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VIRTUAL CONFERENCE

SEPTEMBER 14–15, 2021

SILICON LABS

APP-203: Energy Saving Tips for Battery Powered Metering

SEPTEMBER 2021

Battery Powered Metering Applications

GAS METER	WATER METER	HEAT COST ALLOCATORS
		
Need Picture of Smart Gas Meter	Need Picture of Smart Water Meter	Need Picture of Smart Water Meter

Introduction of the FG23 for Metering Applications

Low Power.
Long Range.
Secure.

Sub-GHz SoCs Optimized for Metering & Home/Industrial Automation Applications

High Performance Radio
Up to +20 dBm TX
-111 dBm RX @ 50 kbps GFSK
-125.6 dBm RX @ 4.8 kbps O-QPSK
RX Antenna Diversity

Low Power
25.9 mA TX @ +14 dBm
89 mA TX @ +20 dBm
4.3 mA RX (915 MHz, 50kbps)
26 µA/MHz
1.4 µA EM2 with 16 kB RAM
Preamble Sense

World Class Software
Z-Wave Mesh & Long Range
Wi-SUN*
wM-Bus
Mioty
Amazon Sidewalk
Flex for Proprietary

ARM® Cortex®-M33 with TrustZone®
78 MHz (FPU and DSP)
512kB of flash
64kB of RAM

Security
SecureVaultTM - Mid
SecureVaultTM - High (select OPNs)

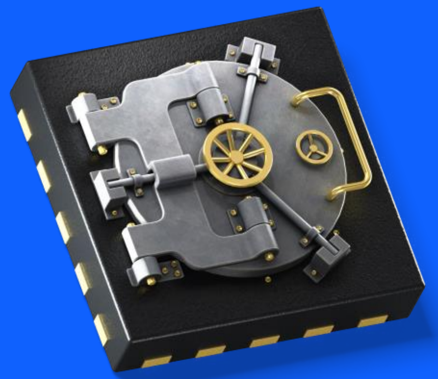
Low-power Peripherals
EUSART, USART, I^2C
16-bit ADC, 12-bit VDAC, ACMP
20 x 4 LCD Controller
LESENSE, PCNT
Temperature sensor +/- 1.5°C

Compact Size
5x5 QFN40 (23 GPIO)
6x6 QFN48 (31 GPIO)

Feature enhancements compared to prior series

SecureVault™

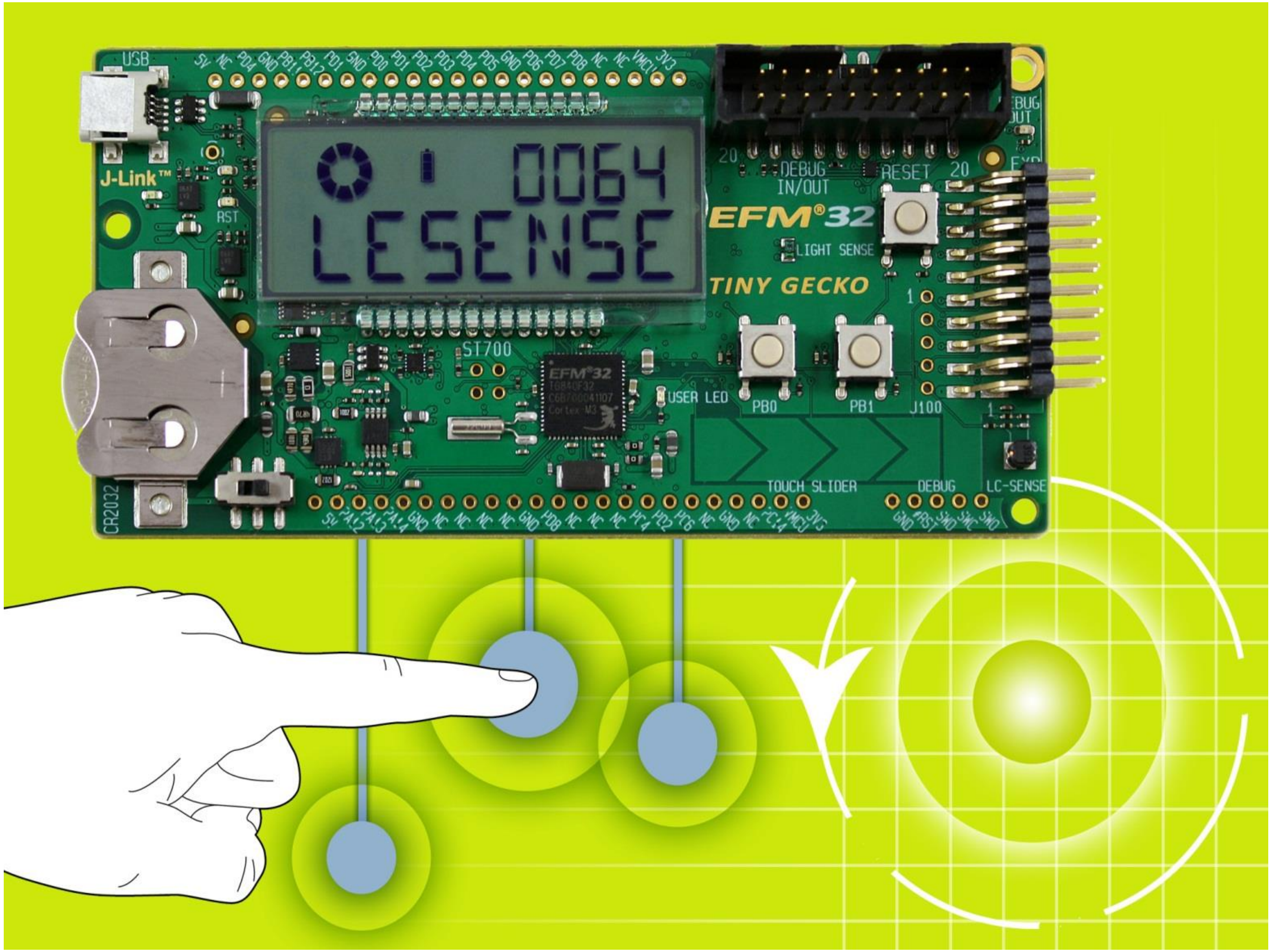
Base	Mid	High	Feature
✓	✓	✓	True Random Number Generator
✓	✓	✓	Crypto Engine
✓	✓	✓	Secure Application Boot
—	VSE/HSE	HSE	Secure Engine
—	✓	✓	Secure Boot with RTSL
—	✓	✓	Secure Debug with Lock/Unlock
—	Optional	✓	DPA Countermeasures
—	—	✓	Anti-Tamper
—	—	✓	Secure Attestation
—	—	✓	Secure Key Management
—	—	✓	Advanced Crypto



Designing Secure IoT Devices

Wireless Comparison (Sub-GHz)

