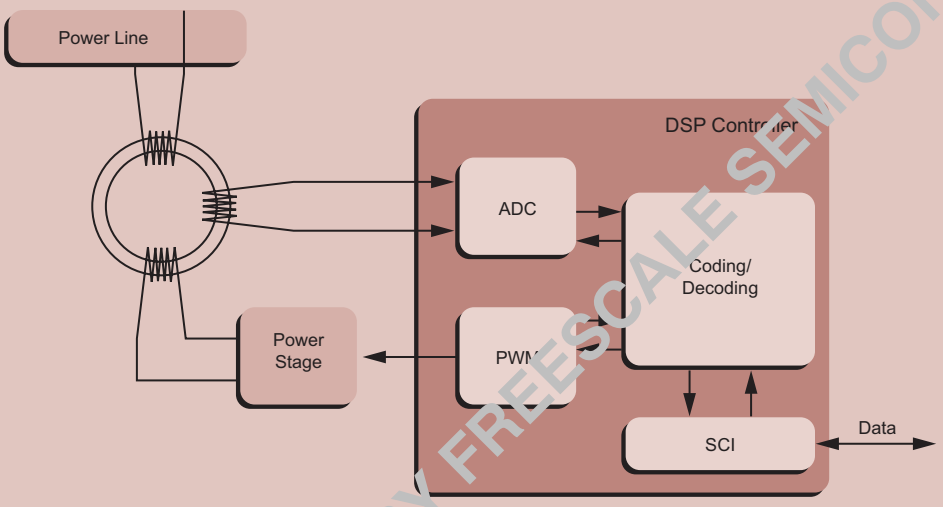
Power Line Modem Applications

Overview

A power line modem, increasingly used for communication between several appliances and an integral component of the smart kitchen, once required both a microcontroller for general control and a specialized application-specific integrated circuit (ASIC) for coding/decoding and sending/receiving functions. Today, both the microcontroller and ASIC in a power line modem are often replaced by a digital signal controller (DSC).

POWER LINE MODEM BLOCK DIAGRAM



Key Benefits

> Interfaces low voltage to high voltage power grid

> Transmits the data using the existing power transmission line

> Supports networking and independent addressing of end devices

> Supports stand-alone operation in small applications

> Requires a small power stage for signal delivery

> Out-of-the-box software components designed to expedite time-to-market and reduce development costs

freescale semiconductor

Freescale Ordering Information

Part Number	Product Highlights	Additional Information
DSP56F800 Family	80 MHz, 40 MIPS, up to 31.5KB Flash, 6K words RAM and Off-Chip Memory, SCI, SPI, ADC, PWM, Quadrature Decoder, Quad Timer, CAN, GPIO, MCU-friendly instruction set, JTAG/OnCE for debug	www.freescale.com
DSP56F827	80 MHz, 40 MIPS, SCI, SPI, SSI, TOD, ADC, Quad Timer and > 64K Program Flash > 1K Program RAM > 4K Data Flash > 4K Data RAM	MCU-friendly instruction set, OnCE for debug, external memory expansion, and up to 52 GPIO available in 128-pin LQFP.
MC56F8322	60 MHz, 60 MIPS, 48KB Flash and 12KB RAM with 2 SPI, 2 SCI, 2 ADC, PWM, COP, PLL, Decoder, 2 Quad Timers, FlexCAN, an MCU-friendly instruction set, Enhanced OnCE for debug, on-chip relaxation oscillator, and temperature sensor.	Industrial (-40°C to 105°C) and Extended (-40°C to 125°C) Temperature Ranges, with up to 21 GPIOs in a 48-pin LQFP.
MC56F8323	60 MHz, 60 MIPS, 48KB Flash and 12KB RAM with 2 SPI, 2 SCI, 2 ADC, PWM, COP, PLL, Decoder, 2 Quad Timers, FlexCAN, an MCU-friendly instruction set, Enhanced OnCE for debug, on-chip relaxation oscillator, and temperature sensor.	Industrial (-40°C to 105°C) and Extended (-40°C to 125°C) Temperature Ranges, with up to 27 GPIOs in a 64-pin LQFP.

