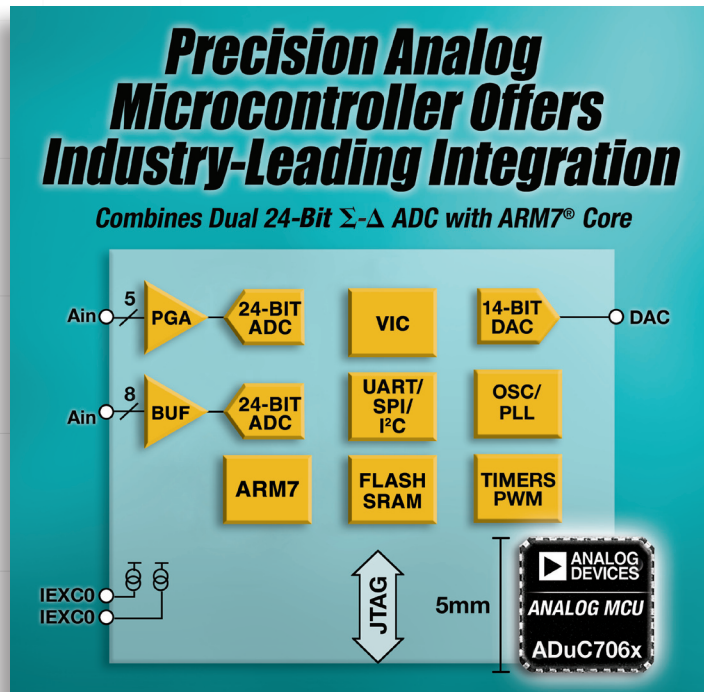- 2.6 mA with all peripherals activated

Memory

- 4 kB SRAM
- 32 kB Flash/EE

Analog I/O

- 2 × 24-bit Σ-Δ ADC
- 14-bit DAC
- 10 ppm/°C V_{REF}
- 3°C temperature sensor

Additional Features

- Programmable gain amplifier (PGA)
- Precision oscillator ($\pm$1%)
- Timers (WDT, wake-up, PWM)
- VIC (vectored interrupt controller)
- 2× excitation current sources
- Temperature range: −40°C to +125°C
- 5 mm × 5 mm, 32-lead LFCSP package

Precision Analog Microcontroller Offers Industry-Leading Integration
Combines Dual 24-Bit Σ-Δ ADC with ARM7® Core

Product Number	24-Bit ADCs	AINs/GPIOs	Flash (kB)	SRAM (kB)	Package	Price @ 1k ($U.S.)
ADuC7060	2	13, 16	32	4	48-lead LFCSP, 48-lead LQFP	4.90
ADuC7061	2	13, 8	32	4	5 mm × 5 mm, 32-lead LFCSP	3.95
ADuC7062	1	5, 8	32	4	5 mm × 5 mm, 32-lead LFCSP	3.40

For more information on Analog Devices' range of precision analog microcontrollers, visit *www.analog.com/microcontroller.*

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