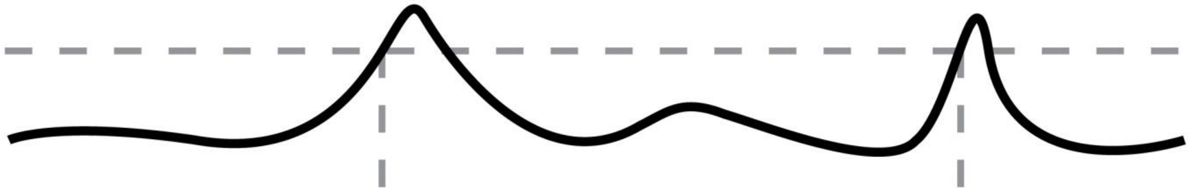
	Si4463	Si4467/8	xG13	xG23*
Description	sub-GHz Transceiver	sub-GHz Transceiver	Dual Band SoC	sub-GHz SoC
Core	N/A	N/A	Cortex-M4 (38.4 MHz)	Cortex-M33 (78 MHz)
Max Flash	N/A	N/A	512 kB	512 kB
Max RAM	N/A	N/A	64 kB	64 kB
Security	N/A	N/A	SecureVault™ - Base	SecureVault™ - Mid SecureVault™ - High (select OPNs)
Supported Modulation	(G)FSK, 4(G)FSK, (G)MSK, OOK	(G)FSK, 4(G)FSK, (G)MSK, OOK	BPSK, (G)FSK, 4(G)FSK, (G)MSK, OOK	BPSK, (G)FSK, 4(G)FSK, (G)MSK, OOK, DSSS-OQPSK
Frequency Range (MHz)	142-175, 284-350, 420-525, 850-1050	142-175, 284-350, 350-525, 850-1050	110-191, 191-358, 358-574, 584-717, 779-956	110-191, 191-358, 358-574, 584-717, 779-970
Preamble Sense Mode (PSM)	Yes	Yes	No	Yes
RX Sensitivity	-110 dBm (40 kbps GFSK 450 MHz) -106 dBm (100 kbps GFSK 450 MHz)	-109 dBm (40 kbps GFSK 915 MHz) -104 dBm (100 kbps GFSK 915 MHz)	-108.2 dBm (50 kbps GFSK 915 MHz) -105.1 dBm (100 kbps GFSK 915 MHz)	-111 dBm (50 kbps GFSK 915 MHz) -108 dBm (50 kbps GFSK 915 MHz)
Active Current	N/A	N/A	87 µA/MHz	26 µA/MHz
Sleep Current (EM2, 16 kB ret)	0.900 µA (transceiver only)	0.740 µA (transceiver only)	1.3 µA	1.4 µA
TX Current @ +10 dBm (915 MHz)	18 mA	19.7 mA	20.3 mA (433 MHz)	18.4 mA
TX Current @ +20 dBm (915 MHz)	85 mA	88 mA	90.2 mA	89 mA
RX Current	13.7 mA (40 kbps GFSK 915 MHz)	13.7 mA (40 kbps GFSK 915 MHz)	8.6 mA (38.4 kbps GFSK 868 MHz)	4.3 mA (50 kbps GFSK 915 MHz)
PSM Current	1.95 mA	1.95 mA	TBD	0.74 mA
Operating Voltage	1.8 V to 3.8 V	1.8 V to 3.8 V	1.8 V to 3.8 V	1.71 V to 3.8 V
GPIO	4	4	16, 31	23, 31
Package	4x4 QFN20	4x4 QFN20	5x5 QFN32, 7x7 QFN48	5x5 QFN40, 6x6 QFN48


USB
J-Link™
0064
LESENSE
DEBUG IN/OUT
RESET
EFM®32
LIGHT SENSE
TINY GECKO
ST700
USER LED
PB0
PB1
J100
TOUCH SLIDER
DEBUG
LC-SENSE
CR2032

