Demonstration Platform

Power Line Modem with e-Meter *Kit # 6449895*

DSP-Based OFDM Modem and MSP430 Enable Automated Meter Reading

Target Applications
- Automated Meter Reading (AMR)
- SCADA
- Smart Applicances (White Goods)
- HVAC
- Industrial Control
- Building Monitoring

The Modem

TI's Power Line Modem/e-Meter platform transmits low to medium speed data across low-voltage power lines for intra-building as well as "last-mile" connectivity to substations and transformers.

Modem Specifications
- 220-V/110-V operation
- Over 10-kbps effective user data rate (> 64-kbps raw bit rate)
- 9-kHz to 95-kHz (A-band)
- CENELEC compliance

By combining advanced DSP techniques with High Performance Analog circuits, TI's OFDM modem solution exceeds the performance of competing FSK or conventional spread-spectrum modem designs. Its open, scalable architecture meets increasing network traffic demands, while offering a high degree of data integrity.

The e-Meter

TI's latest application specific microcontroller, the MSP430FE427, has been designed for single-phase e-Meter applications. An embedded signal processor (ESP) calculates average and peak values for RMS voltage, current and power, as well as power factor [cos(phi)], temperature and energy (kWh) used. Its ultra-low power operation ensures negligible system load and data retention during blackouts, powered only by a small lithium coin cell. With its integrated LCD driver, the MSP430 is the simplest solution for e-Meters on the market. It interfaces via RS-485 to the modem, so it can be part of a larger AMR system feeding into a central data concentrator.

The Demonstration

In addition to the MSP430 e-Meter, the demo can use an internal data traffic generator to test the modem's
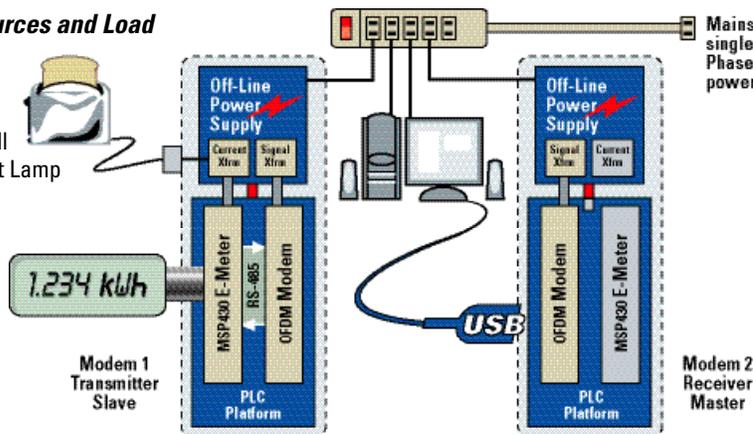

Figure 2: *PLC e-Meter unit*

bit error rate (BER). Performance results and real-time e-Meter data are displayed on a PC, which is connected to the receiving modem with either a USB or RS-232 cable.

A simulation window displays modem performance estimates under different sets of variables, such as a frequency range covering 3-kHz to 500-kHz, various signal processing options, and data packet sizes.

Key Features
- 3-piece modem chipset
- Single-chip e-Meter
- Bit error rate (BER) performance testing
- Performance simulation
- Advanced DSP techniques
  - o Proven OFDM technology
  - o Viterbi detection
  - o DQPSK modulation
- Interface options
  - o RS-485
  - o RS-232
  - o USB

