EMERGING ENERGY APPLICATIONS

Contents

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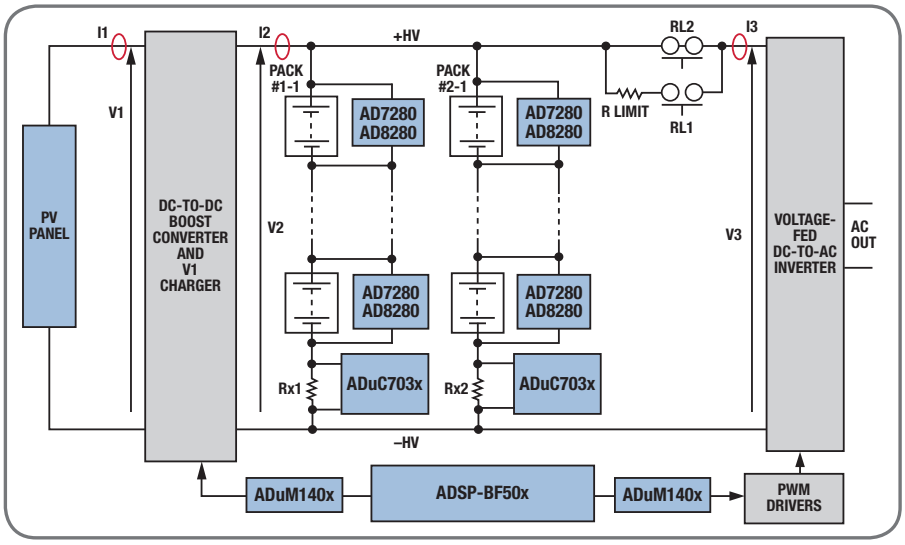
Renewable Energy Generation

Energy Storage System for Solar Photovoltaic and Wind Turbine Generators

In order to provide output power from solar photovoltaic (PV) installations and wind turbine systems over a longer time period than conditions allow (due to darkness or insufficient wind speed), it is necessary to store the generated energy for later use as demand requires. For storing the generated energy in banks of Li-Ion cells, advanced technology solutions from Analog Devices enable safe and efficient systems operation over time and temperature.

The diagram below demonstrates an outline system diagram for a solar PV system where storage components are identical to those in a wind turbine system. Li-Ion cells are generally grouped in modules or packs containing between six to 12 cells, then bolted together in a series (two battery strings shown below) to produce the desired overall stack voltage.



Assigning dedicated monitoring components to each string eases individual string removal and allows tighter control over the Li-Ion cells. Highly specialized cell monitor products such as the AD7280 and the AD8280 provide full monitoring and backup capabilities for each Li-Ion cell in the string while the individual string current can be monitored by the special purpose ADuC703x. The ADuC703x also communicates with its associated series-connected string of Li-Ion cell monitors, running cell balancing algorithms and communicating with the master Blackfin® DSP controller (ADSP-BF50x). The processor communicates with the various system blocks via *i*Coupler® devices (ADuM140x) to allow the entire front-end system to float and to electrically isolate the back end from high voltages for safety reasons.

In the above diagram, common current and voltage measurements are taken in at least three locations to help with the system management; I1 and V1 help with the MPPT algorithm; I2 and V2 help with the V/I charging a circuit; I3 and V3 help with the inverter operation. These three voltages are high voltages and can be measured via resistive dividers into the voltage channels of the ADuC703x. The I1, I2, and I3 current measurements can be made with current monitoring products such as the AD8212 or AD7400.

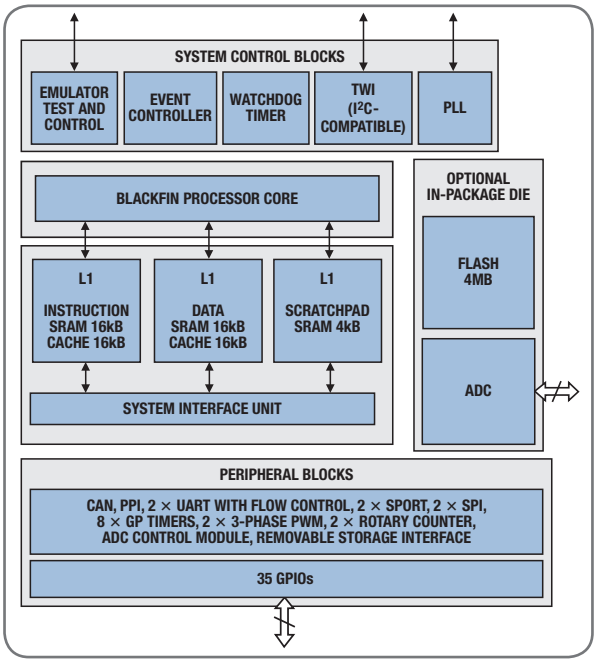
Blackfin Processors with Integrated ADCs Break Price/Performance Barriers for Solar and Wind Applications