LESENSE – Low Energy Sensor Interface

Analog events

Capacitive, inductive or resistive sensors



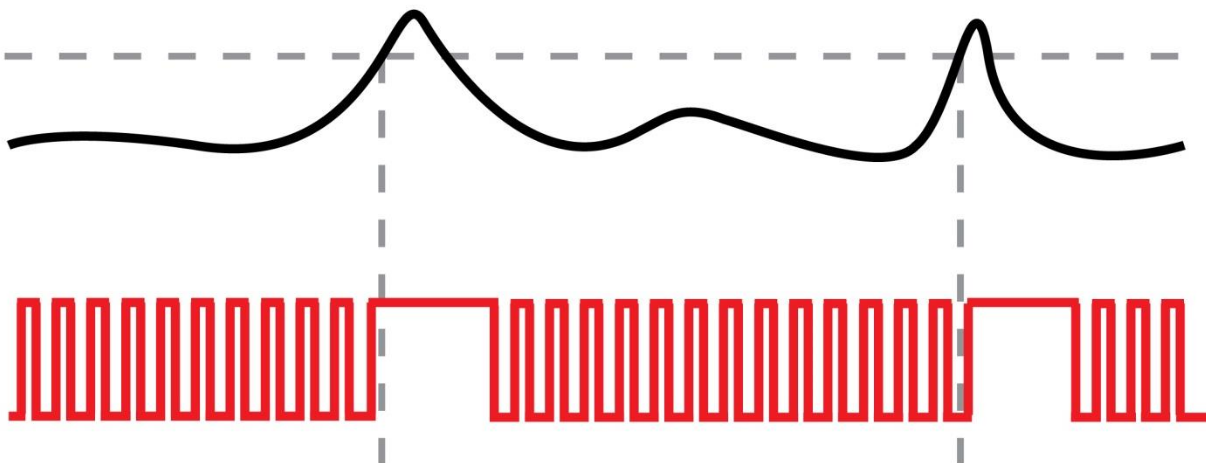
LESENSE – Low Energy Sensor Interface

Analog events

Capacitive, inductive or resistive sensors

Generic MCU

Wake-up periodically to detect the events

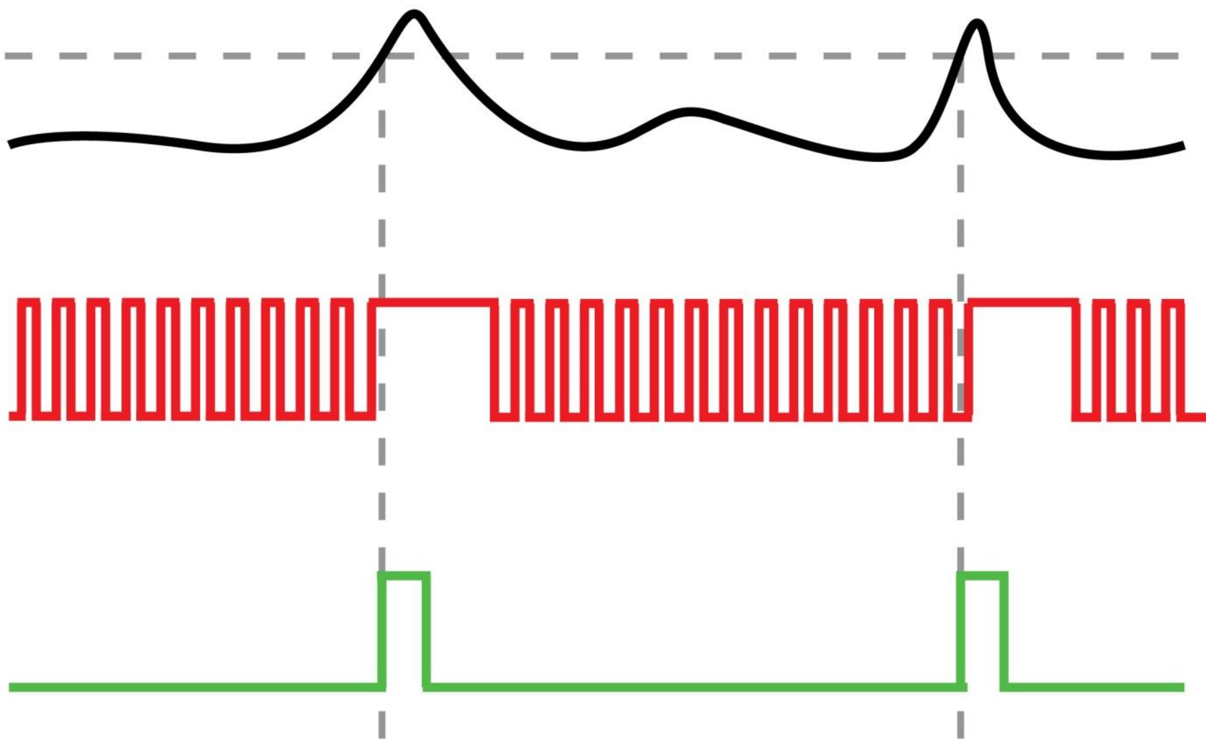


LESENSE – Low Energy Sensor Interface

Analog events
Capacitive, inductive or resistive sensors

Generic MCU
Wake-up periodically to detect the events

EFM32 MCU
Wake-up only on the events



LESENSE – Low Energy Sensor Interface

Analog events

Capacitive, inductive or resistive sensors

Generic MCU

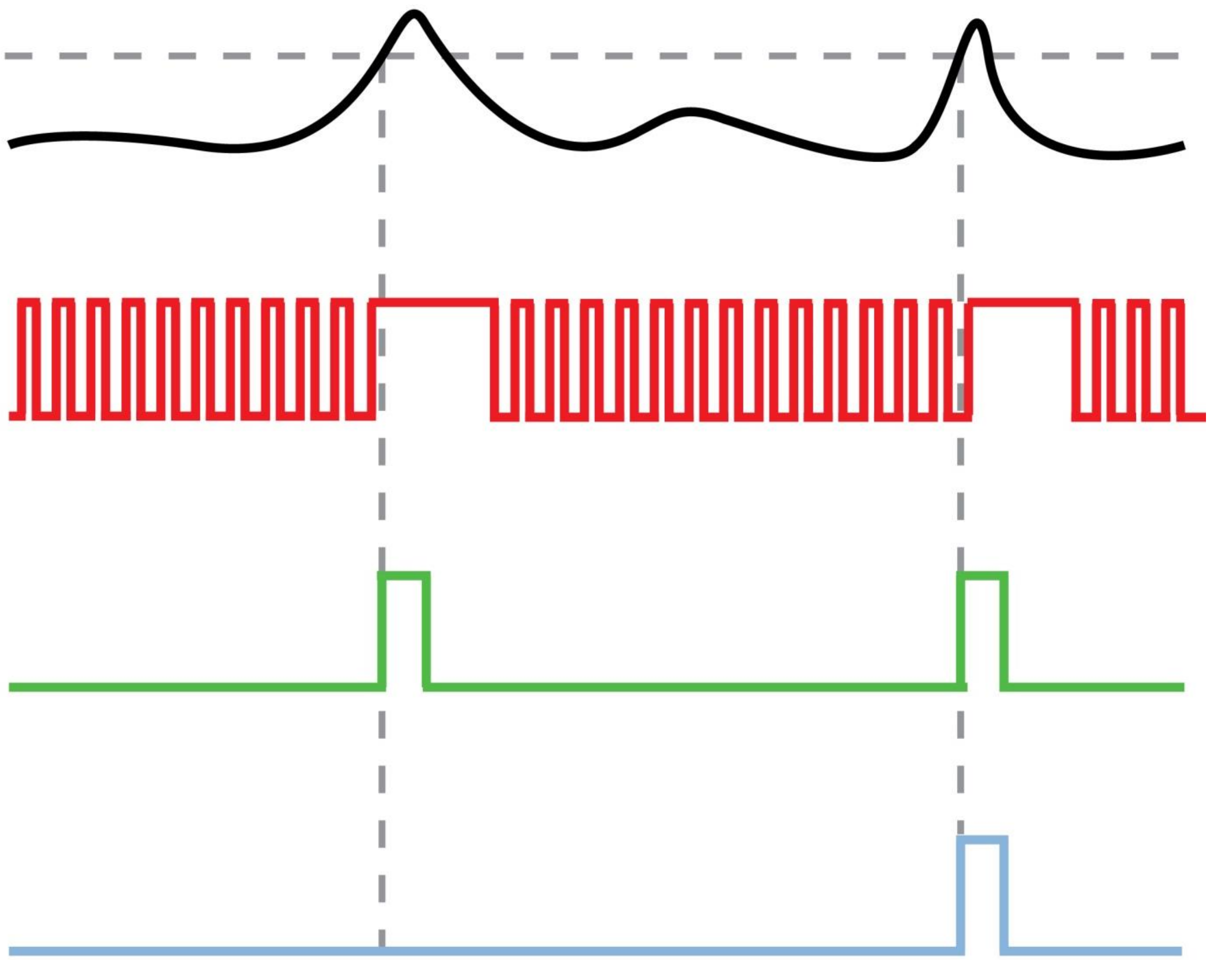
Wake-up periodically to detect the events

EFM32 MCU

Wake-up only on the events

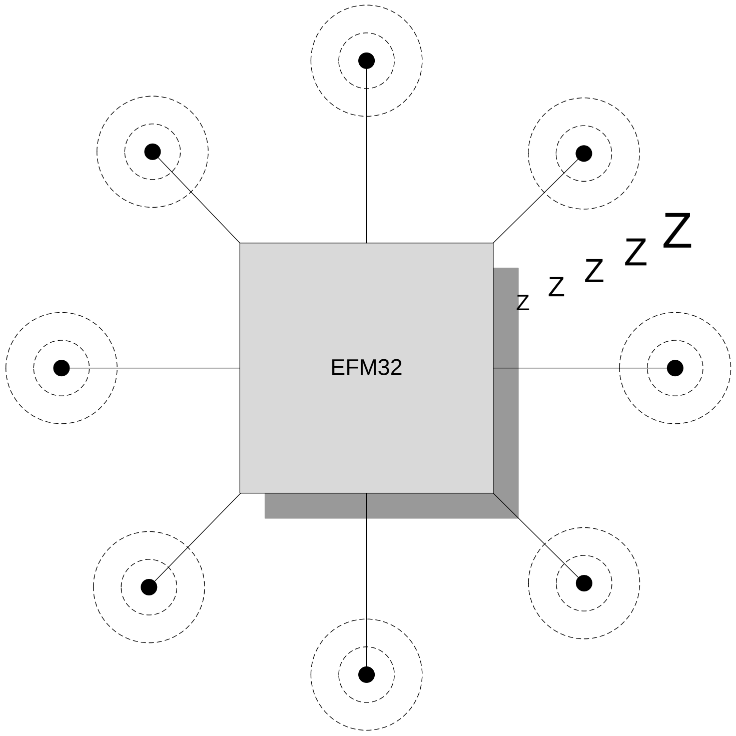
EFM32 MCU

Conditional wake-up (e.g. on every 2nd event)

