Freescale Smart Energy Solutions

Power Generation, Transmission, Monitoring & Control
System solutions for monitoring & control

Grid Power Protection, Relay/Switch Control and Monitoring
Grid Power supervision, control and network protection system solutions; Protective Relays and Switches control for Power Grid

Data Concentrator (Aggregator): Sends data collected (or commands) to and from Neighbor Area Network (NAN) or Home Area Network (HAN) to utility

NAN: Neighborhood Area Network
Wired/Wireless connecting meter to Utility either directly or via a data aggregator

NAN Interfaces
- ZigBee (MC13224/6)
- M-Bus (MC12311)
- Metering comms SoC
- RF4CE (wireless control)

HAN: Home Area Network
Wireless/wired for load control and dynamic response by utilities

Demand Response: Send pricing signals to consumers for smarter energy consumption

Energy Gateway/Manager: Interface to smart objects in home to monitor/control energy

Low End Meters
8-bit MCU
- 9S08LL/LH/AC
- 32-bit MCU
- 9S08GW64

Smart Energy Gateway
- i.MX , MPC8308, P102x
- MK30/ MK10
- HAN Interfaces
- ZigBee (MC13224/6)
- M-Bus (MC12311)
- Appliance Technology
- 8-32bit MCU & DSC
- Touch Sensor
- RF4CE (wireless control)

The Smart Grid

Traditional & Renewable Generation Options

Commercial & Industrial Time of Day Benefits Largely Realized

Grid Level Storage

Home Energy Management Solutions Critical To Realizing Demand Response Potential

Micro-Grids Isolate Service Interruptions and Enable Self Healing

Time of Day Billing Motivates Consumer Participation in Demand Response Programs

Micro-generation Saves Consumers $ While Reducing Peak Load on the Grid
Residential Makes Up Half The Potential Impact of Demand Response Programs

US Demand Response Potential by Class (2019)\(^1\)

1. (FERC Assessment of Demand Response Potential, June 2009)
Utility Motivation: Demand Response aka Peak Shaving
Demand Response and Home Energy Management
Home Energy Management via your Thermostat, Home Security Panel HEM Hub or HEM-enabled WiFi Router

The Smart Meter

Electric Service

Micro-generation

Smart Plugs For Legacy Appliances

Your Smartphone is your HEM UI

Smart Appliances

Electric Vehicle & Charging Station

Triple Play Pipe

Wattsaver Power Adapter

The Smart Meter

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Wattsaver Power Adapter
Consumer motivation for HEM:
Almost $400 in Potential Annual Savings*

- $22: Shift daily dishwashing to off peak rates
- $42: Reduce water heating by one hour / day
- $49: Take automated control of household lighting
- $62: Shift daily clothes drying to off peak rates
- $73: Reduce Central AC usage by 1 hour / day
- $149: Shift electric car charging to off peak rates

* See details in back-up slides
Consumer motivation for HEM:
What about the cool factor?
Home Management is more than Energy
Home Management Could be the Next Core App
Actionable & Relevant Recommendations Critical To Adoption & Realization of Savings Potential

Energy

Security

Automation
Home Energy Manager (HEM) Reference Design

- Smart Meter
- AC
- MC13224V ZigBee chipset SE 1.0
- MC12311 <1GHz Mbus-RF chipset
- MC13224V ZigBee chipset HA 1.0
- ARM9™ Core 400MHz
- UART
- Integrated PMIC
- Integrated Crypto
- NAND Controller
- DDR2
- NAND Flash
- USB w/ PHY
- Wi-Fi 802.11bg Module
- Optional add-on
- Optional Wireless WAN
- Optional add-on

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- Freescale Silicon
- i.MX28 features used in HEM ref design shown

- Board Features
- Enabled Networks

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i.MX283 Key Features for HEM

**ARM9 Processor**
- Open architecture, Enough processing power for fast database search, fast rich UI serving and other apps.

**Scalable**
- Part of a scalable, pin-compatible family with various feature sets allowing for entry level to high end systems.

**Low Power**
- Less than 0.5W in harshest conditions (temperature).

**Security**
- Supports authenticated boot, anti cloning and crypto acceleration for protection.

**Software**
- Supports open OS platforms (Linux, Windows Embedded), JVM and OSGI simplifying upgrades to support new end user use cases.

**Optimized system cost**
- Embedded power management, display and connectivity for reduced cost and complexity, implemented in 4-layer PCB.

