

## MULTI STANDARD NARROWBAND POWER LINE COMMUNICATION MODEM



### Overview

The SM2400 is the ultimate Narrowband Power Line Communication (N-PLC) modem that combines cost effective design optimized for PLC applications with high level of programmability to address multitude of communications schemes and evolving standards. Extremely flexible the SM2400 features a dual core architecture to guarantee superior communication performance while maintaining very high levels of flexibility and programmability for OFDM based and other standards as well as proprietary communications schemes. It contains all the necessary mixed signal components, such as A/D, D/A, OpAmp's, PGA to yield a cost effective PLC system design for any N- PLC application. The SM2400 has sufficient resources to execute basic networking applications, so it can be used as a stand-alone MCU or in conjunction with a host MCU.

### Benefits

- Single-chip integrating Physical Layer (PHY) and Media Access Controller (MAC) / Application core
- High programmability allowing for a single design across various standards and geographies, while addressing standard evolution, and special proprietary modes
- 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
- Can operate as a stand-alone communications

device or in conjunction with external host MCU

- Cost optimized system solution with integrated A/D, D/A, 2 OpAmp's, PGA
- Low power
- Low latency communication schemes

### Features

- Dual core architecture with custom N-PLC optimized DSP and Data Link Layer 32bit controller
- High performing custom 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 modulations
  - Compliant with IEEE 1901.2, PRIME, G3-PLC, CTIA/EIA709.2, G.hnem
  - Proprietary operation modes: NOFDM
  - 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
  - IP adaptation layers – IPv4, 6LoWPAN
  - Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) channel access

- Automatic Repeat Request (ARQ)
- CCM\* with AES128 / AES256 encryption core
- On-chip Peripheral Interfaces:
  - SPI (slave) / UART host i/f
  - Up to 19 firmware controllable GPIO's
  - JTAG
  - SRAM interface (on SM2480)
  - SPI master for external flash
  - Up to 2 additional SPI slaves for metering, wireless transceiver or other devices
- 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
- LQFP64 package

- Meshing and self discovery mechanisms

- Solar and alternative energy management
- Smart home energy monitoring
- Building automation (BA)
- SCADA (Supervisory Control And Data Acquisition)

### Description

The *SM2400* is a highly programmable OFDM based N-PLC modem combining PHY, MAC with mixed signal components for optimal system cost and performance. The *SM2400* combines the benefits of programmable architecture with power and cost efficiency by utilizing two 32bit cores configured specifically for N-PLC modulations and protocols.

The *SM2400* comes with firmware versions implementing 1901.2 compliant PHY and MAC layers and 6LoWPAN data link layer as well as PRIME, G3-PLC, FSK/BPSK, Lon compliant mode and other special modes tailored for smart metering and smart grid applications. The *SM2400* is capable of achieving data rates of up to 500Kbps over 500KHz frequency band.

The *SM2400* enables secure communication featuring a 256-bit AES encryption core with CCM\* mode support.

Integrated analog front end featuring ADC, DAC, gain control and two OpAmp's allows for a very efficient system design with a low cost BOM.

Memory interfaces include serial flash for program storage and external SRAM (available only in the SM2480) for applications requiring extended memory, such as base stations. The *SM2400* can also run simple applications on its DLL core. In case, where a host MCU is being used, they interface via SPI or UART.

### Applications

- Advanced Metering Infrastructure (AMI)
- Automated Meter Reading (AMR)
- Smart grid communication
- Street lighting control