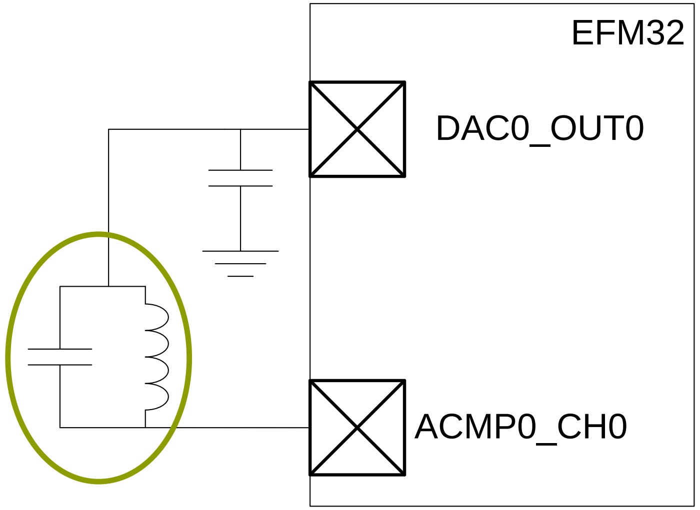


LESENSE – Low Energy Sensor Interface

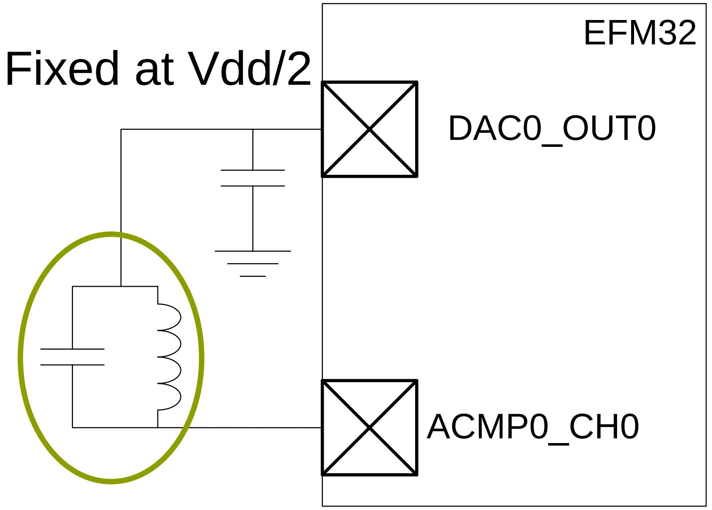
- **Autonomous sensing in Deep Sleep**
  - **LESENSE with central control logic**
  - **ACMP for sensor input**
  - **DAC for reference generation**
- **Measure up to 16 sensors**
  - **Inductive (LC)**
  - **Capacitive (eg. capacitive buttons)**
  - **General analog sensors (e.g. resistive)**
- **Programmable state machine**
  - **16 states, 4 input channels**
  - **Can do quadrature decoding**
- **Interrupt/PRS on sensor events**



