Gas, Water, and Heat Meters

www.ti.com/smartgrid
TI Enabled Smart Flow Meters

Sensing
- Flow Information
- Temperature
- Pressure

Microcontroller

Optional Functionalities
- Valve Control (Motor Driver)
- Prepayment RFID / NFC

Communications
- Sub-1 GHz Solutions
  - Sub-1 GHz
  - RF Front End
- 2.4 GHz Solutions
  - 2.4 GHz
  - RF Front End
- Other Solutions
  - RS-485 / RS-232
  - Wired M-Bus
  - GSM / GPRS

Power Management
- System Power

Battery
# New Products, New Highlights

<table>
<thead>
<tr>
<th>TI New Product Solutions</th>
<th>Highlights</th>
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</table>
| **MCU** | • MSP430 FRAM family  
|   | • Nearly unlimited ultra-low-power writes for data logging  
|   | • Flexible memory allocation for need of more memory in future  
|   | • Security needs addressed |
| **RF Communications** | • CC11xx Performance Line Devices  
|   | • Designed for high performance at low power and low voltage operation in cost effective wireless systems |
| **Power Management** | • TPS62730 (RF Comms)  
|   | • TPS65290 (Flow Meters)  
|   | • Power management solutions dedicated to battery-operated devices (unique solutions for simple systems to complex systems) |
| **Sensing Solutions** | • Ultrasonic sensing front-end development  
|   | • Better accuracy  
|   | • Greater reliability  
|   | • Lower cost of ownership |
| **Other Functionality** | • bq25504  
|   | • DRV8837  
|   | • Bq25504: boost charger for nano-power energy harvesting and management applications increases harvested energy  
|   | • DRV8837: world’s smallest 1.8A brushed DC motor driver |
TI Portfolio Offer for Flow Meters
Hardware + Software + Support

• **Low power for longer battery lifetime**
  – MCU consumption in active and low-power mode (FRAM)
  – Optimized analog power solutions

• **1-way and 2-way communications (AMR/AMI)**
  – 2.4 GHz ZigBee and Sub-1 GHz WMBUS (including software)
  – Wired MBUS solution and other connectivity interfaces also available

• **Migration path for additional performance**
  – Larger memory for more functionality such as software implementation
  – Power management solutions for complex battery-operated systems

• **Accurate sensing**
  – Scan Interface technology for mechanical meters
  – Ultrasonic development for static meters
FRAM in Ultra-low Power MSP430 Microcontrollers

Ultra-Low Power | Non-volatile | Easy-to-Use
TI FRAM Technology Platform – World’s Lowest Power

- Unique mixed signal ultra-low leakage process technology
- Enables variety of new low power peripherals
- Consistently low power over entire temperature range

- World’s lowest power memory type is 250x less energy per bit
- Speed and flexibility of traditional RAM
- Near infinite endurance and 100% non-volatile

- Continuing to pioneer the low power landscape
- Leading power efficiency over entire system architecture
- Industry leading analog integration
- Complete software package for easiest development

Lowest Memory Power  Lowest Standby Power  Lowest Active Power  Lowest Peripheral Power
FRAM - The best of all worlds!

- Best ULP Operation!
- Unified / NV Memory!
- EEPROM substitution!
- Not affected by magnetic fields!
- 100 trillion ultra-fast read/write cycles!
- Lowest Energy at high temperature!
## FRAM for Wireless Updates

**Over the air updates**

<table>
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<tr>
<th>Challenge</th>
<th>FRAM solution</th>
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<tr>
<td>Consumes up to 1 month battery life for a single update</td>
<td>Uses &lt; 1/4 day battery life</td>
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<tr>
<td>Block level erase &amp; program</td>
<td>Bit level access</td>
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<tr>
<td>Need redundant (mirror) memory blocks</td>
<td>Write guarantee in case of power loss</td>
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### Challenge
- Consumes up to 1 month battery life for a single update
- Block level erase & program
- Need redundant (mirror) memory blocks

