IoT 센서를 위한 전력 효율적인 솔루션 설계 및 손쉬운 커넥티비티 구축

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

김기범(Brett Kim) 수석

2022년 2월 15일

Agenda

- Best practices
- Microchip eco-system and power efficient analog
- Typical design process and analog tools
- Real life example – smart water meter

Designing a Power Efficient IoT Application

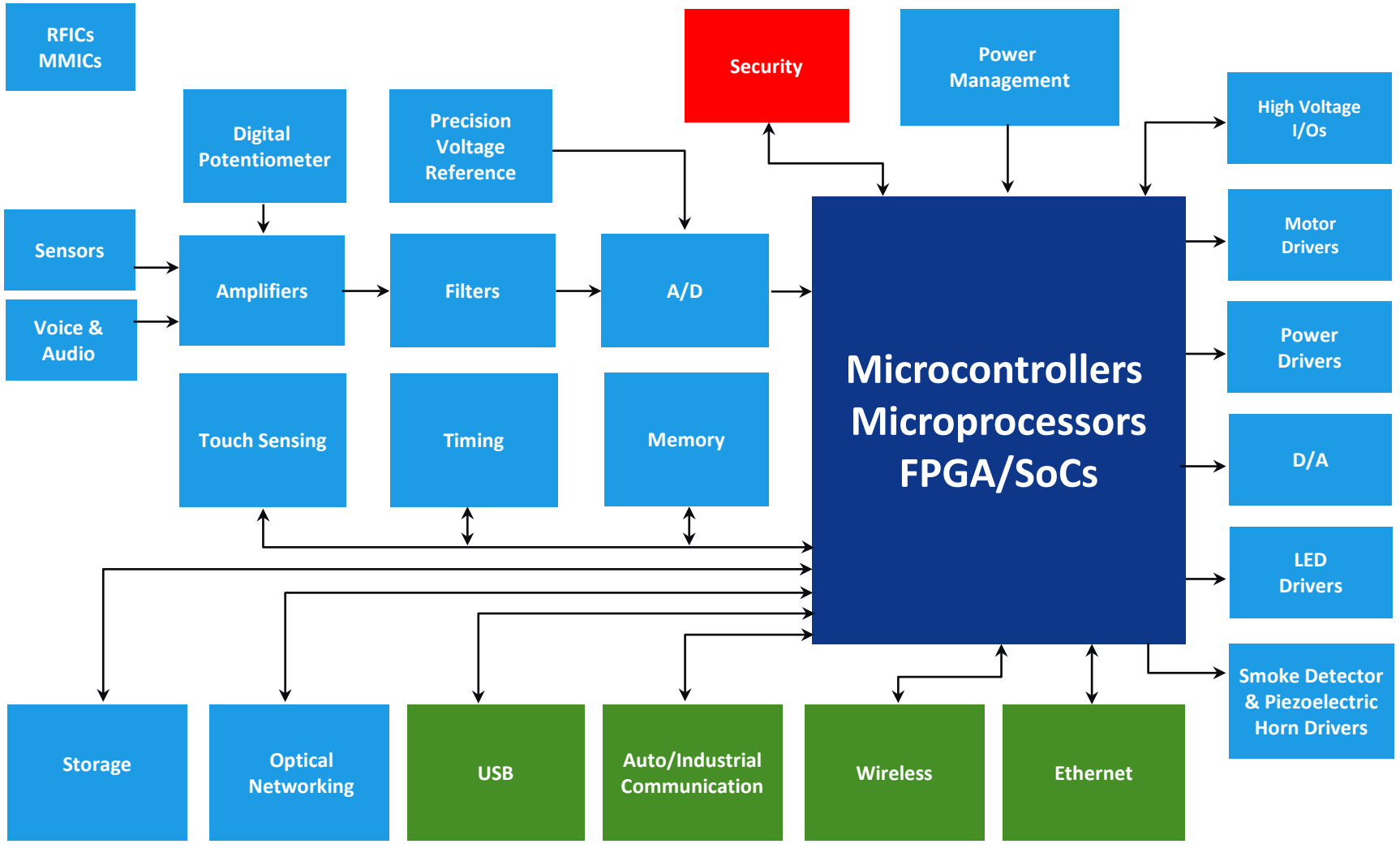
Good Practices

- **There is NO ONE SIZE FITS ALL POWER SOURCE**
  - Many options: switching regulator, LDO, battery (rechargeable or not), battery chemistry and cost