The global movement to drive greater energy efficiency across electrical and industrial infrastructure requires sophisticated technology for intelligent power management. Leveraging advanced power control techniques for applications spanning industrial control and automation, renewable energy generation, and smart grid energy distribution, system designers can achieve significant efficiency gains that yield greater energy conservation, lower pollution emissions, and tremendous economic savings.

Blackfin ADSP-BF50x processors deliver up to 400 MHz of processing performance at a price point where 150 MHz to 200 MHz clock speeds have been the norm. In addition, optional integrated analog-to-digital converters (ADCs) and flash memory are available. This performance profile equips designers to achieve greater system functionality and precision through the use of more sophisticated algorithms and enables a number of system-level design objectives, including real-time processing of more data, reduced latency, consolidation of processing tasks to a single processor, and greater flexibility to optimize system interface and control capabilities.

Blackfin ADSP-BF50x processors are ideally suited to execute the complex algorithms that enable inverters to convert variable dc output into "clean" current and regulate power flow into the commercial electrical grid and/or local electrical networks fed by residential and municipal PV cell arrays and wind turbines. With the signal processing performance to ensure ultraefficient energy extraction and transmission, advanced power switching control functionality, and support for anti-islanding and maximum power point tracker (MPPT) capabilities, Blackfin ADSP-BF50x processors are optimized for renewable energy and smart grid infrastructure.

The ADSP-BF50x family includes the ADSP-BF504 starting at $4.50, the ADSP-BF504F with integrated flash memory starting at $6.50, and the ADSP-BF506F with integrated flash memory and ADC starting at $10.60—all prices are based on 10,000 unit quantities. Processors are sampling to customers today. EZ-KIT Lite® evaluation kits for Blackfin ADSP-BF50x processors are available from ADI's authorized distributors and are priced at $199.00.



Features

- 400 MHz LP process
- 4 MB flash (instructions and data)
- ADC dual SAR, 12 channels, 12 bits, up to 2 MSPS
- 2 UARTs, with flow control
- 2 SPORTs
- 2 SPIs
- 1 TWI (I²C®-compatible)
- Eight 32-bit GP timers
- 1 CAN
- 6-pair PWM unit (in addition to 8 timers with PWM)
- 35 GPIOs (muxed with interfaces)
- Two 32-bit up/down counters with rotary support
- Removable storage interface
- 1 PPI, up to 16 bits

Package Options

- 12 mm × 12 mm, 88-lead, 0.5 mm pitch LFCSP with single exposed paddle, no ADC
- 14 mm × 14 mm, 120-lead, 0.4 mm pitch LQFP with dual exposed paddles, with flash and ADC
- Operating temperature: –40°C to +85°C

Web-Based Tools

It's never been easier to add signal processing to your embedded design with low cost development tools, reference designs, 24/7 support at EngineerZone, on-demand training, free software, and more. For more information, visit *www.analog.com/blackfin50x*.

Next Generation Wind Turbines Utilize Precision ADI Components to Maximize Energy Extraction and Optimize System Controls

Northern Power Systems' Northwind™ 100 delivers 100 kilowatts of rated power for community wind applications such as schools/universities, businesses, farms, and municipalities. ADI's expertise in next generation energy infrastructure assures that companies like Northern Power Systems are equipped with advanced components across the entire signal chain to enhance the value, performance, and innovation of their system designs.

The power flow of the Northwind 100 generator is regulated by the power converter to compensate for variable wind speeds, which helps to maximize energy extraction. This capability ultimately enables a Northwind 100 wind turbine to provide a steady flow of clean power to a local grid, simplifying grid interconnect infrastructure and maintaining grid stability. Eliminating the need for a gearbox transmission dramatically reduces lifecycle maintenance and increases system reliability.

