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Integrated N-PLC SCADA Controller for Solar Micro-inverters and Smart Ballasts

Communication technology by:
Semitech Semiconductor

Product Overview

The SM2480 is a highly integrated Supervisory Control and Data Acquisition controller (SCADA) that combines signal control functions and state of the art smart grid connectivity. Based on the SM24xx platform, SM2480 includes all the communications capabilities of the SM2400 Narrowband Power Line Communication (N-PLC) modem and adds to it a highly capable Analog Controller and an external memory interface. The SM2480 is an ideal fit for applications such as micro-inverters, smart LED controllers and other Grid-connected applications requiring interactive control loops and MPPT type of algorithms. It provides great flexibility in implementing control functions, while allowing for standards based and proprietary modes of N-PLC based connectivity. Similar to all other members of the SM24xx family, the SM2480 features a dual core architecture, dedicating one core to the system control application and the second core to modem PHY, and integrated AFE blocks. This dual core architecture enables cost effective solutions, while maintaining flexibility and programmability for OFDM based standards and proprietary communication schemes. The level of integration of the SM2480 enables cost effective system design and easy and fast implementation.

Features

- Dual core architecture with custom N-PLC optimized DSP and Data Link Layer / Application 32bit controller
  - Supports a multitude of communication schemes and applications via firmware loads
- High speed PWM with 6 channels of outputs with programmable pairing modes and independent settings
- 4 comparators with independent references and programmable fault detection
- 16 channel Signal Monitoring ADC with simultaneous sampling of voltage/current pairs
- High performing custom N-PLC DSP engine with embedded turnkey firmware featuring:
  - Configurable operational band within 5-500KHz range - compliant with CENELEC, FCC and ARIB bands operation
  - OFDM and FSK/S-FSK modulations
  - Compliant with IEEE 1901.2, PRIME, G3-PLC, 1.3.6 and 1.4, CTIA/EIA709.2
  - Proprietary robust operation modes: XR, XXR
  - Selectable differential and coherent BPSK, QPSK, 8PSK and coherent 16QAM modulations
  - Configurable data rate up to 500kbps
  - Programmable frequency notching to improve coexistence
  - Jammer cancellation
  - Adaptive tone mapping (on-off sub-band bit loading)
  - FEC - Convolutional, Reed-Salomon and Viterbi coding
  - CRC16
  - Carrier RSSI, SNR and LQI indicators for best channel adaptation and L2/L3 metrics
  - Zero-crossing detector
- Programmable 32bit RISC protocol engine featuring:
  - Data Link Layer firmware options compliant with IEEE 1901.2, G3-PLC, PRIME, IEC61334-4-32 and others
  - Direct access to Signal Monitoring ADC for SCADA algorithms implementation - Solar micro-inverter, Arc detection, LED control, etc.
  - Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) channel access
  - Automatic Repeat Request (ARQ)
  - Meshing and self-discovery mechanisms

- CCM* with AES128 / AES256 encryption core
- On-chip Peripheral Interfaces:
  - UART
  - 5 GPIO's
  - JTAG
  - SPI master for external flash
  - Up to 2 additional SPI slaves for sensors or other devices
  - Parallel interface for data memory expansion
- Seamless interface to an external line driver for optimal system performance:
  - Integrated A/D and D/A
  - Integrated OpAmp's for RX and TX
  - Integrated PGA
- Low power operation modes
  - Offline mode
  - Listen mode
  - Receive mode
  - Transmit mode
- 3.3V (5V tolerant) digital I/O
- Receiver sensitivity of -80dBV
- -40 °C to +105 °C temperature range
- LQFP128 package

Benefits

- Single-chip grid connected signal controller ideal for solar inverters, smart lighting ballasts and other SCADA applications reducing cost and simplifying the design
- Flexible high-speed PWM and high precision dual ADC allowing simultaneous sampling of I/V values as well as fast and flexible signal adjustments ideal for power-conversion applications
- Programmable comparator triggered events for fault detection and handling
- High speed, flexible and reliable communication through integrated programmable multi-mode N-PLC modem supporting all common OFDM standards including full compliance with: IEEE 1901.2, G3-PLC, PRIME, G.hnem as well as FSK/S-FSK and proprietary communication schemes
- Low latency communication schemes
- Cost optimized system solution with integrated A/D's, D/A's, OpAmp's, PGA
- Can operate as a stand-alone communications and analog controller device or in conjunction with external host MCU

Applications

- Solar micro-inverters
- Smart LED controller
- Building automation (BA)
- Supervisory Control And Data Acquisition (SCADA)
- Concentrators

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Figure 1.   SM2480 Integrated N-PLC SCADA Controller

Description

The SM2480 is a highly integrated Signal Controller optimized for SCADA applications requiring communications to the power grid and digital signal control, such as micro-inverters, LED controllers, etc.