- **Time matters: START EARLY on Analog to maximize efficiency and savings**
  - Application requirements drive your signal chain precision and power budgets
  - The sooner you start, the higher the optimization and savings

- **Implement SYSTEM APPROACH instead of considering components one by one**
  - Accurate and low power source and signal chain solutions
  - Low power and efficient connectivity
  - Secure element to offload CPU: less computing time (crypto) and saves energy
  - Ultra low power MCU with intelligent peripherals: minimize CPU activity thus Active mode

Designing a Power Efficient IoT Sensor



Building a power efficient application requires system approach when defining your architecture and selecting components

A good strategy depends first and foremost on your application requirements

Solutions are often unique although there is always the temptation to get inspiration from legacy block diagrams or reference designs

There is no one size fits all

We have the devices, the tools and the expertise to help you design the optimal solution

MICROCHIP

Power Efficient Analog for IoT Application

Analog

Power Mgt

www.microchip.com/design-centers/power-management

Sensors

www.microchip.com/sensors

Amplifiers and Linear

www.microchip.com/design-centers/amplifiers-linear

Data Converters

www.microchip.com/design-centers/data-converters

Timing

www.microchip.com/design-centers/clock-and-timing

Analog - Key Strengths

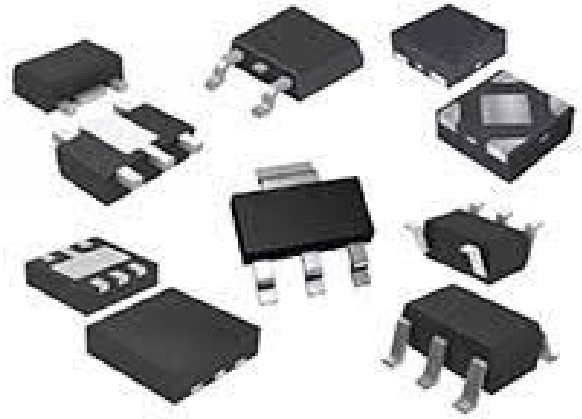
- **High accuracy**
- **High power efficiency**
- **Ultra low power consumption and low voltage operation**
- **High robustness**
- **Web tool**
- **Support**

www.microchip.com/analog

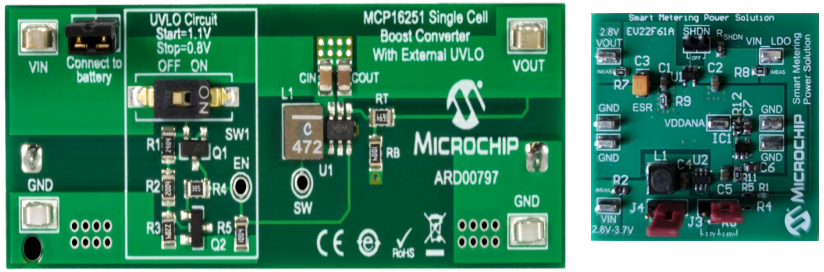
Typical Design Process

Requirements: define your activity profile and power budget

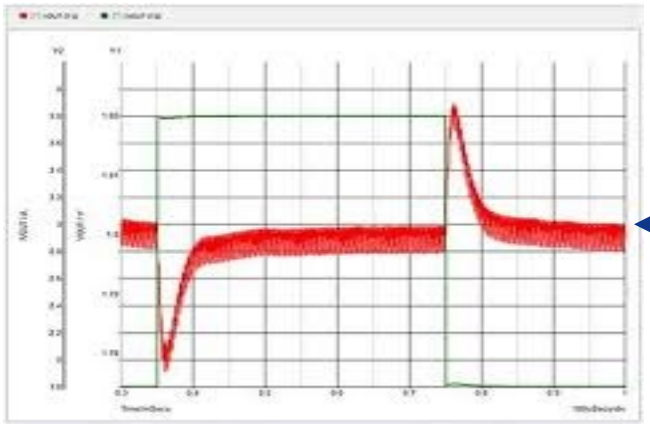
Build your architecture



Select your solutions and packages



Select the evaluation boards you need



Simulate your design

Validate your architecture….Success!!