**Longevity**
- Part of Freescale’s product longevity program: 15 years.
Reference Kit $650 - Includes:

- Free Schematics/ Orcad & Gerbers
- Window Embedded Compact 7 and Linux,
- Microdoc JVM and ProSyst mBS OSGI,

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<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>HEG Documentation</td>
<td>• iMX28 Windows Embedded Compact 7 BSP User Guide</td>
</tr>
<tr>
<td></td>
<td>• HEG Linux Software User Guide</td>
</tr>
<tr>
<td></td>
<td>• HEG Hardware User Guide</td>
</tr>
<tr>
<td></td>
<td>• HEG Schematics, layout and Gerber files</td>
</tr>
<tr>
<td></td>
<td>• HEG Windows Embedded Compact 7 demo tutorial</td>
</tr>
<tr>
<td></td>
<td>• HEG Linux 2.6/Prosys mBS OSGI/MicroDoc JVM demo tutorial</td>
</tr>
<tr>
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<td>• HEG Linux 2.6/QNX demo tutorial</td>
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<th>Delivery</th>
<th>Comment</th>
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<tr>
<td>Windows Embedded</td>
<td>Source Code</td>
<td>• iMX28 LTIB ver L2.6.35_10.12.01_ER</td>
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<tr>
<td>Compact 7</td>
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<td>• HEG Patch for LTIB ver10.05</td>
</tr>
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<th>HEG Application</th>
<th>Remote UI</th>
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<tr>
<td>Windows Embedded</td>
<td>Delivered in Source Code with embedded Web server</td>
<td>Any Web Browsers (supporting Microsoft® Silverlight® plug-in)</td>
</tr>
<tr>
<td>Compact 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linux-Linux 2.6/</td>
<td>Delivered in Binary Object with embedded Web server</td>
<td>Google Chrome® browser, Firefox®</td>
</tr>
<tr>
<td>Prosys mBS OSGI/</td>
<td></td>
<td></td>
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<tr>
<td>MicroDoc JVM</td>
<td></td>
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</tr>
<tr>
<td>Linux-QNX</td>
<td>Delivered in Source Code</td>
<td>Running on i.MX25pdk delivered in Source Code</td>
</tr>
</tbody>
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Get to Know the HEG Board

Get to Know the HEG Board (back side)
HEM Remote User Interface Options

QNX Flash-lite

Java ‘Web’ UI running on web browser e.g. iPod / iPad

Silverlight IHD
Windows Embedded Compact 7
Freescale
Networked Smart Gateway
(NSG)
MPC8308-NSG (Networked Smart Gateway) Reference Design

- ZigBee SE 1.0 HAN
- Smart Meter
- AC
- ZigBee HA 1.0 HAN
- Appliance
- Smart Plug

MC13224V
- ZigBee USB Module SE1.0
- ZigBee Module HA 1.0
- MC13224V
- ZigBee

Optional Wireless
- WiFi

Wi-Fi LAN
- 802.11n Module

USB PHY
- USB PHY
- USB HUB

USB 2.0
- PCIe

MPC8308
- e300c3 Core
- 16 KB I-cache
- 16 KB D-cache
- SDHC
- eMMC
- GigE Phy (2)
- GigE Phy (2)

I2C
- Local Bus
- DDR2

Board Control
- NAND/NOR Flash
- DDR2

Remote Access
- Baseband Router/Residential Gateway

Freescale Silicon
- Board Features
- Enabled Networks
MPC8308-NSG Multi-Application Platform

Wi-Fi Security Cameras (up to 8)

PC

HD Monitor

Tablet

LAN

4G/3G USB

Cable or DSL

WAN

Modlet

MC13226

ZigBee

Home Automation 1.0

Smart Meter

ZigBee

Smart Energy 1.0

MCF51EM256 & MC13224V

NSG

MPC8308 & MC13226

Linux/OpenSource

Enables Smart HH devices to Remotely monitor & control
Key Advantages of MPC8308-NSG

• “Turn-Key” ready design, fully owned by Freescale
  − No third party licensing for hardware or software
• Ready for mass production with little or no modifications
  − Significantly reduces OEM/ODM design effort and cost
  − Greatly reduces program risk
  − Accelerates customer time-to-market
• Supports multiple high-value applications
  − In addition to Smart Energy and Home Automation
  − Supports:
    ▪ Broadband internet access – DSL, DOCSIS, FTTH, 3G/4G
    ▪ Home Security & Surveillance
    ▪ Streaming HD video
    ▪ VoIP
MPC8308-NSG Development Tools and Software

**Hardware**
- MPC8308-NSG with enclosure
- Power supply 12VDC
- Cable, UART, DB9 M/F to 1x3 female header
- Cable, Ethernet, straight thru wiring
- Schematics and GERBER files

**Software / Tools (Basic package)**
- Linux® Board Support Package (BSP)
  - U-boot: u-boot-2009.11-rc1
  - Kernel: Linux 2.6.29.6
  - GCC toolchain: gcc-4.1.2-elibc-2.5.78
  - DLNA: miniDLNA 1.0.17
  - IDS Snort 2.4.4
  - IPS uses Linux iptables 1.4.2