### FRAM solution
- Uses < 1/4 day battery life
- Bit level access
- Write guarantee in case of power loss

### Features
- Home automation
- Metering
- Safety & security
# FRAM for Sensor Data logging

## Challenge

<table>
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<tr>
<th>Power consumption limits locations, increases maintenance</th>
<th>Energy harvesting enables more sensors in more locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited data update/write speed</td>
<td>Continuous and reliable monitoring, storage and RF transmission</td>
</tr>
<tr>
<td>Selective monitoring</td>
<td>Continuous monitoring</td>
</tr>
</tbody>
</table>

## FRAM solution

- Asset Tracking
- Sports & Fitness
- Flow meters
- Seismic monitoring

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*Image credit: Texas Instruments*
FRAM Enables Unparalleled Flexibility & Reduced System Cost

Before

Multiple device variants may be required

16kB Flash (Program)

14kB Flash

32kB Flash

Often an additional chip is needed

1kB EEPROM

2kB SRAM

2kB SRAM

To get more SRAM you may have to buy 5x the needed FLASH ROM

With FRAM

One device supporting multiple options “slide the bar as needed”

64kB Universal FRAM

Data vs. program memory partitioned as needed

- Easier, simpler inventory management
- Lower cost of issuance / ownership
- Faster time to market for memory modifications
FRAM | Endurance

Write Endurance

10,000 cycles

> 100,000,000,000,000 cycles

Trillions

Supports more than 150,000 years of continuous data logging
FRAM in the Energy Plane

A small up-front payment in wake-up time!

For a huge energy pay-back in active mode!

factor: 100x - 250x

factor: 100x - 1000x

LPM3

Active

Flash Write

FRAM Write

Wake-up event

time

power

energy

Texas Instruments
FRAM - Realtime Data Logging!

- Superior Realtime performance due to fast write!

- External events
  - Incoming interrupts

- Weak interrupt performance
  - "Stuck in Flash"

- Strong interrupt performance
  - Quick Low energy FRAM update
FRAM = Increased flexibility

- Use Case Example: EEPROM Vs MSP430FR5739
- Many systems require a backup procedure on power fail
- FRAM IP has built-in circuitry to complete the current 4 word write
  - Supported by internal FRAM LDO & cap
- In-system backup is an order of magnitude faster with FRAM

Write comparison during power fail events

*Source: EE Times Europe, An Engineer’s Guide to FRAM by Duncan Bennett*
Flow Metering Differentiation with FRAM

Meter System

• Encryption HW
  – Lockable memory for tamper detection and ID

• Fast wakeup <6us
  – 7 low power modes

• Built-in NVM
  – Flexible memory for to replace standalone NVM memory
  – Reduce BOM and size

• Wireless firmware updates
  – Save 12-15% battery life

• Low power system
  – Secure, low power peripherals + NVM for fast restore from “standby”

• Integration in small package

• Flexible memory for higher RAM and reduced system cost

Sensing

• Lowest power ADC12
  – 75uA at 200ksps
  – Up to 8 differential inputs from 16 channels
  – Window comparator on every input
  – Works 1.8 – 3.6V with auto-power down

• FRAM Memory
  – Fast storage of data in critical situation
  – Replace battery backup with eco-friendly solution

Security

• 128-/256-bit AES Hardware
  – Low power advanced encryption

• Lockable memory segments
  – IP Protection, Device ID, secure data logging

• Inherently tamper resistant FRAM
  – Physical detection of memory impossible
## TI Focus: Key Sensing Interfaces Supported

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<th>Static Meter Sensing Techniques</th>
<th>Applications</th>
<th>TI Solution</th>
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<tr>
<td>Ultrasonic Time-of-Flight</td>
<td>Gas, Water, and Heat</td>
<td>Ultrasonic analog-front-end solution (AFE+ TPL7200)</td>
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<th>Mechanical Meter Sensing Techniques</th>
<th>Applications</th>
<th>TI Solution</th>
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<tr>
<td>LC, GMR, etc.</td>
<td>Water</td>
<td>MSP430FW42x devices that measures rotation with MCU in sleep mode</td>
</tr>
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</table>
Static Meter Sensing Techniques