Noice Sources and Load
Toaster
Dimmer
TV Monitor
Electric Drill
Fluorescent Lamp

Figure 1: *PLC/eMeter Demonstration System*

Figure 3: *Power-Line Modem /e-Meter Block Diagram*
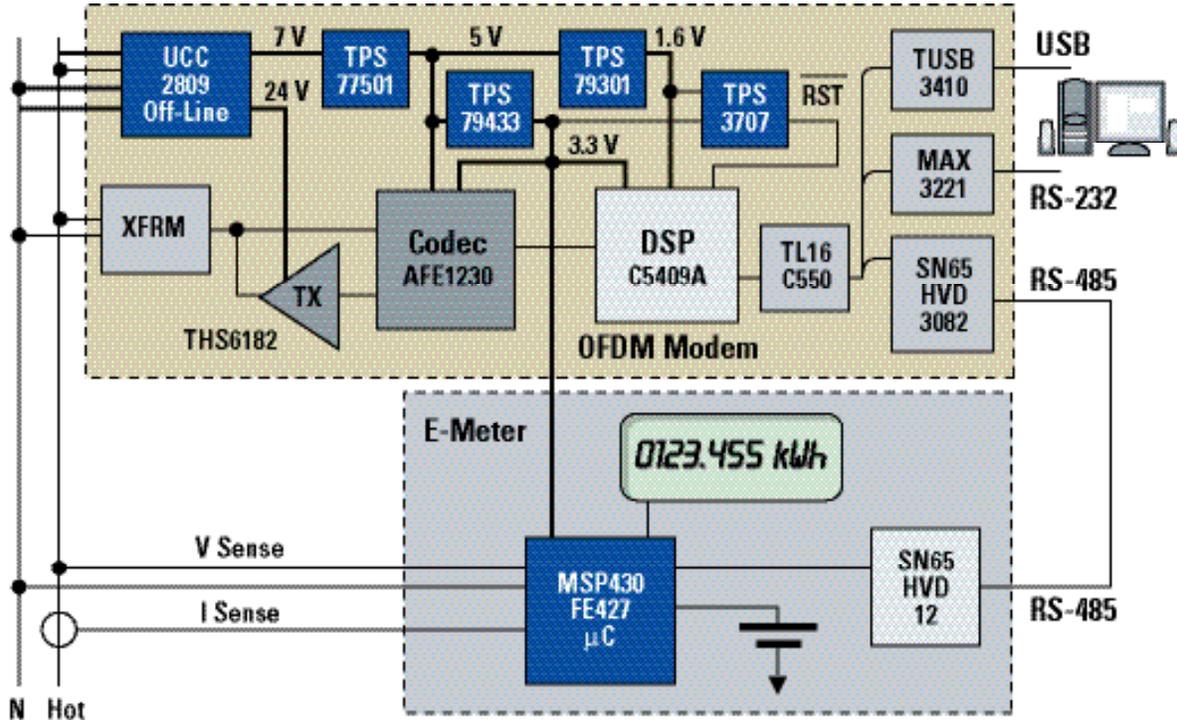
Modem Architecture
The core modem design consists of three components:
- TMS320C5409A DSP for signal processing
- AFE1230 Analog Front End to acquire, filter and scale the appropriate signals for processing
- THS6182 line driver to couple the modulated signals into the output transformer

The most popular serial interfaces have been provided to allow field-testing of the orthogonal frequency division multiplexing (OFDM) modem under a variety of conditions. An RS-485 interface provides a standard industrial and low cost means to connect remote e-Meters to a central dataconcentrator containing the modem. The ubiquitous RS-232 port is universal to connect the modem to nearly any peripheral, and the USB is a convenient port for portable, laptop-based instrumentation. Designed with the most stringent European (CENELEC) specifications

in mind, advanced signal processing techniques have been employed to offer high data integrity over the "last mile" of connectivity to a residential e-Meter or data concentrator, located in a high-rise or an industrial complex.

Technology
Compared to conventional frequency shift keying (FSK) techniques, TI's OFDM modem will yield lower bit error rates (BER) at much improved data throughput. These benefits are particularly realized in impulse-noise polluted environments with severe multipath interference, such as on a power line. OFDM has already been proven in DSL, cellular and digital TV applications. Viterbi detection improves signal-to-noise performance by statistical analysis of the bit stream and error correction. Differential quadrature phase shift keying (DQPSK) improves the bandwidth efficiency of each carrier across the spectrum and eliminates the need for a phase-locked loop (PLL) device.

An off-line switch-mode converter provides power to the modem, which is then sub-regulated with TI's low noise LDOs to maximize signal-to-noise ratio (SNR) performance.

Power Line Modem with e-Meter Platform Kit (#6449895)
This platform kit contains the following:
- Two fully functional printed circuit boards containing modem, e-Meter and power supply in a protective enclosure
- One RS-232 serial cable
- One USB cable
- A CD containing:
  - Bill-of-materials
  - GUI software (executables)
  - Design documentation
  - Application notes
  - Getting Started guide

Software source code, schematics and Gerber files available upon request.