**Software / Apps (Enhanced package)**
- Network Video Recorder Stack
- VoIP: Asterisk-1.4.21.1

**Other:**
- CodeWarrior Development Studio for Power Architecture® 8.8, Service Pack 2 (Win & Linux Hosted)

Available Collateral:
- Schematics, Gerbers, Linux BSP, Sample Application code, GUI
Freescale
In Home Energy Display
In Home Energy Display (IHED) Reference Design

- **WMbus devices**
  - MC12311 (Sub 1GHz) Wireless M-Bus 868MHz
  - MC13226 2.4GHz 802.15.4 ZigBee HA / SE

- **320 Segment LCD controller**
  - UART

- **MK40**
  - ARM Cortex M4
  - 512K FLASH
  - 128K RAM
  - SPI

- **SDHC slot**
  - USB 2.0

- **UMI connector**
**Kinetis K30/40 In Home Energy Display (MMC) : Overview**

**Key Features:**

- **Seamless Wireless Connectivity** (2.4GHz & sub 1GHz)
  - Smart Metering with ZigBee SE 1.x
  - 802.15.4 proprietary
  - 868MHz Wireless M-Bus
  - Remote management & control of Smart Appliances (via ZigBee HA1.0)
- **Simple/clear Segment display**
  - Provides long battery life
  - Meter reading, energy consumption & history
  - Alert Notifications of tariff changes by utilities in real time
  - Demand Response - manage energy usage (HVAC, lighting, car charging, etc.)
- **Integration of essential software stacks**
  - Wireless M-Bus for Europe
  - ZigBee Home Automation 1.0 Profile
  - ZigBee Smart Energy 1.0 Profile

**Availability: Q**

**Includes:**
- ✓ Free Schematics/ Orcad & Gerbers
- ✓ Code for:
  - K30/40
  - MC12311
  - MC13226 & Zigbee BeeKit
- ✓ Free demonstration software
- ✓ Complete BOM < $20 in qty
Connectivity
Freescale’s Multi-PHY/MAC Smart Energy Software Strategy

- Plug-n-Play Profiles
- IPv6 Centric Networking

Separate PHY/MAC silicon Solutions... isolates you from PHY/MAC Churn

Kinetis MCU Scalable Portfolio w/MQX

Profile API
- Smart Energy 2.0
- Last Mile Profile

MAC API
- ZigBee IP
- MQX RTCS
- IPv6 Tool Box
- IPv6 Light

Profile API

Profile API

15.4 Modem
PLC Mode
WiFi Mode

802.15.4 2.4GHz
PowerLine (HPG, G.hn)

802.15.4 Sub GHz

IPv6 Tool Box
IPv6 Light

IPv6 Centric Networking

Separate PHY/MAC silicon Solutions... isolates you from PHY/MAC Churn

Plug-n-Play Profiles
Kinetis
Design Potential. Realized.

Ultra-Scalable – Market’s most scalable portfolio of low-power ARM Cortex-M4 MCUs with over 200 hardware and software compatible devices

Innovative Flex Memory – Low Power 90nm Thin-Film Storage Flash with FlexMemory offers EEPROM capability with unprecedented programming speed and endurance

Mixed Signal – Exceptional integration with fast 16-bit ADCs, DACs, PGAs and more. Powerful, cost-effective signal conversion, conditioning and control

Comprehensive Enablement – Freescale MQX RTOS and Eclipse-based CodeWarrior IDE, as well as IAR, KEIL and other ARM ecosystem providers
Multiple compatible families with scalable performance, memory and peripherals
### Freescale RF IC Roadmap

<table>
<thead>
<tr>
<th>High Performance Platforms</th>
<th>Low Cost Platforms</th>
<th>RF Transceivers</th>
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<tr>
<td><strong>MC13224</strong></td>
<td><strong>MC13233</strong></td>
<td><strong>MC1320x</strong></td>
</tr>
<tr>
<td>• PiP (Platform-in-Package)</td>
<td>• 2.4 GHz SoC</td>
<td>• 2.4 GHz RFIC</td>
</tr>
<tr>
<td>• 2.4 GHz RFIC + 32-bit ARM</td>
<td>• 8-bit HCS08</td>
<td>• 82 KB Flash, 5 KB RAM</td>
</tr>
<tr>
<td><strong>MC13226</strong></td>
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<td></td>
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<tr>
<td>• 2.4 GHz ZigBee</td>
<td></td>
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<tr>
<td>ROM</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MC1321x</strong></td>
<td><strong>MC12311</strong></td>
<td></td>
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<tr>
<td>• SiP (System-in-Package)</td>
<td>• Sub-GHz SiP</td>
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<tr>
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<td>2K RAM</td>
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</table>