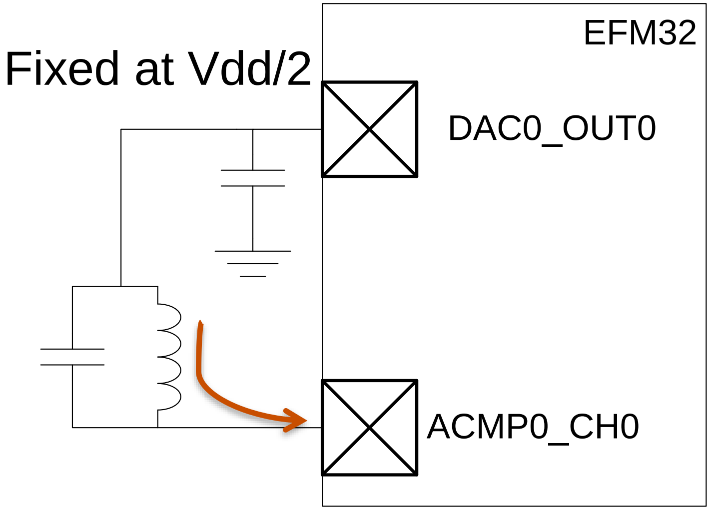
LESENSE Inductive Measurement



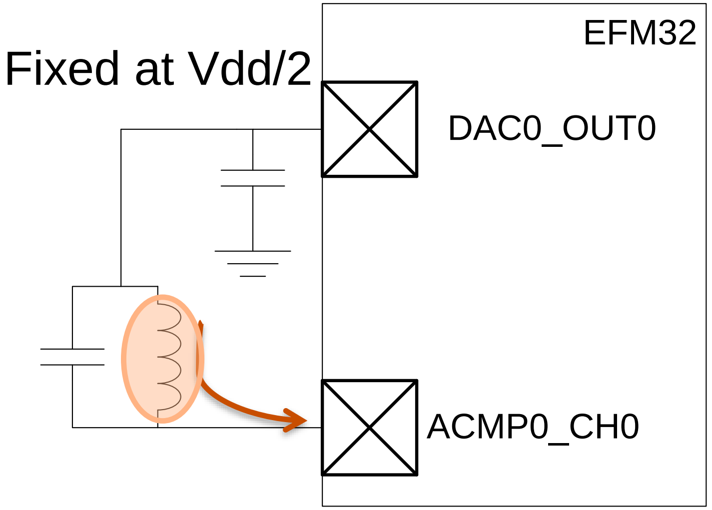
LESENSE Inductive Measurement



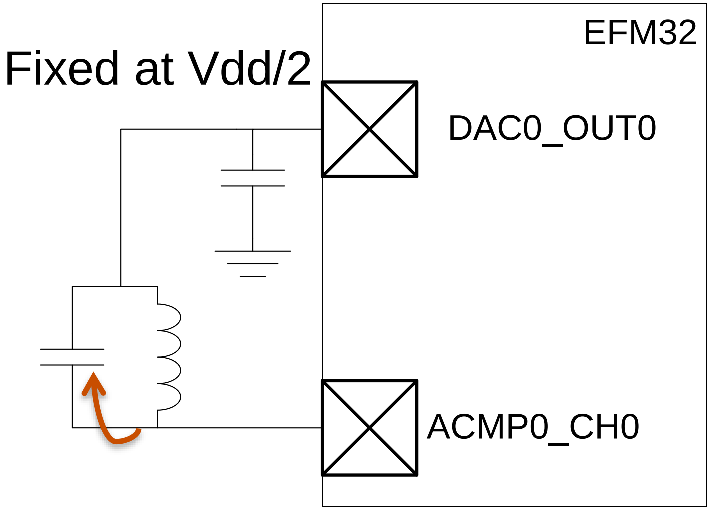
LESENSE Inductive Measurement



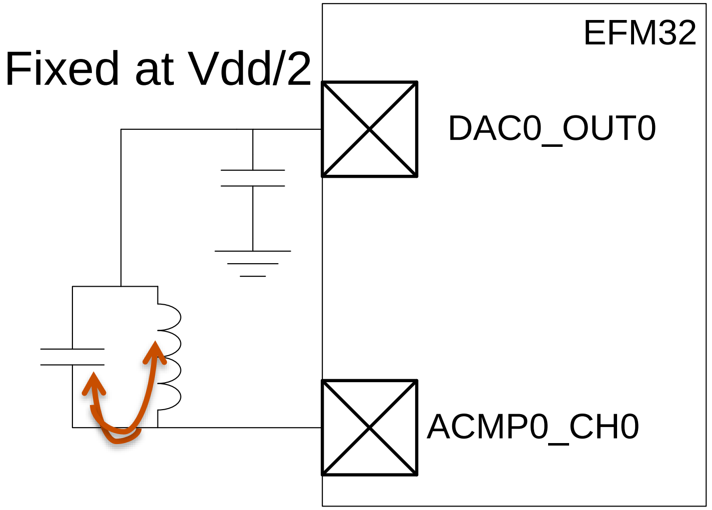
LESENSE Inductive Measurement



LESENSE Inductive Measurement



LESENSE Inductive Measurement



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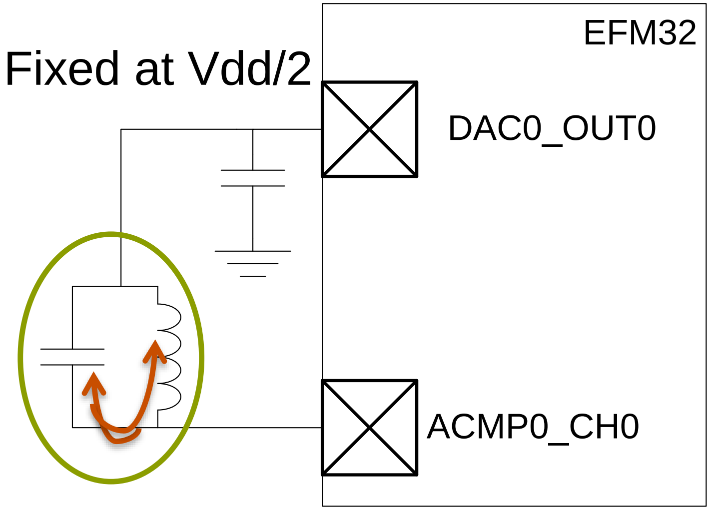
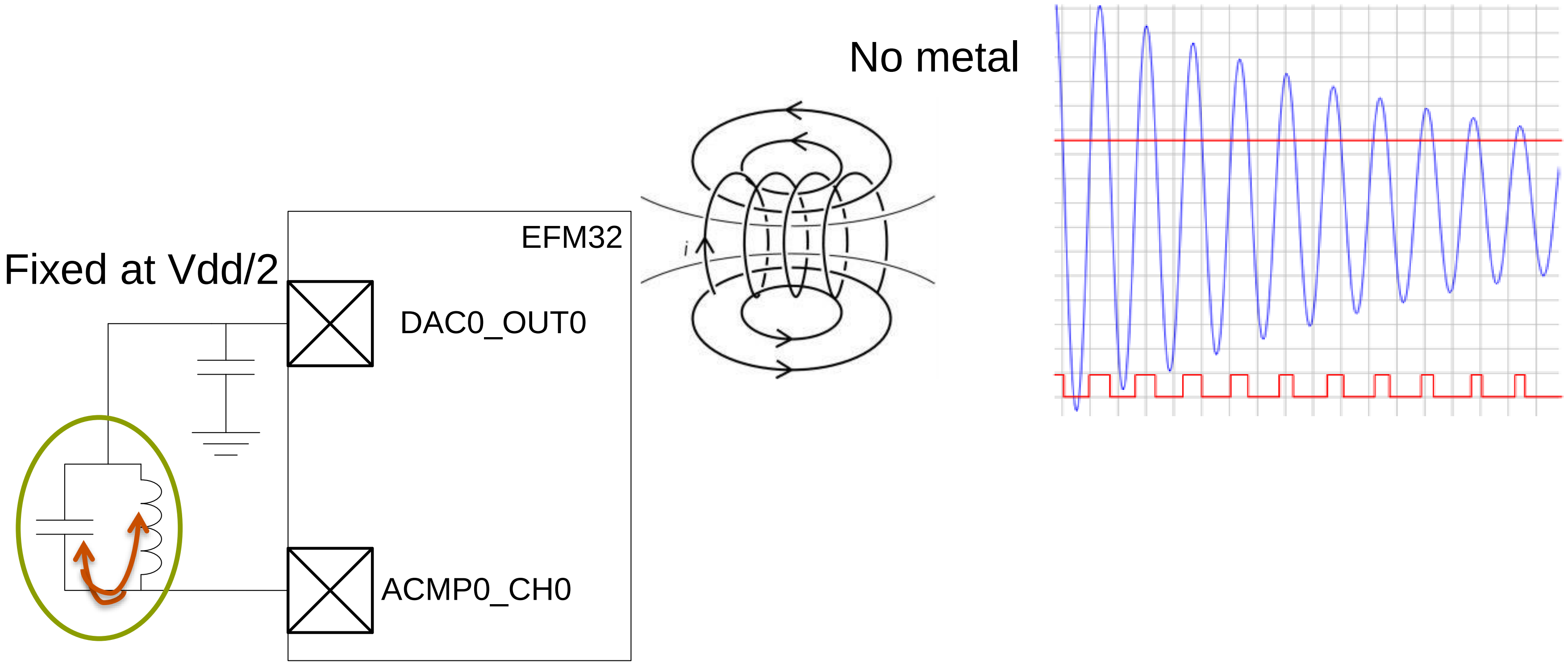
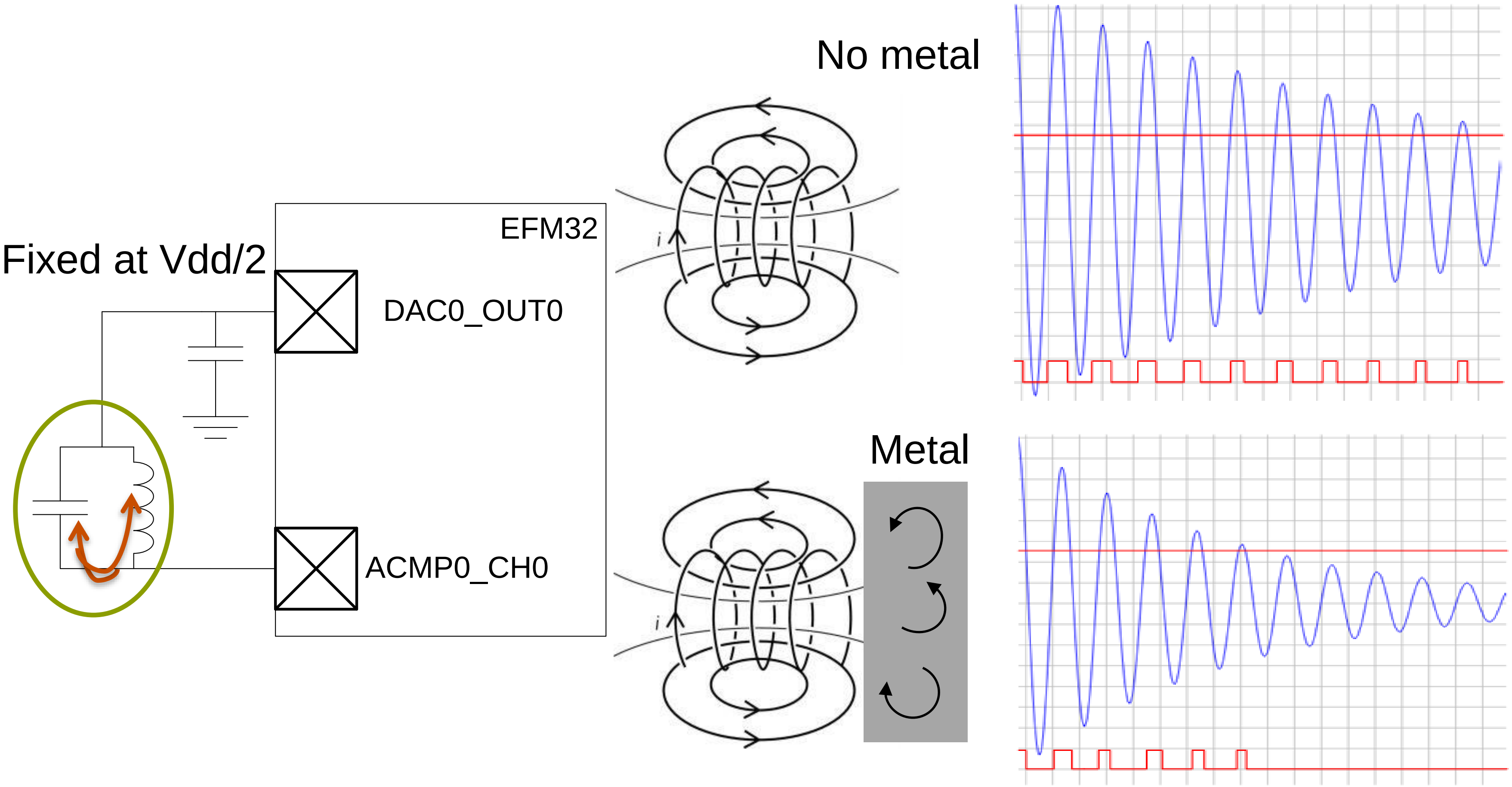
LESENSE Inductive Measurement



