Project Code: APM_SOLAR-PV_2017

# ADI RENEWABLE ENERGY—SOLAR PV INVERTER SOLUTIONS

## ADI Energy Segment Overview

Analog Devices leads the industry in highly accurate and precise signal measurement and control by delivering cost competitive, high quality ICs for reliable metering, measurement, monitoring, and control. These products are used in renewable energy, electrical power transmission, and distribution applications, as well as electric, gas, and water metering. The combination of ADI's proven expertise in optimized system-level signal processing performance and its extensive range of product offerings provides developers with accurate, reliable, and easy-to-design energy management solutions.

## Main Challenges and System Considerations

- Reduces the dollar per watt system cost
- Increased grid compliance capability
- Reduced weight/size through minimization of magnetic and passive components
- Higher reliability and longer lifetime capability
- DC arc detection for fire mitigation
- Minimization of dc injection current onto the ac grid

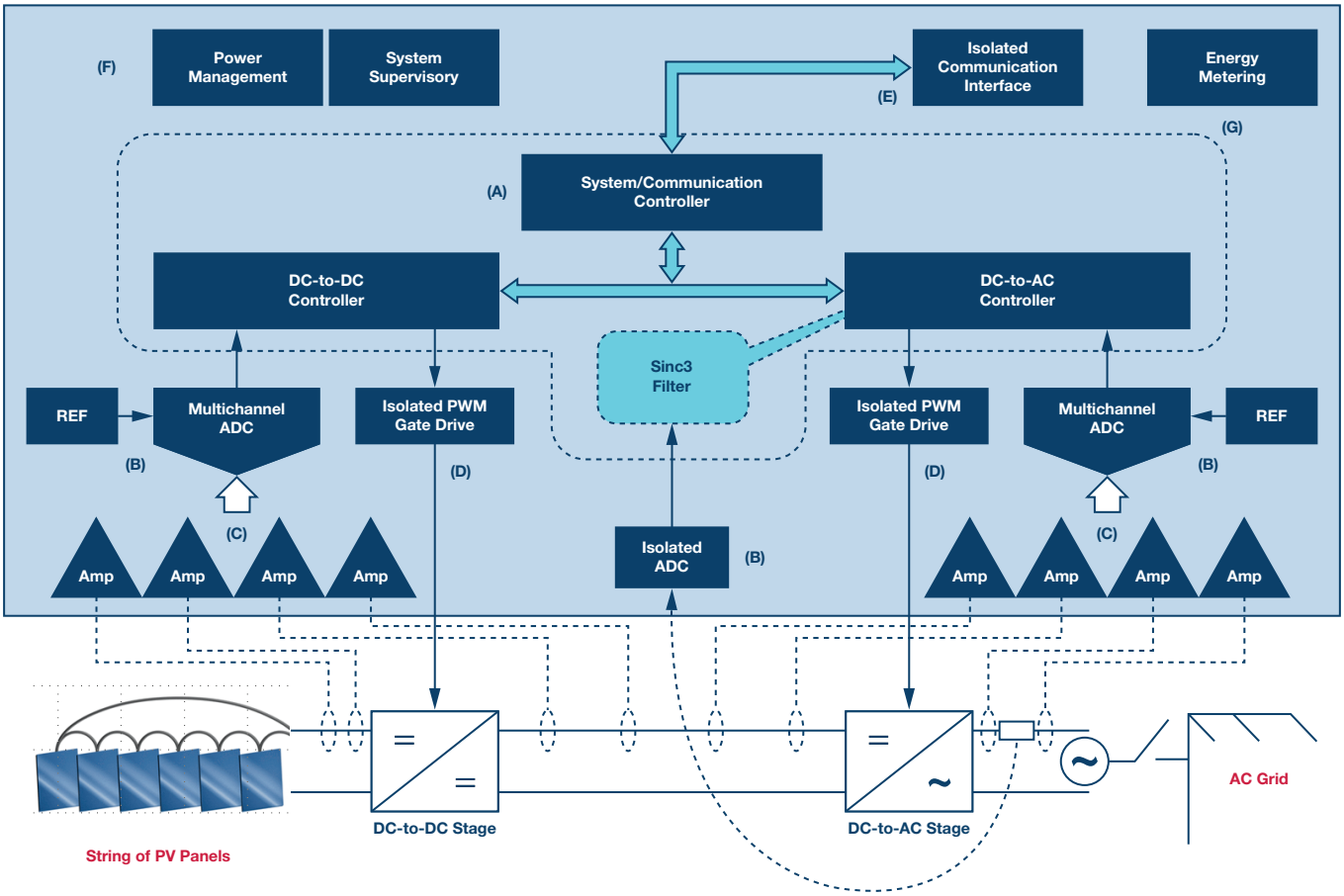
## Solar PV Application Categories

- Offline solar PV systems
- Grid-connected solar PV systems
  - Utility scale 3-phase PV inverters (>100 kW)
  - Distributed 1-phase and 3-phase PV string inverters (1 kW to 50 kW)
  - 1-phase microinverter and dc optimizers (200 W to 300 W)

## Why Choose ADI

- Expertise in integrated energy measurement—300 million ADI metrology-based meters have been deployed
- Industry leadership in next-generation, higher reliability, isolation technology (*i*Coupler®)
- 50% of all electrical grid equipment worldwide uses ADI converters
- Precision measurement of current and voltage through highly accurate converters and amplifiers
- Enabling power networks and smart grids through the use of high performance processing technology engineered with robustness and reliability
- System-level, mixed-signal conversion and processing, whole signal chain products optimized for solar PV inverters, reduced time to market, and differentiated end equipment

## Solar PV Inverter Signal Chain




*Notes: The signal chain above is representative of solar PV inverter systems. The technical requirements of the blocks vary, but the products listed in the table are representative of ADI solutions that meet some of those requirements.*