At the heart of this system is ADI's 32-bit floating-point SHARC® ADSP-21363 digital signal processor, which hosts real-time, closed-loop control algorithms to efficiently control the Northwind 100 generator and power converter subsystems, based in part on incoming data provided by the AD7656 16-bit analog-to-digital converter (ADC) embedded in the data acquisition hardware. Vibration monitoring uses ADI's dual-axis *i*MEMS® ADXL203 accelerometer subassembly part affixed to the turbine's nacelle.

SHARC ADSP-21363 Digital Signal Processor

- Integrated 3 Mb SRAM/4 Mb ROM on-chip memory
- Rich peripheral set to accommodate a wide range of configuration options
- 6 high speed serial ports (SPORTs)

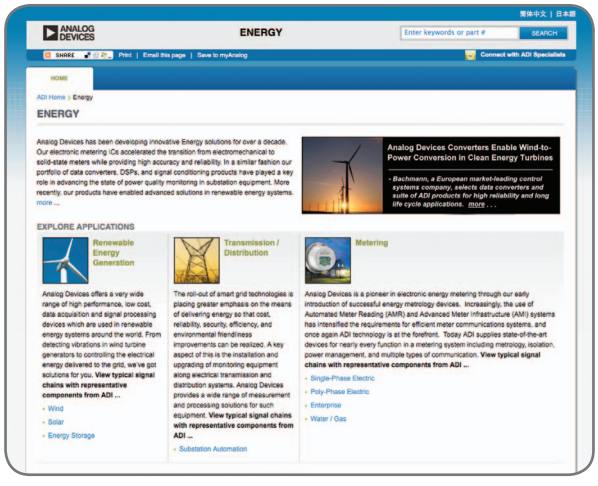
AD7656 Analog-to-Digital Converter

- Provides the high speed signal sampling and data conversion that feeds into the system's real-time, closed-loop control algorithms
- 250 kSPS, 6-channel simultaneous sampling bipolar 16-bit analog-to-digital converter
- Manufactured using industrial CMOS (*i*CMOS®) process technology, combining high voltage silicon with submicron CMOS and complementary bipolar technologies

ADXL203 iMEMS Accelerometer

- Precision dual-axis *i*MEMS accelerometer
- Measures acceleration with a full-scale range of ± 1.7 *g*
- Typical noise floor: 110 $\mu g/\sqrt{Hz}$

New Energy Website Features Our Leading Measurement, Processing, and Communications Solutions



From energy generation to transmission, distribution, and metering, our high performance product and technology offerings have enabled next generation energy solutions for over a decade. Our electronic metering ICs accelerated the transition from electromechanical to solid-state meters while providing high accuracy and reliability. In a similar fashion our portfolio of data converters, DSPs, and signal conditioning products have played a key role in advancing the state of power quality monitoring in substation equipment. More recently, our products have enabled advanced solutions in renewable energy systems.

Analog Devices is one of the few companies providing the full range of required technologies and a global support infrastructure.

Now we make it even easier to design and deploy these systems with a dedicated online resource highlighting our systems-level expertise, product recommendations, news, articles, and more. Explore the new website at *www.analog.com/energy*.

Emerging Energy Applications Selection Guide

ADCs

Part Number	Number of Input Channels	Input Voltage Range (V)	Resolution (Bits)	Accuracy
AD7280	6 per device (180 per system)	7.5 to 30	12	±1 LSB typ
AD7656	6	±5, ±10	16	±1 LSB typ
AD8280	6 per device (180 per system)	6 to 30	N/A	±50 mV
AD7400	1	±200 mV for specified performance	16	±2 LSB

Amplifiers

Part Number	Common-Mode Voltage Range (V)	Output Format	Operating Temperature Range	Package
AD8206	–2 to +65	Voltage	–40°C to +125°C	8-lead SOIC
AD8212	7 to 65 (500 possible)	Current	–40°C to +125°C	8-lead MSOP

Analog Microcontrollers

Part Number	Core	Analog Input Structure	Input Voltage Range (V)	Interface
ADuC703x	ARM7	3 × 16-bit ADCs	–0.5 to +18	LIN, SPI, UART

Multichannel Digital Isolators

Part Number	Isolation Rating (kV rms)	Channel Count	Max Data Rate (Mbps)	Interface Type
ADuM120x	2.5	2	1/10/25	Digital isolator
ADuM141x	2.5	4	1/10	Digital isolator
ADuM220x	5	2	1/10	Digital isolator
ADuM240x	5	4	1/10/90	Digital isolator