MICROCHIP

Designing a Power Efficient IoT Sensor

Step 1: Start with Your Power Requirements

1 Is there a power source to recharge my battery?

- Solar panel
- Wall charger
- Energy harvesting
- Other

YES ▷

2a What rechargeable battery do I need?

- Temperature range
- Capacity and aging
- Charge rate
- Self-discharge rate
- Internal impedance
- Reliability, lifetime

NO ▽

▽

2b What non-rechargeable battery do I need?

- Temperature range
- Capacity and aging
- Self-discharge rate
- Internal impedance
- Reliability, lifetime

▷

Impact your analog signal chain and power management decision

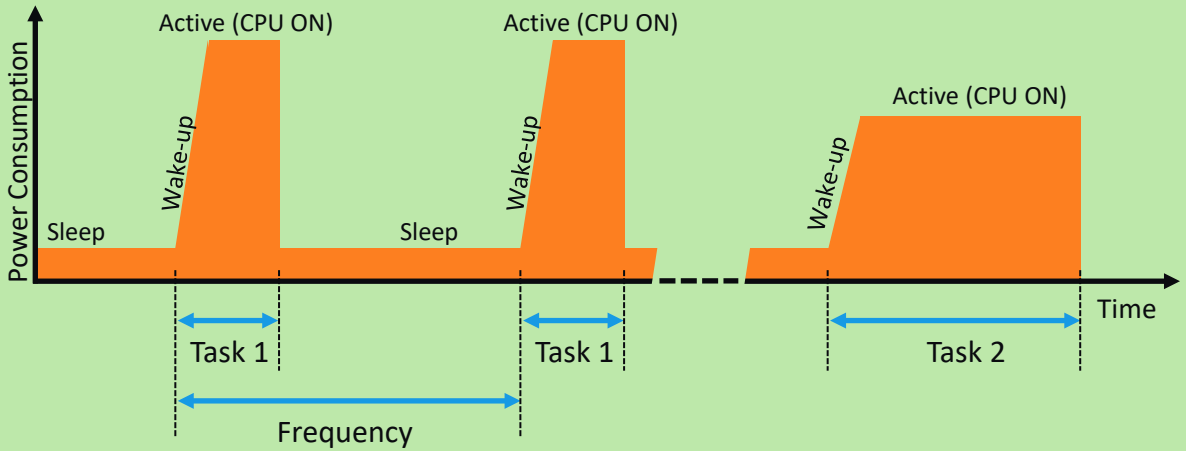
Thus, your BOM and architecture

Designing a Power Efficient IoT Sensor

Step 2: Define Your Power Budget and Select Your Battery

3 Define Your Activity Profile

How long is your application active? How often?
What tasks get executed with which peripherals (connectivity, secure element, sensor)?



4 Calculate Your Power Budget

Based on activity profile, calculate how much power will be needed overall

5 Calculate Your Battery Life

Evaluate battery life for different batteries, typical and max conditions.
If needed, test other options such as different radio or key components

BATTERY					BATTERY LIFE							
Brand Type PN	% of usage	Nominal Battery Voltage (used for PSU efficiency)	CAPACITY		CURRENT BUDGET		NOMINAL		MID-POINT		WORST CASE	
			Nominal	Worst Case	Nominal	Worst Case	RF CASE 1	RF CASE 2	RF CASE 1	RF CASE 2	RF CASE 1	RF CASE 2
Battery 1	70%	3.6V	2554.57mAh	1680.mAh	19.44µA	12.79µA	15.8 years	17.1 years	11.5 years	12.4 years	7.3 years	7.7 years
Battery 2												
Battery 3												