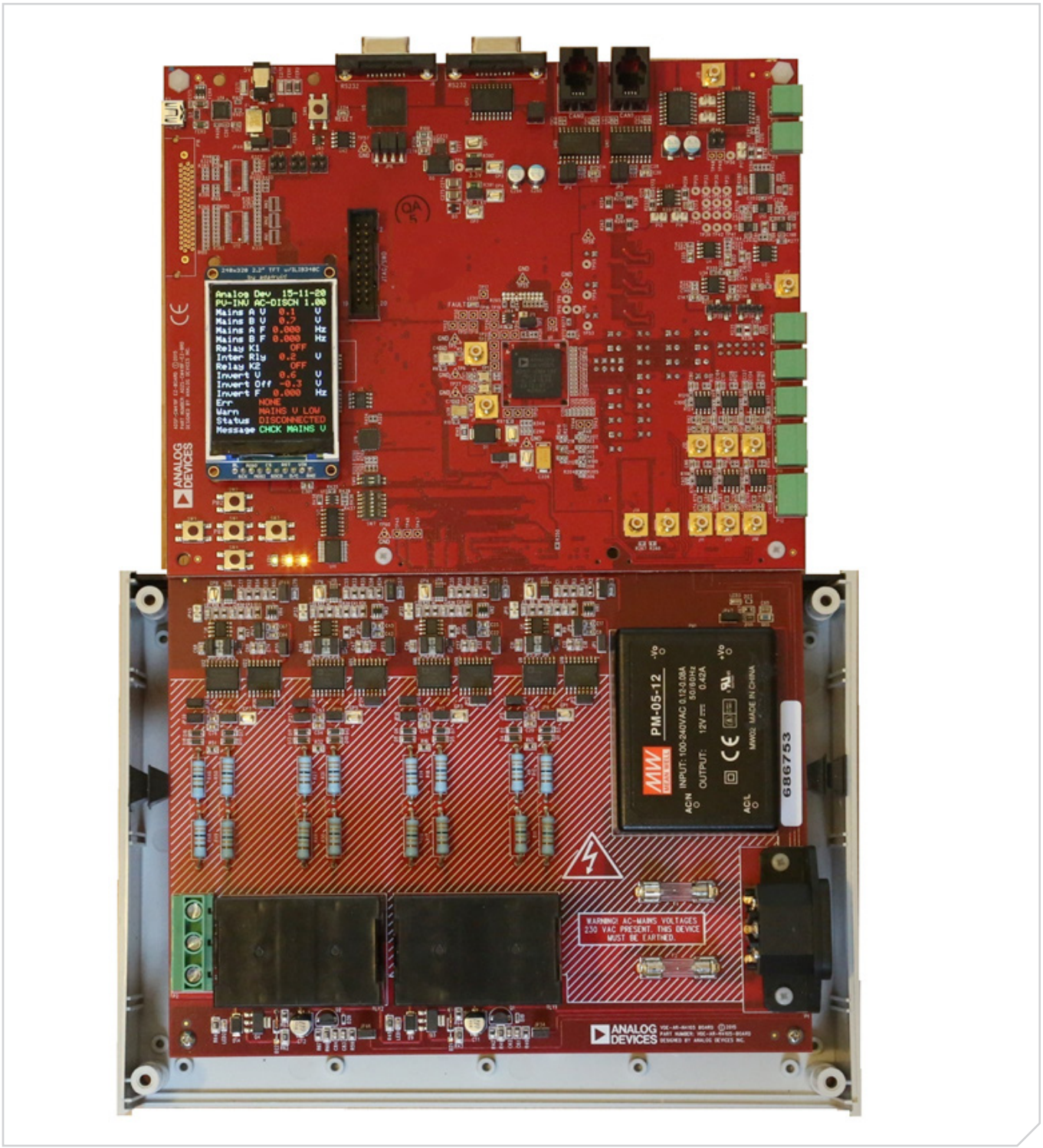
| (A) Controllers and Processors | (B) ADC and Voltage References | (C) Signal Conditioning | (D) Isolation and Gate Drivers | (E) Power Management | (F) Communication Interfaces | (G) Energy Meters |
|---|---|---|---|---|---|---|
| ADSP-2147x/ ADSP-CM403F/ ADSP-CM419F | ADCs: AD7606/AD7607 AD7266/AD7265 Isolated ADCs: AD7401A/ AD7403 Reference: ADR34xx | Op Amps: ADA4177-x/ AD8479/ AD8604 Current-Sensing Amp: AD8212 | Isolation Drivers: ADuM14x/ADuM6000 Isolated Gate Drivers: ADuM3223/ ADuM4223/ ADuM4135/ ADuM4136/ ADuM4121 | DC-to-DC: ADP211x PMUs: ADP5034/ ADP5071 Supervisors: ADM6305/ADM6306 | RS-485: ADM2587E CAN: ADM3053/ADM3054 | ADE7953/ADE7880 |

## Featured Products

| Part Number | Description | Key Features | Benefits |
|---|---|---|---|
| *Processors* | | | |
| ADSP-CM403F | Mixed-signal processor | 240 MHz ARM® Cortex®-M4, 384 kB SRAM and 2 MB flash memory, dual, 16-bit SAR ADCs and 14 bits of accuracy, 2.6 MSPS, integrated sinc filters | ADI processor family with Cortex-M4 core for solar inverter applications |
| ADSP-CM419F | Mixed-signal processor | 240 MHz ARM Cortex M4 ,100 MHz ARM Cortex-M0, 160 kB SRAM and 1 MB flash memory, 6-way 16-bit ADCs, 4.3 MSPS, integrated FFT and CORDIC accelerator | The processor, specifically made for solar inverters, eliminates the need for external safety processors as well as processors for arc detection; the internally integrated FOCP circuit, among others, can reduce the need for extra external circuitry |
| ADSP-2147x | Floating-point DSP | 300 MHz SHARC® core, 5 MB SRAM, rich peripherals such as PWM and SPORTs | High performance floating-point calculation and peripherals to connect to high performance ADCs |