Design Challenges

A power line modem transmits and receives data through a power line, or mains. Its use in home applications requires a duplex-mode power line modem that transmits and receives data at approximately 10 kbit/s.

The block diagram on page 1 shows a simple block diagram of a power line modem. An incoming signal is coupled to the receiving component of the modem that decodes the data and delivers it to the application through an interface. The application returns data to the modem, where it's coded. The transmitter then generates an amplified signal that is coupled into the power line.

Among factors to consider in power line communications are:

> Easy signal coupling into and out of the power line.

> Efficient transmission through the power line and ongoing separation between the communication signal and the power line frequency.

> Resistance to noise and interference such as electromagnetic interference (EMI) and electromagnetic compatibility (EMC).

The regulations for power line communication in America, Europe, and Asia differ greatly. A common standard does not exist. In Europe, for example, several frequency bands and frequencies ranging from 3 kHz to 148.5 kHz have been defined for power line communications. The frequency range of 95 kHz to 148.5 kHz is open for home interconnectivity applications, with the modulation frequency band, 125 kHz to 140 kHz, defined as carrier sense multiple access (CSMA).

The modulation band selected for power line communications must meet the required data rate while maximizing resistance to noise and interference with the signal on any power line, there are several sources of noise and interference, each with individual characteristics:

> Multiples of the main frequency; i.e., 50 Hz, 100 Hz, 150 Hz

> High-voltage transients from flashes or switches

> High-frequency noise of power factor corrections (PFCs), motors, and inverters

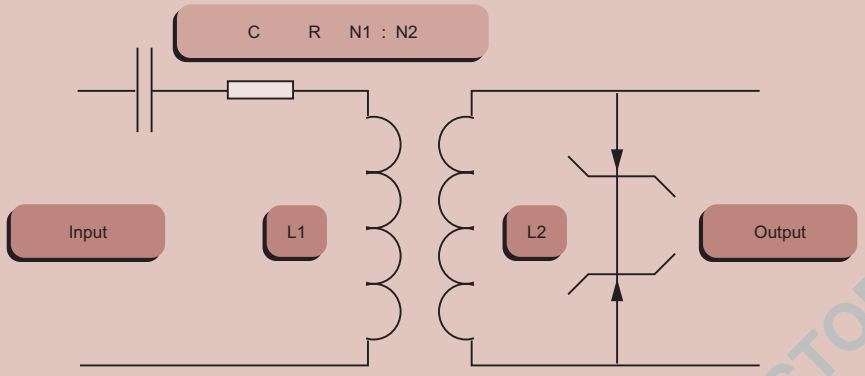
Every modulation band has advantages and disadvantages. Commonly used schemes for modulation include binary phase shift keying (BSK), frequency shift keying (FSK), and several spread spectrum techniques. In all applications, a modulation scheme should support networking and independent addressing of the end devices. The physical interface should provide for coupling the signal from the transmitter to the power line and from the power line to the receiver.

Freescale Semiconductor Solution

A coupling transformer with high pass characteristic is a reliable solution, providing necessary galvanic isolation of the power line from the main voltage. In a one-phase operation, the transformer should be connected in parallel between one phase and neutral for 220 V and between two of the three phases for a three-phase operation. A serial connection of the coupling transformer is not recommended, because it results in a high current through the transformer that causes a magnetic saturation of the transformer core. The figure below shows a basic schematic often used for a coupler.

In the figure below, values of R, C and the ratio of the transformer depend on the actual data rate and power and frequency of the signal. For use in frequencies ranging from 95 kHz to 148.5 kHz, the coupled signal voltage can reach up to 116 dBµV, equaling 631 mV.