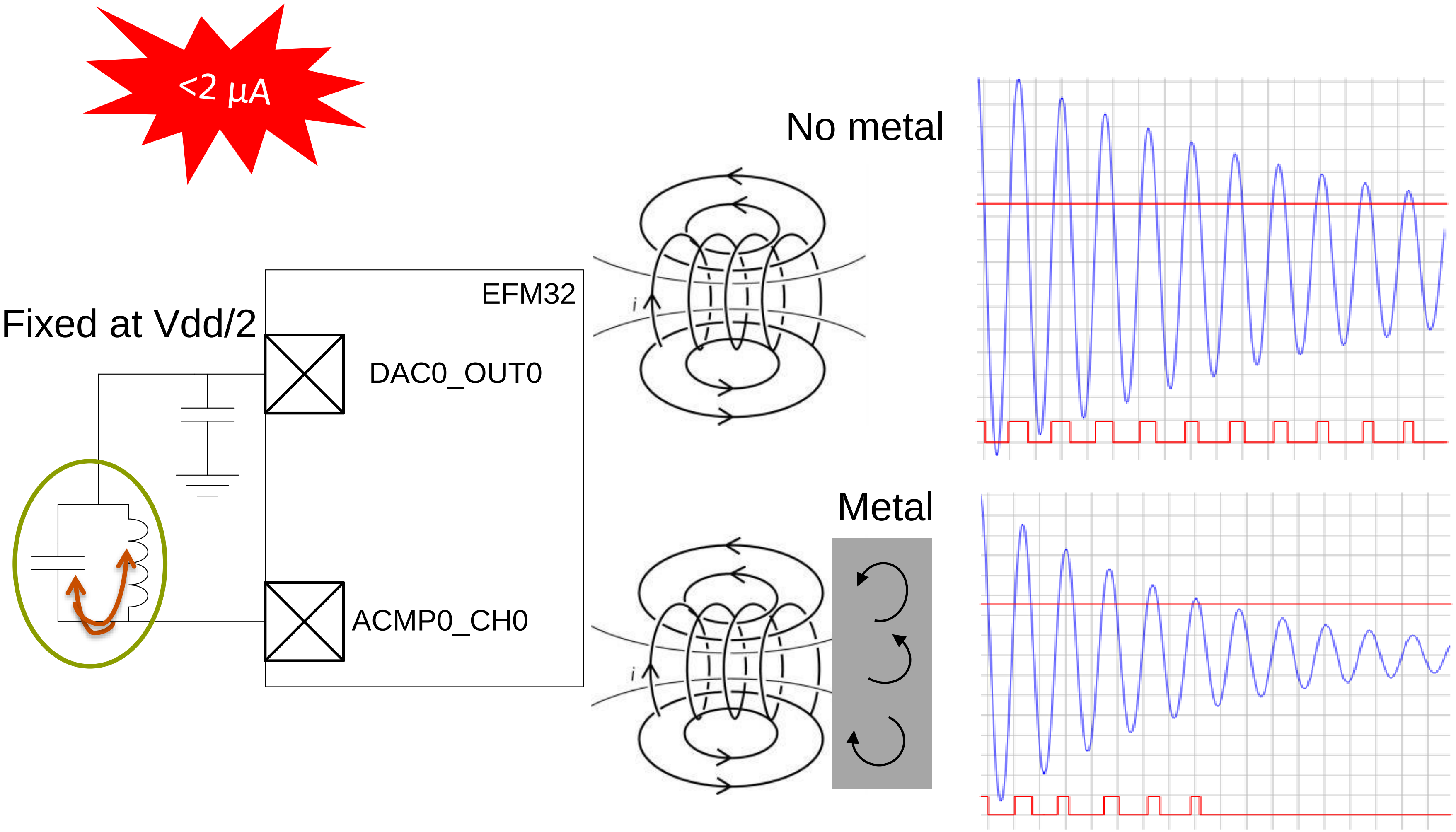
LESENSE Inductive Measurement



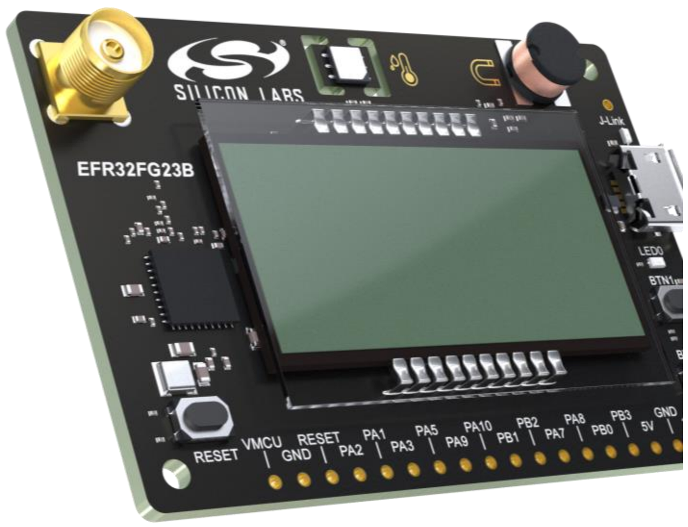
LESENSE Inductive Measurement



LESENSE Inductive Measurement



How to Configure LESENSE



SiliconLabs / platform_applications

Code · Issues · Pull requests 3 · Actions · Projects · Wiki · Security

feature/platfo... platform_applications / platform_lcsense_segmentLCD / README.md

silabs-Ruibin Adds platform_lcsense_segmentLCD example · Latest commit 3e951c4 26 days ago · History

1 contributor

53 lines (43 sloc) | 2.39 KB

LCSENSE with Segment LCD

Summary

This project shows how to use LESENSE peripheral on BRD2600A board to detect metal near the LCSENSE tank circuit, then display the detection via segmentLCD.

Gecko SDK Version

v3.2

Hardware Required

- Board: Silicon Labs EFM32FG23 Dev Kits (BRD2600A)

Setup

Clone the repository with this project from GitHub onto your local machine.

From within the Simplicity Studio IDE, select Import -> MCU Project... from the Project menu. Click the Browse button and navigate to the local repository folder, then to the SimplicityStudio folder, select the .sls file for the board, click the Next button twice, and then click Finish.

Build and flash the hex image onto the board. Reset board and observe the segment LCD displaying 00000. Make sure no metal is near the tank circuit yet

To test:

1. Place a metal near the LC sensor
2. Observe the segmentLCD counter increment by 1
3. Remove metal, and then place the metal near the LC sensor again
4. Observe the segmentLCD counter increment by 1
5. Press push button 0, observe segmentLCD display reset to 0
6. Repeat step 3 five times, observe segmentLCD increment by 1