| Part Number | Description | Key Features | Benefits |
|---|---|---|---|
| *ADCs* | | | |
| AD7403 | Isolated Σ-Δ modulator | Isolated Σ-Δ modulator with 5 kV isolation, ±250 mV (±320 mV full scale), 88 dB and more than 14-bit ENOB | High resolution isolated ADC, easy to interface to a shunt-based current sensing |
| AD7266 | Multichannel ADC | The AD7266 is a dual, 12-bit, high speed, low power, successive approximation ADC that operates from a single 2.7 V to 5.25 V power supply and features throughput rates up to 2 MSPS | Simultaneous sampling with multiplexer |
| AD7606 | 8-channel, 16-/14-bit, simultaneous ADC | True bipolar analog input ranges: ±10 V, ±5 V, single 5 V analog supply, 2.3 V to 5 V VDRIVE, 1 MΩ analog input impedance, analog input clamp protection | 8-channel simultaneous sampling, single 5 V supply |
| *References* | | | |
| ADR34xx | Voltage reference | Maximum temperature coefficient: 8 ppm/°C, operating temperature range: −40°C to +125°C, output current: +10 mA source/−3 mA sink | 8 ppm max; low cost voltage reference |
| *Amplifiers* | | | |
| ADA4177-x | Bipolar op amp with OVP | ±32 V OVP op amp, EMI filter inside, 60 µV max; $V_{OS}$ and 1 µV/°C $V_{OS}$ drift, up to ±18 V power rail, 3.5 MHz GBP, rail-to-rail output | High reliability bipolar op amp, ±32 V OVP, and EMI filter integrated |
| AD8479 | Difference amplifier | Difference amplifier, common-mode voltage up to ±600 V, 10 µV/°C maximum offset voltage drift, 5 ppm/°C maximum gain drift | Difference amplifier up to ±600 V common-mode voltage |
| AD8212 | Current-sense amplifier | 6 V to >500 V common-mode range, adjustable gain, current-sensing amplifier | High common-mode input range |
| *Isolation Drivers* | | | |
| ADuM14x | 4-channel digital signal isolator | 4-channel digital 3.75 kV isolation up to 150 MHz baud rate, 100 kV CMTI and the operation temperature range extends up to 125°C, 1.8 V to 5 V level translation, has fail-safe high or low options | High reliability, 4-channel digital isolation with 100 kV CMTI, suitable for switching power application |
| ADuM6000 | Isolated dc-to-dc | 5 kV *iso*Power® integrated isolated dc-to-dc converter, up to 400 mW output power | Easy to use, dc-to-dc, combine with the AD7403 to have a shunt-based current-sensing solution |
| *Isolated Gate Drivers* | | | |
| ADuM3223/ ADuM4223 | Isolated gate drivers | 2-channel gate drivers with onboard isolation (working voltage > 849 V peak), propagation delay < 54 ns, channel-to-channel matching <5 ns | Very fast, isolated, 2-channel half-bridge driver, low propagation delay |
| ADuM4135/ ADuM4136 | Isolated gate drivers for IGBT/MOSFET/SiC/GaN | Isolated gate driver with protection function integrated (ULVO, DESAT), up to 5 kV isolation, 100 kV/µs CMTI, 4 A drive capability, 55 ns propagation delay | 100 kV/µs CMTI and low propagation delay |
| ADuM4121 | Isolated gate drivers for IGBT/MOSFET/SiC/GaN | High voltage, isolated gate driver with internal Miller clamp, 2 A output with thermal shutdown | 150 kV/µs CMTI and low propagation delay |
| *Interfaces* | | | |
| ADM2587E | Isolated RS-485/ RS-422 transceiver | Half- or full-duplex, 500 kbps, 5 V or 3.3 V operation, 5 kV isolation | Integrated isolated dc-to-dc converter, ±15 kV ESD protection |
| ADM3053 | Isolated CAN transceiver | Signal and power isolated CAN transceiver, complies with ISO 11898 standard, high speed data rates up to 1 Mbps | Integrated isolated dc-to-dc integrated CAN bus single chip solution |
| *Energy Meters* | | | |
| ADE7880 | 3-phase energy meter (with harmonic monitoring) | Less than 0.1% error in active and reactive energy over a dynamic range of 1000 to 1, less than 0.2% error in active and reactive energy over a dynamic range of 3000 to 1 at TA = 25°C | Polyphase energy metering with high performance harmonic analysis |
| ADE7953 | 1-phase energy meter | Less than 0.1% error in active and reactive energy measurement over a dynamic range of 3000:1, less than 0.2% error in instantaneous IRMS and VRMS measurements over a dynamic range of 500:1 | High performance, wide dynamic range |
| *Power Management* | | | |
| ADP5034 | Multioutput dc-to-dc regulator | Dual 1.2 A bucks and dual 300 mA LDOs in LFCSP, up to 96% buck power efficiency | 4-channel output PMU, single part power chain solution |
| ADP5071 | 2 A/1.2 A switching regulator with independent positive and negative outputs | Single positive input, dual output (positive and negative) switch regulator; output current up to 2 A/1.2 A, and output voltage up to ±39 V | Easy to use, single input, bipolar voltage output voltage regulator, reduces ac-to-dc power design effort |
| ADM6306 | Dual voltage supervisor | Small package, dual voltage supervisor, low power consumption of 5 µA | Low cost small package and low power consumption 5 µA |