***iso*Power Digital Isolator**

Part Number	Isolation Rating (kV rms)	Channel Count	Max Data Rate (Mbps)	Interface Type
ADuM540x	2.5	4	1/25	Digital isolator with *iso*Power®

Digital Interface

Part Number	Isolation Rating (kV rms)	Channel Count	Max Data Rate (Mbps)	Interface Type	Supply Voltage (V)
ADM485	None	1 half duplex	5	RS-485	5
ADM487E	None	1 half duplex	250	RS-485, enhanced ESD	5
ADM3072E	None	1 half duplex	115	RS-485, enhanced ESD	3.3
ADM2483	2.5	1 half duplex	500	RS-485, isolated	5
ADM2484E	5	1 half/full duplex	500	RS-485, isolated	3.3
ADM2587E	2.5	1 full duplex	500	RS-485, *iso*Power	5.3

Energy Measurement ICs

Part Number	Number of Phases	Energy Measurements	Current Sensor Interface	Output Interface
ADE7878	3	Watt, VA, V rms, I rms, VAR	Shunt, transformer, Rogowski coil	Pulsed, SPI, I²C, HSDC
ADE7858	3	Watt, VA, V/I rms, VAR	Shunt, transformer, Rogowski coil	Pulsed, SPI, I²C, HSDC
ADE7763	1	Watt, VA, V rms, I rms	Shunt, transformer, Rogowski coil	Pulsed, SPI
ADE7753	1	Watt, VA, V/I rms, VAR	Shunt, transformer, Rogowski coil	Pulsed, SPI

Processors

Part Number	Core Architecture	Core Performance (MHz)	On-Chip Flash (Mbits)	ADC ENOB Performance
ADSP-21363	Floating-point	333	No	External
ADSP-BF504	Fixed-point	400	No	External
ADSP-BF504F	Fixed-point	400	32	External
ADSP-BF506F	Fixed-point	400	32	11-bit

RF ICs

Part Number	Bands (MHz)	Bandwidth	Details	Relevant Standards
ADF7020	431 to 478, 862 to 956	Medium	Data rate = 200 kbps	EN 300-220, FCC Pt. 15.247
ADF7021	80 to 650, 862 to 940	Narrow	External inductors option, data rate = 32 kbps	FCC Pt. 90/95/15, ARIB T67, EN 300-220 (NB)
ADF7021-N	80 to 650, 862 to 940	Narrow	External inductors option, data rate = 18 kbps	FCC Pt. 90/95/15, ARIB T67
ADF7022	686.25, 868.95, 869.85	Medium	io-homecontrol® communications processor	EN 300-220, io-homecontrol
ADF7023	431 to 464, 862 to 928	Medium	Communication processor, encryption, data rate = 300 Kbps	EN 300-220, FCC Pt. 15.247
ADF7242	2400	Wide	Communications processor, dual mode 802.15.4 and 2 Mbps GFSK	802.15.4, ZigBee

MEMS

Part Number	Full-Scale Range (*g*)	Resolution	Power Consumption	Package
ADXL203	±1.7	1 m*g* @ 60 Hz	3.5 mW @ 5 V	5 mm × 5 mm × 2 mm LCC package

I²C and USB Digital Isolators

Part Number	Isolation Rating (kV rms)	Channel Count	Max Data Rate (Mbps)	Interface Type
ADuM125x	2.5	2	1	I²C
ADuM225x	5	2	1	I²C
ADuM4160	5	1	1.5/12	USB

Enterprise Energy Measurement and Monitoring

Easy Single-Phase Energy Measurement

Energy awareness is increasingly driving product features and customer purchase decisions. From data centers to consumer appliances, customers are demanding the ability to monitor and manage their energy consumption. To meet this need, manufacturers need cost-effective, easy to use, accurate energy measurement solutions.

Analog Devices is the only energy measurement supplier to offer a broad family of both energy measurement analog front ends (AFEs) and complete energy measurement solutions with an integrated MCU. All of the AFEs from Analog Devices offer high performance energy measurement easily paired with a customer's preferred MCU, while its energy measurement ICs with an integrated 8052 MCU offer an easy to use single-chip solution.