#### 2007 Timeline
- **2007**: MC1320x, 2.4 GHz RFIC
MC13233 System-on-Chip

• MCU Features
  - Integrated HC9S08 8-bit up to 32 MHz
  - Up to 82 KB Flash and 5 KB RAM
  - Peripherals: SCI, SPI, I2C, up to 12x12 KBI, carrier modulated timer (IR)
  - Up to 32 General Purpose Input/Output ports (GPIO)

• Radio Features
  - Programmable Tx from -30 dBm to +2 dBm
  - RX sensitivity of -94 dBm
  - <34 mA Rx & 27 mA Tx with radio and MCU
  - 802.15.4 compliant 2.4 GHz RF transceiver
  - Auto-trim feature for crystal accuracy
  - Integrated Transmit/Receive switch

• General Features
  - Power supply range: 1.8V to 3.6V
  - AES 128-bit hardware encryption/decryption
  - 7 mm x 7 mm 48pin LGA
  - Operating Temperature Range: -40°C to 85°C

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<table>
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<tr>
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<tr>
<td>Protocol Stack</td>
<td>SMAC</td>
</tr>
<tr>
<td></td>
<td>IEEE © 802.15.4</td>
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<tr>
<td></td>
<td>SynkroRF</td>
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<tr>
<td></td>
<td>ZigBee 2007</td>
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<tr>
<td></td>
<td>ZigBee RF4CE</td>
</tr>
<tr>
<td>Memory</td>
<td>82 KB Flash</td>
</tr>
<tr>
<td></td>
<td>5 KB RAM</td>
</tr>
<tr>
<td>2011 1K SRP</td>
<td>$2.99</td>
</tr>
</tbody>
</table>
Features

- Integrated 2.4 GHz transceiver with 32-bit CPU
  - 802.15.4-compliant transceiver
  - ARM7TDMI up to 26 Mhz
- Lowest power
  - Significant power reduction – up to 45%
  - 22 mA Rx & 29 mA Tx with radio and MCU
- Plenty of memory for ZigBee applications
  - ROM, Flash, RAM
- Improved RF performance
  - -96 dBm sensitivity (DCD mode)
  - -100 dBm (NCD mode, +3-4 mA current)
  - +4 dBm power output
- Hardware accelerator reduces MCU overhead
  - MAC accelerator
  - AES 128-bit hardware encryption/decryption
- Best-in-class peripherals
  - UART, SPI, KBI, 8-channel 12-bit ADC, 4x16-bit timer, I²C, SSI (I2S), 64 GPIO
- Unique platform in a package
  - RF matching in package
  - Requires power, crystal and 50 Ohm antenna
  - 9.5 mm x 9.5 mm 99-pin LGA

Protocol Stack

- SMAC
- IEEE © 802.15.4
- SynkroRF
- ZigBee 2007
- ZigBee RF4CE

Memory

- 128 KB RF
- 96 KB Flash
- 80 KB RAM
MC12311 SiP Overview

**MCU Features**
- Up to 50 MHz HCS08 QE core
- 32 KB Flash and 2 KB RAM
- <1.0 µA stop mode
- Multiple 16-bit timers
- Up to 33 GPIO
- 8-bit port keyboard interrupt (KBI)
- 10-channel 12-bit analog-to-digital converter (ADC)
- SCI interface supports up to 115.2 kbps
- I²C with 100 kbps maximum bus loading
- Low-voltage detection
- In-circuit debug and Flash programming

**RF Features**
- Highly integrated sub-GHz RF transceiver
  - 290-340 MHz, 424-510 MHz and 862-1020 MHz
  - FSK, GFSK, MSK, GMSK and OOK modulations
    - Filtered 2FSK at 50 kbps and 200 KHz channel spacing
      - 863–870 MHz (Europe)
      - 902-928 MHz (North America)
      - 950-958 MHz (Japan)
  - -105 dBm @ 38.4 Kbps
  - 16mA RX
  - 20mA TX @ 0dBm
  - 33mA TX @ +10 dBm
  - -18 to +13 dBm in 1dB steps
  - Packet handler with 66 byte FIFO buffer
  - 16 bit CRC and AES encryption

**System Features**
- 1.8V to 3.6V
- RoHS compliant
- Supported Protocols
  - SMAC
  - 802.15.4 2006
  - Wireless M-Bus

**MC12311**
- 32 KB Flash, 2 KB RAM
- -40°C to 85°C
- 8x8 56 pin LGA
- Production – September 2011
- 2011 SRP 1K - $2.99