### Typical Application Diagram

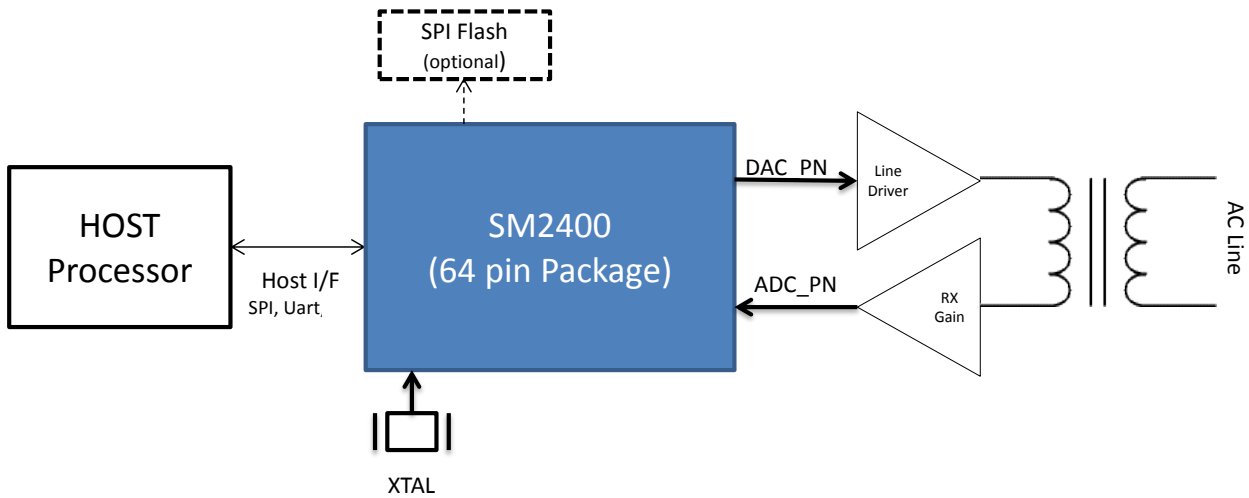


Figure 1 - SM2400 Application Block Diagram

### Block Diagram

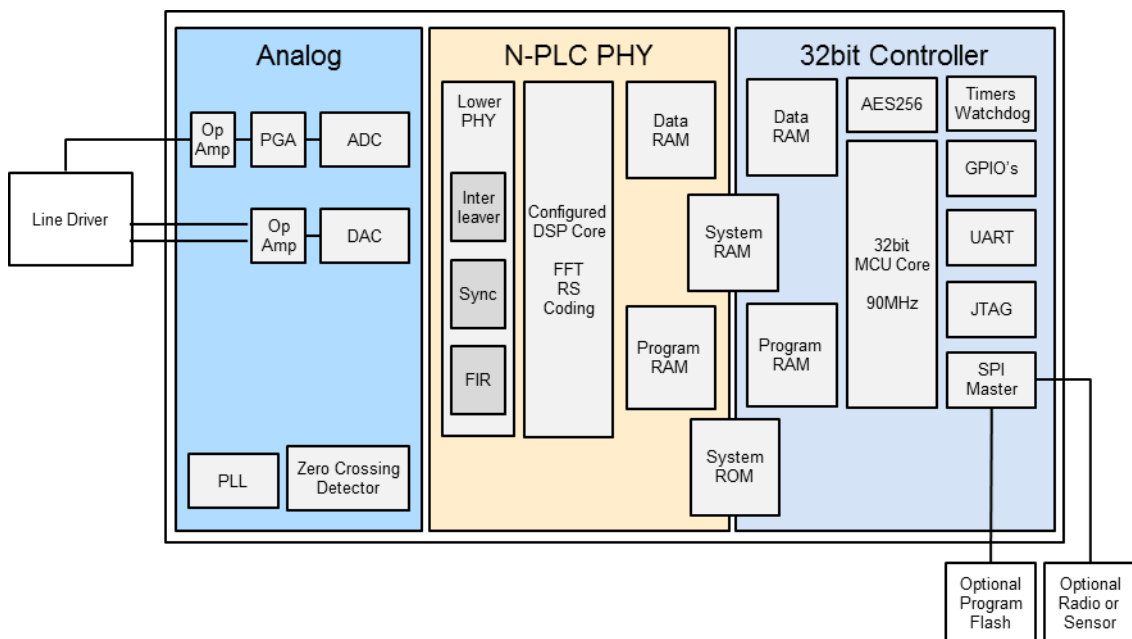


Figure 2 - SM2400 Block Diagram

## Modem

### Selectable Modes and Modulations

The SM2400 can be configured to operate in one of several modes, such as: 1901.2, G3-PLC, PRIME, ITU1901/2, G.hnem, S-FSK, NOFDM, 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 SM2400 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 SM2400 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 to determine the signal to noise ratio of different nodes on the network. It may be that the noise in a particular band is low but the signal is also 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 finding where repeaters are needed in a difficult environment even if they are dynamic.

### 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 SM2400 has a zero-crossing input pin which takes signals generated by an external zero-crossing detector based on the transition through zero volts of a 50Hz (or 60Hz) sinusoidal on the power line. The SM2400 provides a phase detection feature allowing the transmission beginning at an arbitrary phase offset and

measuring the phase offset of the received packet.

### Analog Front End (AFE)

The SM2400 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 SM2400 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 SM2400 can be configured to boot in one of the following ways:

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 (only available in SM2480)
Reserved	"1xx"	Reserved