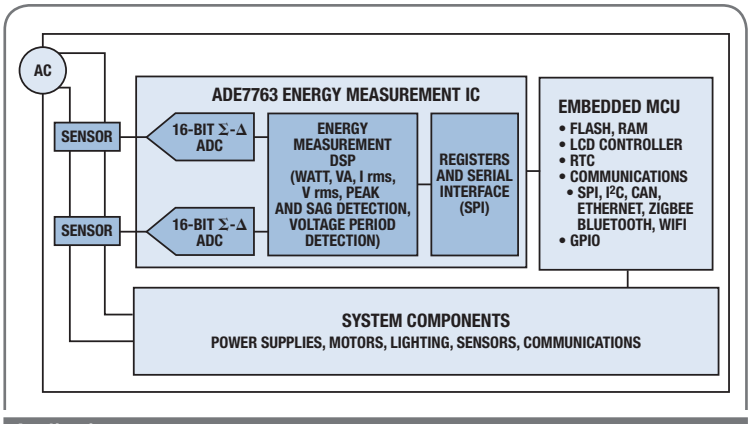
The ADE7763 single-phase active and apparent energy metering IC features proprietary ADCs and fixed-function DSP for high accuracy over large variations in environmental conditions and time. The ADE7763 incorporates two second-order, 16-bit Σ-Δ ADCs, a digital integrator (on Ch. 1), reference circuitry, a temperature sensor, and all the signal processing required to perform active and apparent energy measurements, line-voltage period measurements, and rms calculation on the voltage and current channels. The diagram demonstrates a typical energy measurement solution based on the ADE7763 energy measurement AFE.

Why Choose Analog Devices?

- Analog Devices has been the leading supplier of energy measurement products for over a decade, with more than 250 million energy measurement ICs sold.
- The ADE series of energy measurement ICs offers the highest performance and most flexible solutions available for electrical energy measurement.
- The energy measurement solutions from Analog Devices exceed Energy Star server and GreenGrid.org data center electricity measurement accuracy specifications.

Energy Measurement Solutions Features

- 1000:1 dynamic range at 0.1% energy measurement accuracy
- Active, reactive, and apparent energy measurements, in addition to I rms and V rms
- Detection: voltage sag, peak, and period
- Interfaces: I²C and SPI serial
- Supports direct interface to low cost shunt, as well as transformer based current sensors



Applications

- Data center equipment (servers, storage, communications)
- Industrial equipment
- Lighting
- Uninterruptible power supply
- Refrigeration
- HVAC
- Consumer electronics
- Household appliances

AN-639 Application Note, *Frequently Asked Questions (FAQs), Analog Devices Energy (ADE) Products.* For more information on ADE products, and to access this note, please visit *www.analog.com/AN-639*.

Digital Isolation Technology Enables Cost-Effective, Reliable Solutions

*i*Coupler®

Isolation is an important component of energy metering systems and is used at different parts of the system depending on the specific system topology. For example, if shunt resistors are used for current measurement, isolation is often used at the output of the ADC or metrology IC to protect the microcontroller and communications system from the mains voltage. Other areas where isolation is commonly used include external interfaces (such as RS-485), communications interfaces, and human interfaces.

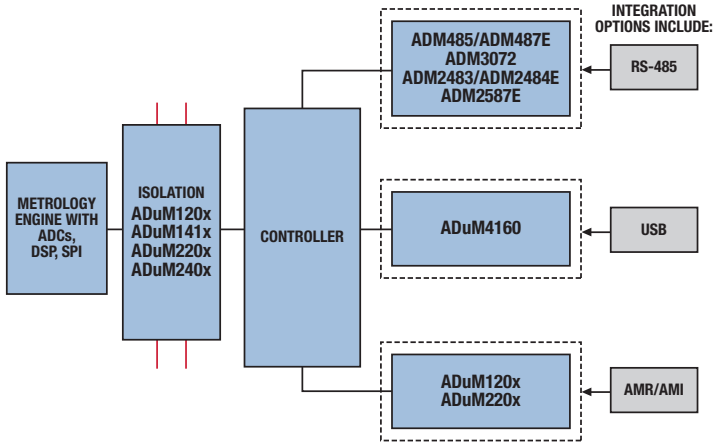
Most modern utility meters include complex communications boards for interfacing to automatic meter reading (AMR) or advanced meter infrastructure (AMI) systems. The two most common communications methods are wireless and power-line communication (PLC). Similar methods are used for enterprise or nonutility metering applications, in addition to USB (ADuM4160) and network connections. Isolation is used to protect both the communications and metrology modules in the event that a large voltage differential develops between the modules.

Analog Devices offers a comprehensive portfolio of isolation ICs, both *i*Coupler digital isolators and *iso*Power isolators that include power isolation. Integrated power isolation allows the designer to reduce the number of components required for a design or to implement isolated power domains in challenging areas.