	Match Target
	Below but in Range
	No Match

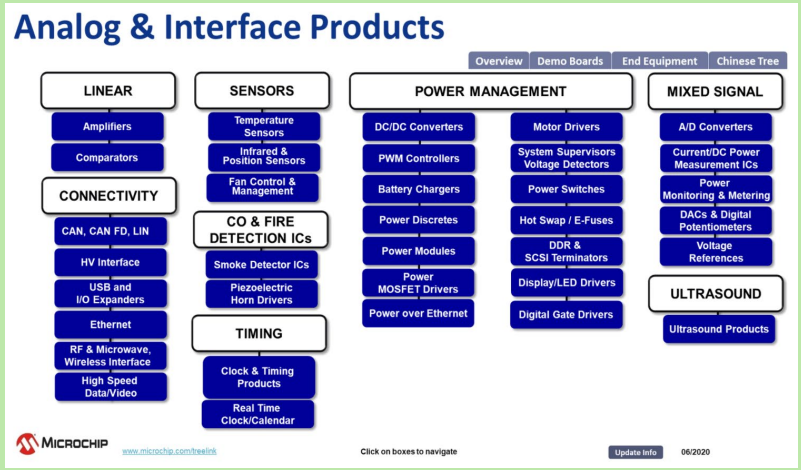
6 Select Your Battery!

Compare your data with application requirements
Find best compromise between capacity, power efficiency during active mode and/or sleep mode, size and cost
And that's it: you are done!

MICROCHIP

Tools to Maximize Your Power Efficiency

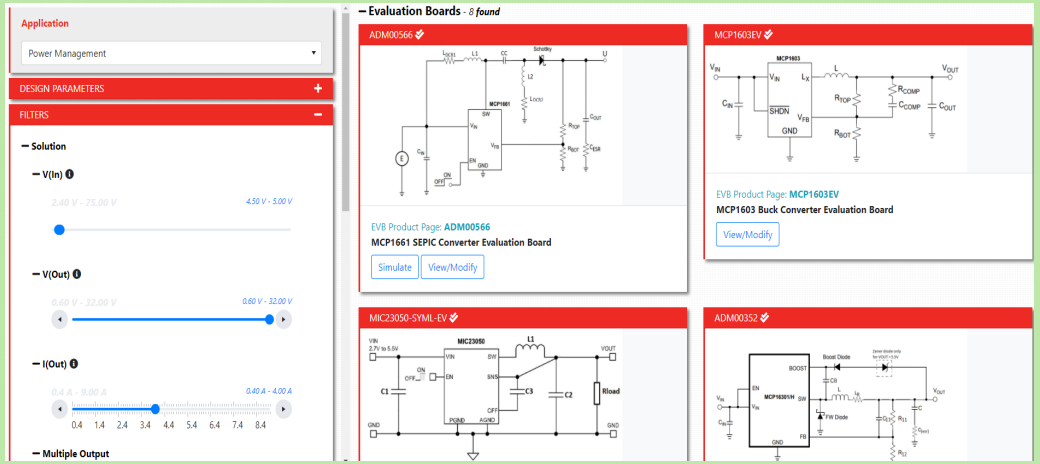
1 Treelink www.microchip.com/treelink



2 https://da.microchip.com/PWR_MGMT

MPLAB® ANALOG DESIGNER

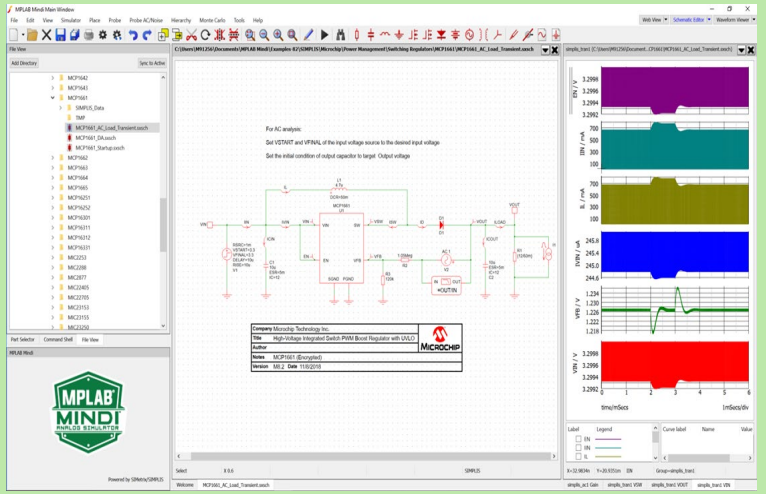
Design



3 www.microchip.com/mindi

MPLAB® MINDI™ ANALOG SIMULATOR

Verify



4 https://www.microchip.com/en-us/products/power-management/power-check-design-service

Support

Real Life Example: Smart Water Meter

What Do You Think of When You Design a Water Meter ?