## Reference Design and Demo Boards




*ADSP-CM419-EZKIT and VDE-4105 extension board.*

## Circuits from the Lab® Reference Circuits for Energy Management

- 500 V Common-Mode Voltage Current Monitor (CN-0218)—*www.analog.com/en/cn-0218*
- More reference circuits are available at—*www.analog.com/circuits*

## Technical Articles/Application Notes

- The Next Wave of Power Conversion—Designing for Safety, Speed, and Cost Efficiency in Solar PV Inverters—*www.analog.com/en/The-Next-Wave-of-Power-Conversion-Designing-for-Safety-Speed-and-Cost-Efficiency-in-Solar-PV-Inverters.pdf*
- Recommendations for Control of Radiated Emissions with *iso*Power Devices (AN-0971)—*www.analog.com/en/an-0971.pdf*
- ADSP-CM403 HAE Harmonics Analysis in Solar Applications (MS-2543)—*www.analog.com/en/ms-2543.pdf*
- ADSP-CM403 SINC Isolated Measurement for Solar-Applications (MS-2544)—*www.analog.com/en/ms-2544.pdf*
- Integration of Isolation for Grid-Tied Photovoltaic Inverters (MS-2356)—*www.analog.com/en/ms-2356.pdf*
- ADSP-CM41x Mixed-Signal Control Processors for Power Conversion video—*www.analog.com/en/education/education-library/videos/4915396705001.html*
- Dual Independent Core Safety Concept for Power Conversion—*www.analog.com/en/education/education-library/videos/4786733692001.html*
- Arcing detection demo video—*www.analog.com/en/arcing-detection*
- New Power Switch Technology and the Changing Landscape for Isolated Gate Drivers—*www.analog.com/en/new-power-switch-technology-and-the-changing-landscape-for-isolated-gate-drivers.pdf*

## Design Tools/Forums

- ADI's Fastest and Most Accurate DC-to-DC Power Management Design Tool (ADIsimPower™)—*www.analog.com/en/ADIsimPower*
- Online Technical Support Community (EngineerZone®)—*ez.analog.com*
- The ADSP-CM40x EZ-Board® and EZ-KIT Lite®—*www.analog.com/en/CM40X-EZ*
- The ADSP-CM41x EZ-Board and EZ-KIT Lite®*www.analog.com/en/CM41X-EZ*

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