Many meters utilize RS-485 connections for calibration, debugging, and/or local control/reading. ADI also supports a comprehensive portfolio of isolated (ADM248x/ADM249x) and nonisolated (ADM487E) RS-485 transceivers and has introduced RS-485 products that include built-in power isolation (ADM2582E).

Critical specifications for an isolation solution include the insulation rating, maximum continuous working voltage, data rate, power consumption, and channel count. ADI offers the broadest range of isolation ratings with products specified at 1 kV rms, 2.5 kV rms, and 5 kV rms. Also critical is the lifetime at which an isolator can operate at high voltage. Many types of isolators (including optocouplers) degrade significantly over time when exposed to the maximum continuous working voltage. For applications that are connected directly to the mains voltage, both the peak voltage and degradation of the isolator over time at the mains voltage need to be considered. The lifetime of *i*Coupler devices are fully specified in the data sheets; for example, the ADM2587E is specified to have a minimum lifetime of 50 years at a continuous working voltage of 565 V p-p ac.

Isolation/Interface Options for Metering Architectures



Web-Based Tools

For additional tools and resources such as application notes, videos, brochures, and presentations, visit *www.analog.com/icouplertools*.

Analog Devices, Inc.
600 North Bedford Street
East Bridgewater, MA 02333-1122

Utility Metering

Energy Measurement Solutions for Utility Meters

In addition to enterprise energy applications, Analog Devices' ADE energy measurement ICs address the challenges of next generation smart meter architectures and are ideal for measuring active energy (kWh), apparent energy (kVA), reactive energy (kVAR), rms, and power quality with the highest accuracy in single-phase and polyphase revenue meters, industrial instruments, and energy monitoring applications. Superior in quality, reliability, and performance, Analog Devices' ADE energy measurement ICs combine analog-to-digital converters (ADCs) with fixed-function digital signal processors (DSPs) to perform critical measurements, while providing unparalleled functionality and ease of use.

With more than 250 million energy meters using ADI's technology deployed worldwide, Analog Devices has delivered more energy measurement solutions than any other semiconductor company.

For metering communications, ADF70xx transmitters and ADF702x transceivers are well suited for short range designs such as automatic meter reading (AMR), industrial automation, alarm and security systems, home automation systems, remote controls, and other wireless network and telemetry systems where low power consumption and very long range are required.

With the move toward more smart metering applications, the complexity of power management devices continues to rise. ADI's broad range of power solutions offers higher efficiency, smaller size, and lower cost than traditional solutions.

In a variety of architectures for energy metering systems, ADI offers a full portfolio of RS-485 transceivers and *i*Coupler digital isolators, along with other support functions: switches and multiplexers, temperature sensors, voltage references, and accelerometers for antitamper.

ADE7753/ADE7763 Single-Phase Metering ICs

- Surpasses IEC 61036 requirement
- Less than 0.1% error over a large current dynamic range
- Digital calibration
- ADE7763: no VAR and lower price

ADE78xx Polyphase Metering ICs

- 0.2% error over 3000:1
- Dynamic range: V rms 0.1% error over 1000:1
- Dynamic range: I rms 0.1% error over 1000:1
- Bandwidth: 2 kHz V rms and I rms
- Easier calibration

Analog Devices, Inc.
Worldwide Headquarters
Analog Devices, Inc.
One Technology Way
P.O. Box 9106
Norwood, MA 02062-9106
U.S.A.
Tel: 781.329.4700
(800.262.5643,
U.S.A. only)
Fax: 781.461.3113

Analog Devices, Inc.
Europe Headquarters
Analog Devices, Inc.
Wilhelm-Wagenfeld-Str. 6
80807 Munich
Germany
Tel: 49.89.76903.0
Fax: 49.89.76903.157

Analog Devices, Inc.
Japan Headquarters
Analog Devices, KK
New Pier Takeshiba
South Tower Building
1-16-1 Kaigan, Minato-ku,
Tokyo, 105-6891
Japan
Tel: 813.5402.8200
Fax: 813.5402.1064

Analog Devices, Inc.
Southeast Asia
Headquarters
Analog Devices
22/F One Corporate Avenue
222 Hu Bin Road
Shanghai, 200021
China
Tel: 86.21.2320.8000
Fax: 86.21.2320.8222

All prices in this bulletin are in USD in quantities greater than 1000 (unless otherwise noted), recommended lowest grade resale, FOB U.S.A.

I²C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

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