Ultrasonic Time-of-Flight (TOF) Principle

1. Measure Time of Flight (TOF) Up & Down Stream
2. Calculate the speed of the Medium
3. Calculate the Volume Flow of the Medium
Static Meter Sensing Techniques
Ultrasonic TOF Flow Meter Solution

Key Features
• No moving parts (static)
• Fully electronic system
• Smaller form factor

Benefits
• **Lower cost of ownership**: faster to install, easier AMR/AMI integration
• **Better accuracy**: Faster leakage detection, bi-directional flow capability
• **Greater reliability**: No damage on mechanical parts, pressure reduction in pipe
• **Lower manufacturing cost potential**: Flow meter market transitioning from mechanical meters to static meters

Applications: Gas, water, and heat meters (residential and industrial)
Static Meter Sensing Techniques
TI’s Ultrasonic TOF Flow Meter Solution

- Advantage of the 2-chip approach:
  - **Flexibility** for component selection, roadmap for final application
    (water/gas with different frequency, time base)
- Other advantages:
  - Transit-time measurement with accuracy **as low as 50ps resolution**
  - XVR with up to 5V and 500kHz to 5MHz fundamental frequency
  - Reduced processing required from MCU
Mechanical Meter Sensing Techniques

What is Scan Interface (Scan I/F)?

- Sensor interface is delegated to the Scan I/F
- Measures mechanical rotation of mechanical meters with the MCU in sleep mode for minimal current consumption
- Wakes CPU only when the count has reached a particular value or to handle errors
**Mechanical Meter Sensing Techniques**

**Supported Sensing Techniques**

**Induction Sensor**

“Oscillation” or “Envelope” Measurement

- Coils are positioned above a plate that is partially covered with a damping material.

**Magnetic Sensor**

- Magnets on an impeller

- GMR sensors detect changes to magnetic field. Rotation detection similar to LC.

**Optical Sensor**

- Supply of optical sensor is fully controlled by Scan I/F


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**App Note:** Rotation Detection With the MSP430 Scan Interface App Note [slaa222]

**App Note:** Using GMR Sensors With the MSP430 Scan Interface App Note [slaa358]

**App Note:** Rotary and Linear Motion Detection Using the MSP430 Scan Interface and Optical Sensors App Note [slaa289]
Mechanical Meter Sensing Techniques
Current Consumption Comparison between SW vs. HW Solution

Scan Interface hardware benefits:
1. Current consumption much smaller (20uA at 1000 samples/sec)
2. Allows smaller steps for sample rate selection
3. Higher sample rates along with significantly lower current consumption

![Graph showing current consumption comparison between SW and HW solutions.]

- Rotation Detection using “optimized” software (MSP430F41x)
- Rotation Detection using hardware (MSP430FW42x)
Flow Metering Software Solutions

- ZigBee® 2007 (Pro) + Smart Energy with ZigBee stack 2.3.0
  - MSP4305438 today
  - Stellaris® CM3 (Beta today, RTM 2Q10)
  - CC2530
- Z-Stack™ 2.x OAD
- 6LowPan (3P)
- ZigBee IP Stack (Alpha-Q3 10, RTM-Q4 10)

- SimpliciTI-1.1.1 (supports both IAR and CCS)
- WMBUS

- TRF7960 + MSP430™ code ISO15693/1443A&B
- Mifare support
TI Enabled Water Meter (1)
Flash Memory, Anti-tamper, RF Communication

System available today

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Sensing
Water Flow Information
Temperature
Pressure

LCD Driver

Wide Area Network (WAN)
CC1101 ISM-band Transceiver
Matching Circuit

MSP430F4616
Ultra Low Power MCU

ADC
Temp Sensor

UART

32,768 Hz

Battery
Example:
Li-SOCI2
2.5-3.6V
10-15Ah
Imax=20mA

Antenna

TPS73033
3.3V

Texas Instruments
TI Enabled Water Meter (2)
Flash Memory, Scan Interface, Anti-Tamper, RF Communication

System available today