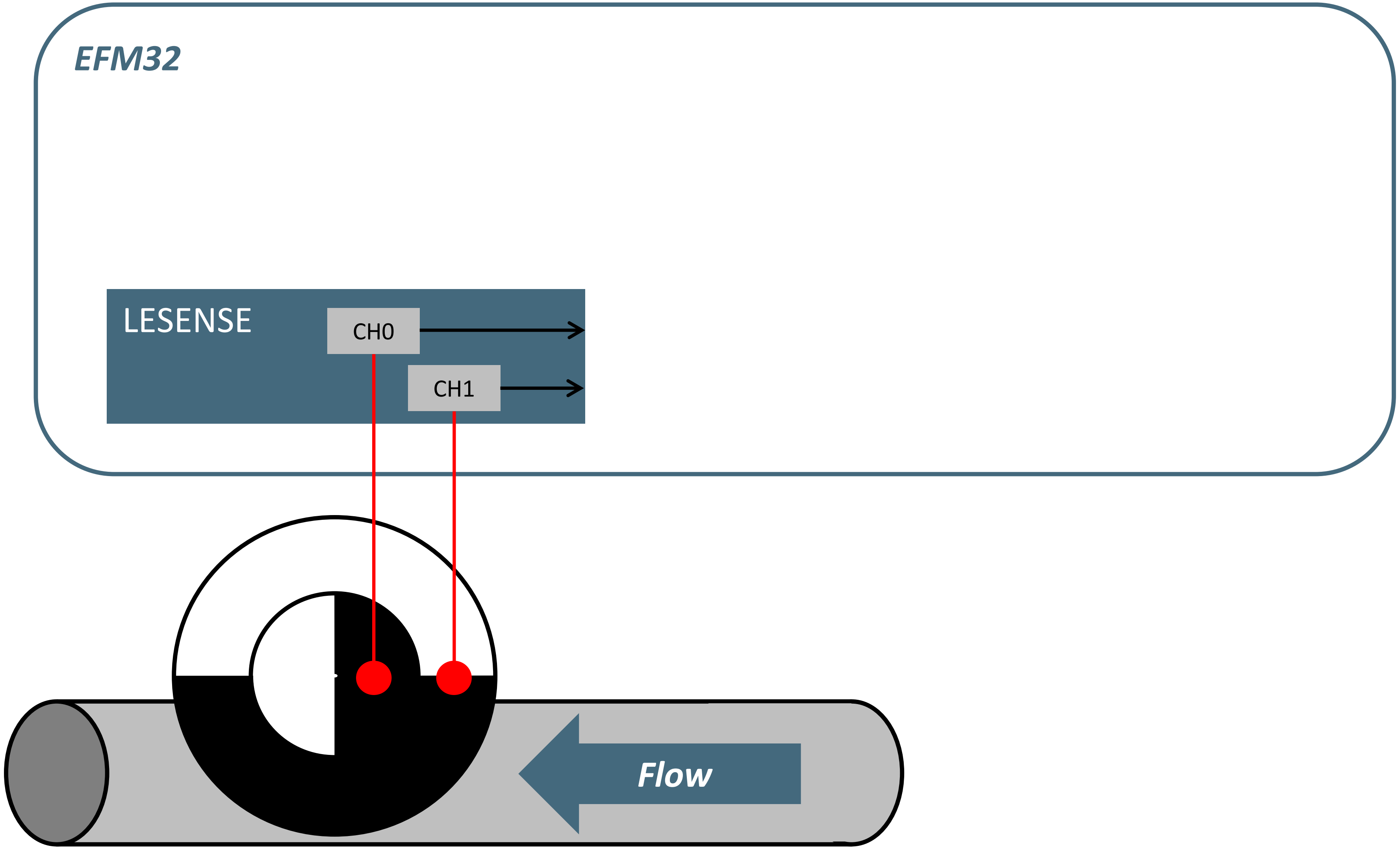
How the Project Works

The LESENSE is configured to scan the sensor periodically. The sensor is routed to PB3 which in this case is configured as LESENSE channel 0. The ACMP is also routed to this pin and is controlled by the LESENSE to compare the dampling waveform with a divided voltage of about 1.7 V. The VDAC is used to short the two end of the tank circuit, where during excite stage, the measure pin is pulled low to charge the circuit. The ACMP pulse count is then compared with a threshold to determine if metal is near. When metal is near the sensor, the waveform damps faster, which makes the ACMP pulse less than no metal case. The LESENSE decoder then sends signals to the pulse counter when metal is detected. The pulse counter will trigger an interrupt on counter overflow to update the segmentLCD

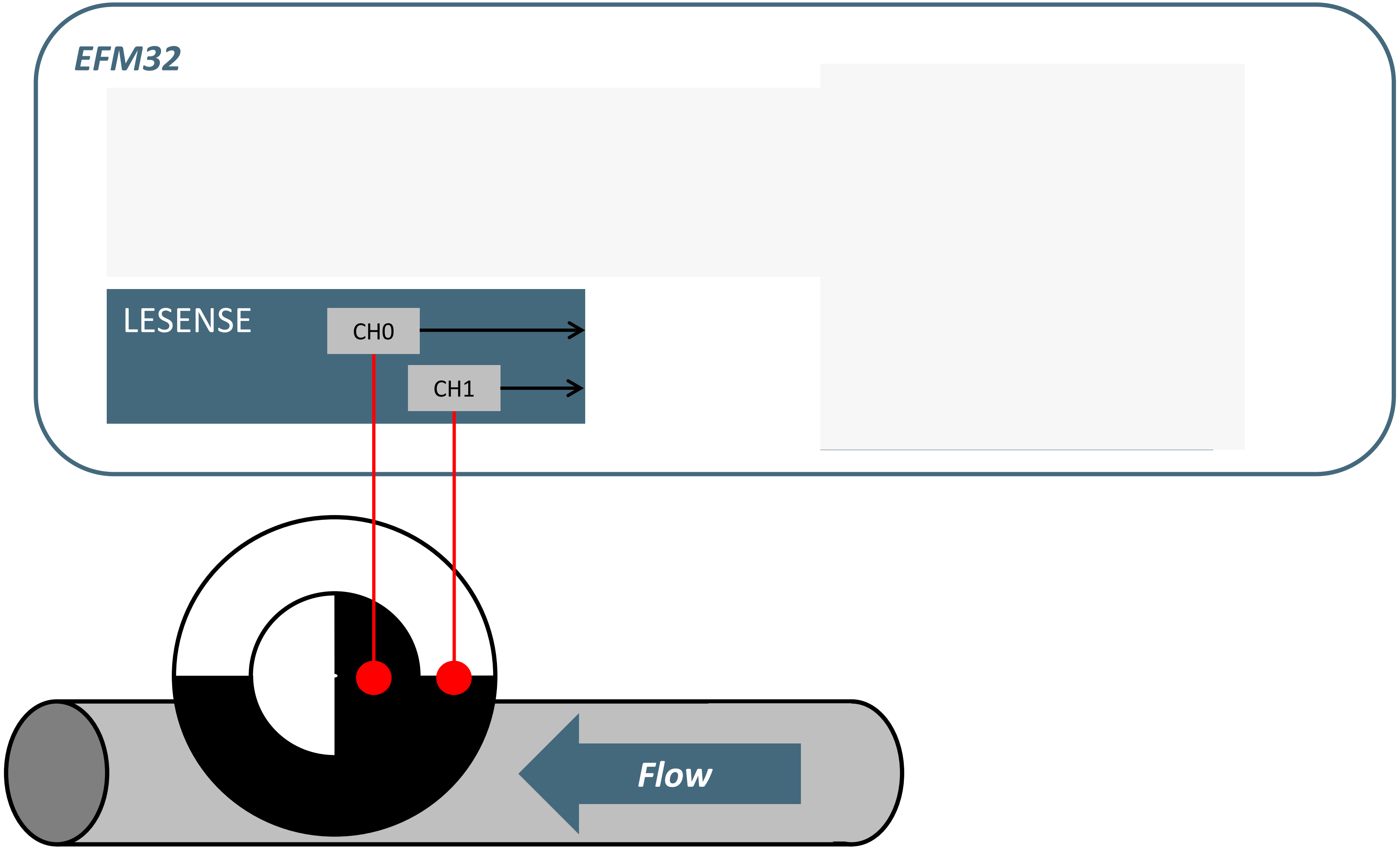
.sls Projects Used

- platform_lcsense_segmentLCD.sls

Feel the flow!!



Feel the flow!!