The SM2480 is single chip "grid connected" solution that combines the most advanced N-PLC connectivity with high speed PWM control logic. The extensive computational power available in this solution enables complete and flexible implementation of solar-microinverter, Arc detection, LED control and similar algorithms. The SM2480 combines the benefits of programmable architecture with power and cost efficiency by utilizing two 32bit cores designed specifically for N-PLC modulations, voltage/current signal monitoring and M2M protocols.

To efficiently address solar micro-inverters and similar applications, the SM2480 features a high speed flexible PWM controller with individually programmable 8 pairs of outputs with independent timing. Analog interfaces include 16 12-bit ADC channels and 4 comparators for high speed monitoring of I/V pairs and other sensors.

As a member of the SM24xx family the SM2480 features programmable OFDM based N-PLC modem including PHY, MAC and AFE featuring ADC, DAC, gain control and two OpAmp's for optimal system cost and performance.

The SM2480 comes with a number of firmware versions implementing various N-PLC schemes, such as IEEE 1901.2, PRIME, G3-PLC, and other special modes tailored for SCADA and smart grid applications.

The SM2480 enables secure communication with its 256-bit AES encryption core with CCM* mode support.
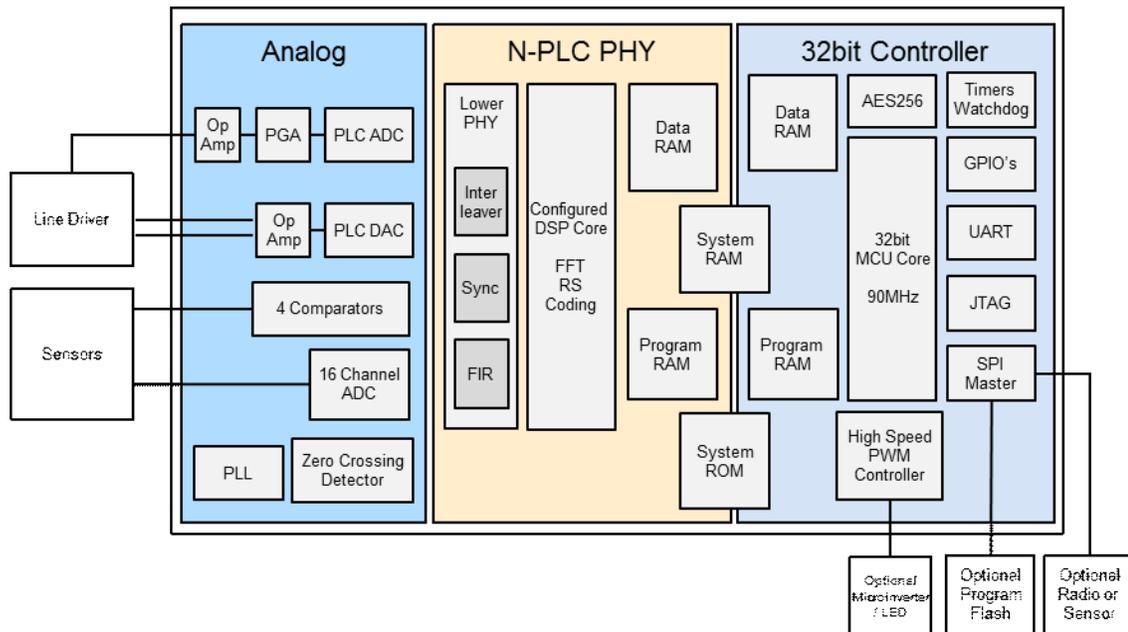
Typical Application Diagram

Figure 1-1.   SM2480 Based Grid Connected Solar Micro-inverter Diagram
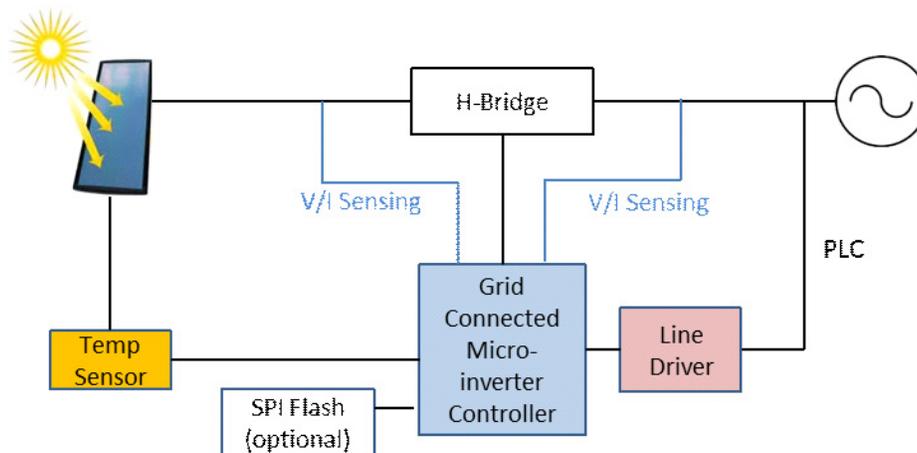
Block Diagram