BASIC SCHEMATIC OF A DATA COUPLER FOR A POWER LINE MODEM

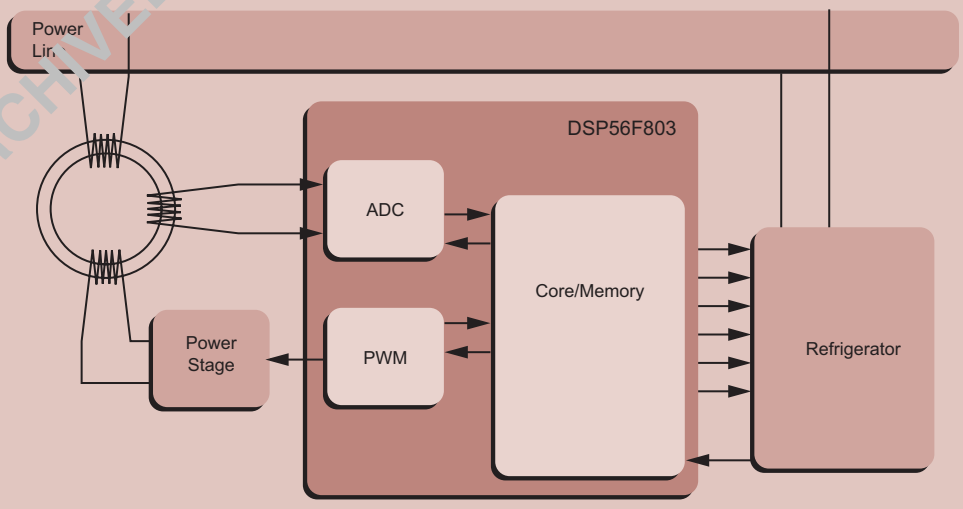


Freescale Semiconductor's DSP56F8xx offers a superior solution in a power line modem. The DSP56F8xx's small form factor, internal clock generator, and microcontroller functions make this device ideal in a stand-alone operation in small applications. The 12-bit analog-to-digital converter (ADC) has sufficient resolution to detect information signals, and a 15-bit pulse width modulation (PWM) generates clear transmissions. The on-chip flash memory and calculating power code and decode data is transmitted to the application by the integrated serial communications interface (SCI). Only a small power stage is required to deliver the signal to the coupling transformer.

As shown in the figure on page 4, a power line modem may be added to an existing application using a DSP56F8xx. The combination and interaction between the algorithms used for the power line modem and an appliance mean an influence of the appliance's power stage to the power line communication can be avoided.

A special reference design can demonstrate the benefits of including the DSP56F8xx in a power line modem. After successfully proving the functionality via the reference design, the software for power line communication may be integrated into the embedded Software Development Kit (SDK).

POWER LINE MODEM AS AN ADD-ON IN A REFRIGERATOR



Development Tools

Tool Type	Product Name	Vendor	Description
Software	CW568X	Freescale Semiconductor	CodeWarrior™ Development Studio for 56800/E Controllers with Processor Expert (Metrowerks)
Software	Processor Expert	Freescale Semiconductor	Software infrastructure that allows development of efficient, high level software applications that are fully portable and reusable across all 56800/E family of processors.
Software	CWDSP56800	Freescale Semiconductor	CodeWarrior Software Development Tools for DSP56800E (Metrowerks)
Hardware	56F800DEMO	Freescale Semiconductor	56F800 Demonstration Kit
Hardware	DSP56F801EVM	Freescale Semiconductor	Evaluation Module for the 56F801 and 56F802
Hardware	DSP56F803EVM	Freescale Semiconductor	Evaluation Module for the 56F803
Hardware	DSP56F805EVM	Freescale Semiconductor	Evaluation Module for the 56F805
Hardware	DSP56F807EVM	Freescale Semiconductor	Evaluation Module for the 56F807
Hardware	DSP56F827EVM	Freescale Semiconductor	Evaluation Module for the 56F827
Hardware	MC56F8300DSK	Freescale Semiconductor	56F8300 Developers Start Kit
Hardware	MC56F8323EVM	Freescale Semiconductor	Evaluation Module for 56F8322 and 56F8323
Development Kit	DSPOSRTOS	Freescale Semiconductor	Emulation Support for DSP56F8xx Processors (Requires Ethernet Network)

Disclaimer

This document may not include all the details necessary to completely develop this design. It is provided as a reference only and is intended to demonstrate the variety of applications for the device.

Learn More: Contact the Technical Information Center at +1-800-521-6274 or +1-480-768-2130.
For more information about Freescale products, please visit **www.freescale.com**.

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