Introduction to Preamble Sense Mode (PSM)

ANDRAS BIROS

The problem of the idle current

- **IoT devices are in idle most of their time**
- **However, most devices need to be able to receive with or without significant latency**
- **Rx current is significantly higher than sleep current (4-5mA vs 1.7uA)**
- **Turning the radio into receive mode only when it needs to receive packets could significantly lower power consumption!**
- **But how should a device know when it needs to receive?**

Well known solutions

Out of band wake-up

- Something with significantly lower power consumption wakes up the radio
- E.g.: button, NFC, RFSense on EFR32FG22
- Drawbacks: Requires physical interaction (Button, NFC), or significantly lower sensitivity (RFSense)
- Implementation is easy, but usage is difficult

Synchronized communication

- The two sides agree when will they communicate next time
- E.g.: Bluetooth Low Energy
- Drawbacks: Requires accurate low power oscillator, a lot of communication needed to set up and maintain the sync
- Very complex implementation

Polling

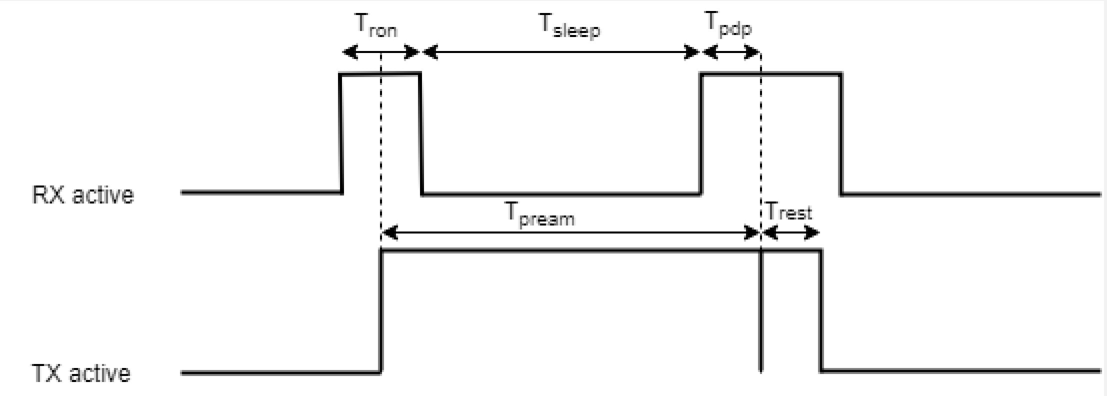
- Device can only receive after sending a message
- E.g.: IEEE 802.15.4, wireless M-Bus
- Drawbacks: high latency (if the device polls rarely) or higher power consumption (if the device polls often)
- Easy implementation, somewhat difficult to use

Receiver duty cycling

- Radio is enabled for just a enough time to detect a packet
- E.g.: None, but it is commonly used in proprietary protocols
- Drawbacks: High power consumption on the tx device
- Quite complex implementation, except with hardware support

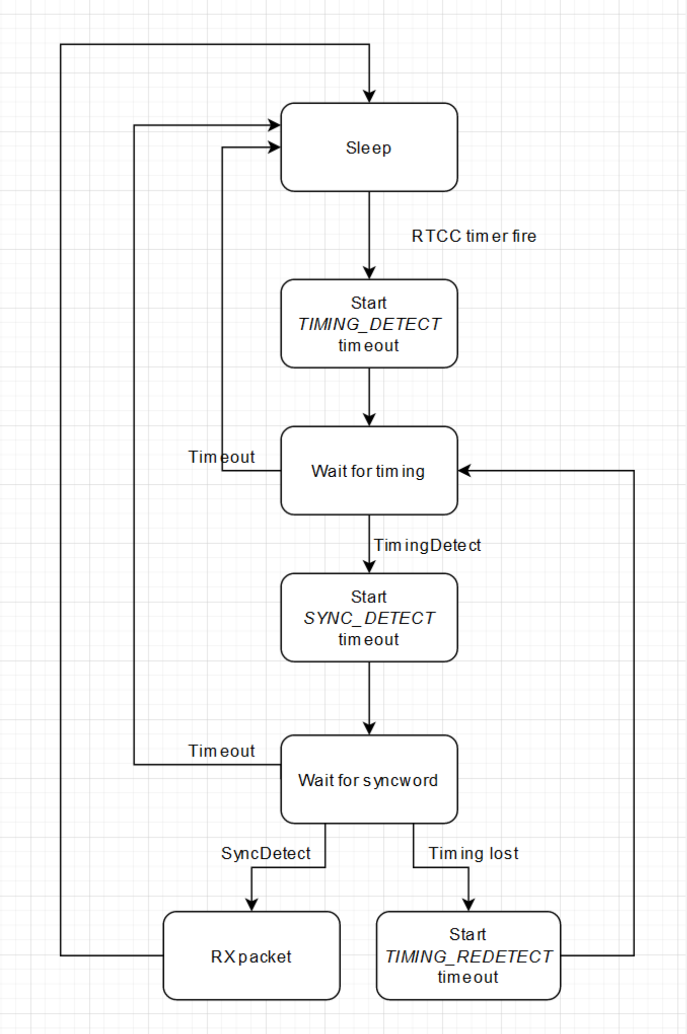
Receiver duty cycling theory

- Usually timing comes from the maximum allowed latency, typically, e.g. 1s
- Preamble tx time is 1s
- Rx on time depends on detection time and propagation delay. E.g. 8+8 symbols at 10kbps = 1.6ms
- Rx side needs to turn on twice during this cycle to meet worst case scenario (tx turned on just after rx)
- Duty cycle rate is 1.6ms/1s=0.16% or 10uA (with some switching time)
- If preamble is detected, the radio is left on until the end of the packet (or for preamble length at max)



Problems with duty cycling in practice

- **Power consumption can be significantly improved by using shorter Rx window**
- **But shorter time for detection results higher false detection rate**
- **Staying in rx for a full cycle is unacceptable**
- **Solution: Drop packet on signal loss**
- **But losing the signal due to interference looks just like a false detect!**
- **Solution: Second stage filter must accept redetection**
- **Result:**
  - Complex software with tight timing requirements
  - Every timeout needs to be calibraed for the config



Hardware accelerated duty cycling

Hardware Components Used in PSM (Signal Qualifier)

- **Signal Qualifier (SQ): 3 staged detector in hardware**
  - 1st stage: Detects signal quickly with relatively high false detect rate
  - 2nd stage: Filters false detects
  - 3rd stage: Times out if sync word is not received (e.g. Due to jamming)
- **For 2FSK signals:**
  - Phase DSA (Digital signal arrival): Fast detector for the first stage
    - Can detect signals in 4 symbol time
    - Relatively high false detect rate, but no missed detection!
  - TRECS (Timing RECovery System)
    - New timing detector, pattern matching system with CFE (cost function engine)
    - Output can drive SQ stage1 or stage2

How to configure for duty cycling in Simplicity Studio

How to configure for duty cycling in Simplicity Studio

- **Radio Configurator**
  - (screenshots, settings TBD)
  - Calculates all the timeout automatically, even sleep time, from preamble length!
- **RAIL**
  - Init:
    - RAIL_ConfigRxDutyCycle() with RAIL_RX_CHANNEL_HOPPING_MODE_SQ and <sleep time macro>
    - RAIL_EnableRxDutyCycle()
    - RAIL_StartRx()
  - Process:
    - No detection:
      - RAIL_EVENT_RX_DUTY_CYCLE_RX_END event lets the application know that no signal was detected
      - RAIL_ScheduleRx() with <sleep time macro>
      - PowerManager will set the MCU to EM2 sleep
    - Detection:
      - RAIL_EVENT_RX_PACKET_RECEIVED event lets the application know that a packet was received

DEMO of Power Savings

Closing and wrap-up

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- Wi-SUN sessions

Session ID	Session Name
WSN-101	Introduction to Wi-SUN, It's markets and the Alliance
SMC -102	Smart City Network Management in the Cloud Using Pelion
SMC-103	Why Wi-SUN is Ideal for Smart Street Lighting?
WSN-300	Building Large Scale Smart City Networks with Wi-SUN

- Also don't miss

Session ID	Session Name
SMC-101	Introducing the Smart City
LPW -101	What options do I have for LPWAN Applications
APP-203	Energy Saving Tips for Battery Powered Metering
LOC-102	Energy Reduction & Utility Grid Stabilization with Demand Response

Bluetooth® Multiprotocol Proprietary 100s of Technologies
THREAD WiFi Wi SUN zigbee Z WAVE

Thank you!

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