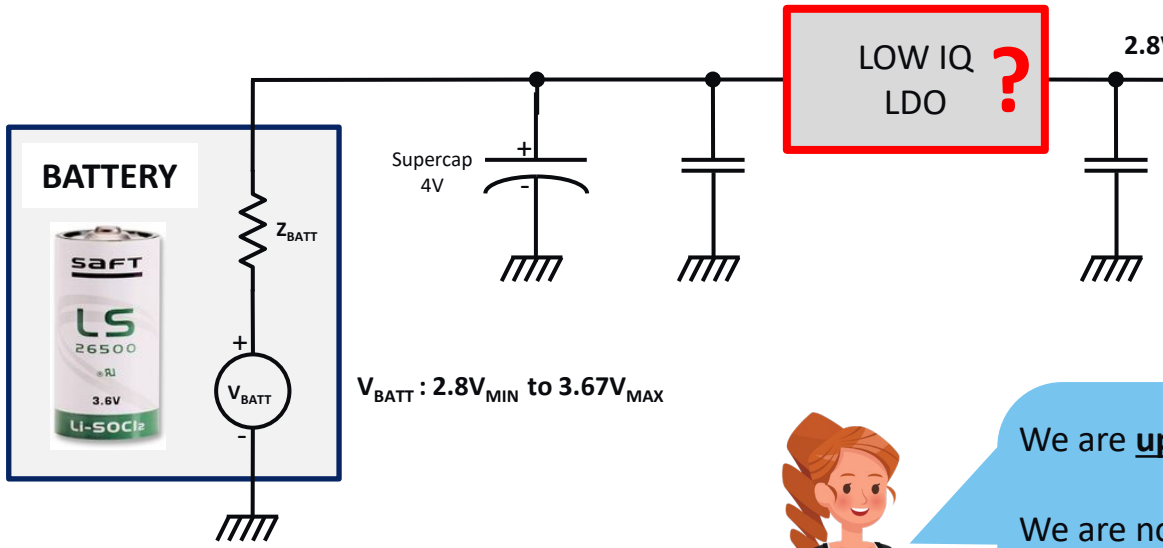
Reliable

Convenient

Low Cost

Real Life Example: Smart Water Meter

Customer's Initial Demand



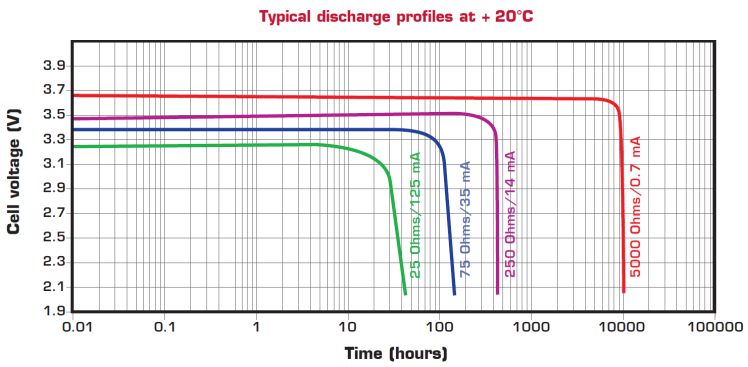
V_{BATT} : 2.8V_{MIN} to 3.67V_{MAX}

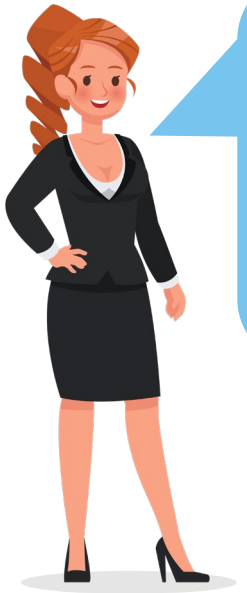
www.microchip.com/wlr089u0

LoRaWAN

TRUST&GO

www.microchip.com/trustgolora





Customer

We are **upgrading our water meter with wireless** connectivity.