Figure 1-2.   SM2480 Block Diagram

Signal Control

In addition to its high performance 32-bit core, the SM2480 integrates advanced features necessary for implementing a complete analog control system. Those include High Speed PWM, Monitoring ADC, DAC and 4 analog comparators as well as triggering logic for fast fault detection.

High Speed PWM

The high speed PWM includes 12 channels and is designed to control analog peripherals with high short response time and high degree of accuracy such as power inverters and LED lighting.

Signal Monitoring Dual ADC

Signal monitoring is possible using the Simultaneous Sampling Dual ADC which is designed to sample a multitude of sensors and in particular simultaneously sample current-voltage pairs. Conversions can be independently triggered by the PWM module or by a timer.

Timer Capture

Three timer capture modules are available for mains synchronization and detection.

Analog Comparators and DACs

The SM2480 incorporates four high-speed analog comparators with individual reference DAC's and individual multi-level hysteresis control.

N-PLC Modem

Both the SM2400 and the SM2480 support all common N-PLC standards in addition to several proprietary modes of operation. This enables maximum flexibility to the designer in implementing closed or grid connected SCADA systems utilizing analog control functions.

Selectable Modes and Modulations

The SM2480 can be configured to operate in one of several modes, such as: 1901.2, G3-PLC, PRIME, ITU1901/2, S-FSK, Lon, XR, XXR, etc. Different modes require different firmware images and imply different operational frequency bands with a varying number of carriers.

The SM2480 allows for configurable modulations per carrier. While most configurations are implied by the different standards, special modes can be created using specific combinations of carriers and modulations to achieve best performance in given channel conditions. The following modulations are available: Differential and coherent BPSK, QPSK and 8PSK and coherent 16QAM.

Forward Error Correction

The SM2480 supports Reed-Solomon (255,239) and (255,247), and rate half Convolutional coding with constraint length 7 (generator polynomial is [133,171]). In G3 and IEEE modes Convolutional coding is concatenated with RS to achieve the best reliability. Special error correction modes include extra repetition coding for increased robustness and puncturing for increased data rate on capable channels.

Communication Medium Metrics

The SM2480 provides several metrics to assist L2 and L3 channel adaptation and routing. These metrics are: RSSI, SNR and LQI, which is a measure of the data rate. The RSSI is an estimate of received signal strength. Each packet received can be interrogated for its estimated signal strength. This is very useful in determining the signal to noise ratio of different nodes on the network. Even in low noise conditions in a particular band the signal level might be attenuated significantly making data transmission unreliable. Network management systems can also interrogate each node for signal to noise ratios to create a database of all transmission path conditions. This produces a deterministic way of identifying the need for repeaters are needed in difficult and dynamically changing environments.

Security

AES encryption engine conforms to FIPS 197 standard featuring CCM*, ECB, CBC, CTR modes and of up to 256 bit key size.

Zero-crossing Detector

The SM2480 has a zero-crossing input pin which received signals generated from an external zero-crossing detector. This signal is activated when a 50Hz (or 60Hz) sinusoidal wave on the power line crosses the 0 volts threshold. The SM2480 provides a phase detection feature allowing the transmission to begin at an arbitrary phase offset and to measure the phase offset of the received packet.

Analog Front End (AFE)

The SM2480 integrates an AFE optimized for N-PLC communication, which includes ADC, DAC, PGA and 2 OpAmp's to achieve the best signal power with minimum external BOM. External components include coupling circuitry and high voltage line driver that can vary for different applications and for different operational bands.

Peripheral Interfaces

The SM2480 includes several peripheral interfaces for adding optional components. Those interfaces include UART, SPI master for external flash interface and JTAG. The second SPI extends to two additional devices that can be used for telemetry or to interface to a wireless transceiver.

Boot Options

The SM2480 can be configured to boot in one of the following ways:

Table 1-1.   Boot Options

Boot Mode	MODE[2:0]	Description
SPI Master	"000"	Read and process valid bootsector from SPI Master SSb0
CI SPI Slave	"001"	Wait on Command Interface via SPI Slave
CI UART	"010"	Wait on Command Interface via UART
Parallel Memory	"011"	Read and process valid bootsector from Parallel Memory
Reserved	"1xx"	Reserved

Contact Information

For more information regarding the SM2400 including application notes, product samples, demonstration modules, pricing and ordering please contact:

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