Product Selection Guide

Analog Front End

Device	ADC	DAC	Sampling Rate	Gain / per step	Features	Supply Voltage(s)
AFE1230	16 bit	16 bit	1250 kHz	21 dB / 3 dB	Programmable Rx, Tx filters	3.3 V, 5 V

Processor

Device	Data (bytes)	Program (bytes)	FLASH	MIPS @cycle time	Power Supply	Package(s)
Single-Phase E-Meter						
MSP430FE427	1 K	32 K	256 B	8 @ 125 ns	2.7 V to 3.6 V 400 µA @ 3 V, 1 MHz	64-pin QFP
Poly-Phase E-Meter						
MSP430F449	2 K	60 K	256 B	8 @ 125 ns	1.8 V to 3.6 V [1] 280 µA @ 2.2 V, 1 MHz	80-pin QFP 80-pin QFP or 100-pin QFP

Device	Data (bytes)	Program (bytes)	DMA	MIPS @cycle time	Supply Voltage(s)	Package(s)
Modem / DSP						
TMS320VC5409A-160	64 K	32 K	6 ch	160 @ 6.25 ns	1.6 V / 3.3 V	144 LQFP, 144 BGA
TMS320VC5410A-160	128 K	32 K	6 ch	160 @ 6.25 ns	1.6 V / 3.3 V	144 LQFP, 144 BGA
TMS320C5502-200	64 K	32 K	6 ch	400 @ 5 ns	1.2 V / 3.3 V	176 LQPF, 201 BGA

[1] 2.7 V to 3.6 V needed for FLASH programming

Line Driver

Device	Description	Drivers	Output Current	GBW	I_{CC}	I_{STDBY}	Supply Voltage
THS6182	ADSL Line Driver	2	600 mA	100 MHz	11 mA	0.25 µA	10 V to 30 V
OPA2677	Dual Op Amp	2	500 mA	220 MHz	18 mA	0.8 mA	5 V to 12 V
OPA561	Power Op Amp	1	1,200 mA	17 MHz	50 mA	250 µA	7 V to 15 V
TLE2301	Power Op Amp	1	1,000 mA	8 MHz	10 mA	1.73 mA	9 V to 40 V

Interface

Device	Description	I_{CC}	I_{STDBY}	Speed	ESD	Supply Voltage
SN65HVD12	Differential Transceiver, RS-485	9 mA	1 µA	25 Mbps	16-kV HBM	3.3 V
SN65HVD3082	Low-Power RS-485 Transceiver	0.3 mA	1 nA	200 kbps	16-kV HBM	3.3 V
TL16C550	Single UART with 16-Byte FIFO	10 mA			2-kV HBM	3.3 V, 5 V
TUSB3410	USB-to-Serial Port Converter 1	5 mA	200 µA	12 Mbps 921 kbps	2-kV HBM	3.3 V
MAX3221	Single-Channel RS-232 Line Driver/Receiver	1 mA	1 µA	250 kbps	15-kV HBM	3.3 V to 5 V

Power Management

Device	Description	I_{CC} I_{STDBY}	Input Voltage Range	Output Voltage(s)	Output	Package(s)
UCC2809	Off-Line Converter	600 µA no load	8 V to 17.5 V	Adjustable	< 1-MHz N-chFET	SOIC 8, MSOP 8 TSSOP 8
TPS71533	High Input Voltage, Micropower LDO	4.3 µA	2.5 V to 24 V	2.5 V, 3.3 V	50 mA	SC 70, SOT 323
TPS77501	Low Drop-Out (LDO) regulator	85 µA 1 µA	2.7 V to 10 V	1.5 V to 5.5 V	500 mA	SOIC 8, TSSOP 20 [1]
TPS79433	Low Drop-Out (LDO) regulator	172 µA, 1 µA	2.7 V to 5.5 V	3.3 V	250 mA	MSOP 8, SOT 223
TPS79301	Low Drop-Out (LDO) regulator	170 µA, 1 µA	2.7 V to 5.5 V	1.2 V to 5.5 V	200 mA	SOT 23, CSP [2]
TPS3707	Supply Voltage Supervisor	50 µA	2 V to 6 V			MSOP 8, SO 8

[1] *PowerPAD™*

[2] *NanoStar™*

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