We are now **working on power management**: Target is 15 years battery life. Based on our power budget, selected the Saft LS26500. So our **need: LOW IQ LDO at 1uA**.

Microchip, what do you propose to us?

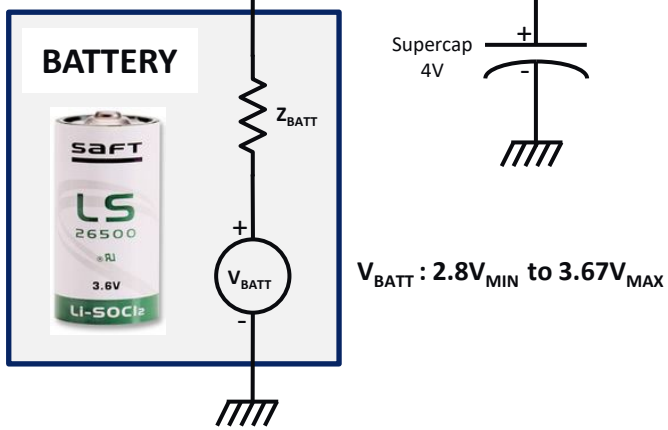
Average efficiency with LDO will be 60% with 10µA standby current, 1µA LDO IQ, 2µA leakage through Supercap.

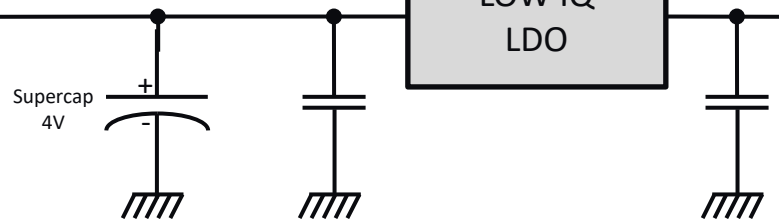
$$eff = \frac{P_{OUT}}{P_{IN}} = \frac{V_{OUT} \cdot I_{OUT}}{V_{IN} \cdot (I_{OUT} + I_Q)}$$

Our local Analog Expert

Real Life Example: Smart Water Meter

Total System Solution





www.microchip.com/wlr089u0

LoRaWAN

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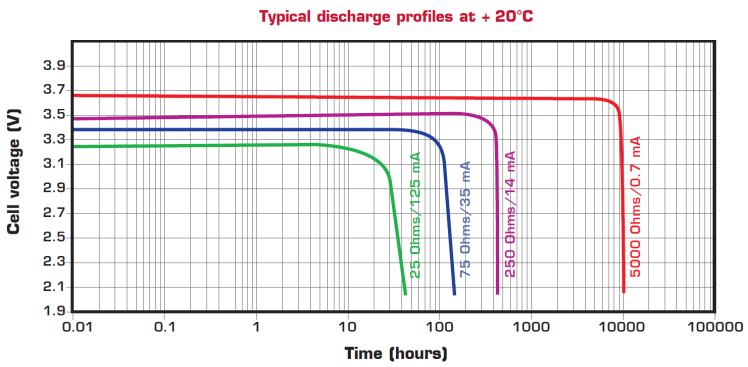
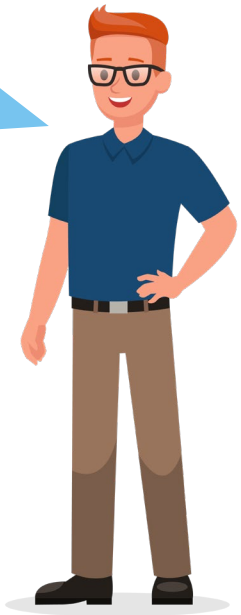
V_{BATT} : 2.8V_{MIN} to 3.67V_{MAX}



YES, we have the LDO that you requested. This Saft LS26500 is the right choice for your proposed hardware topology



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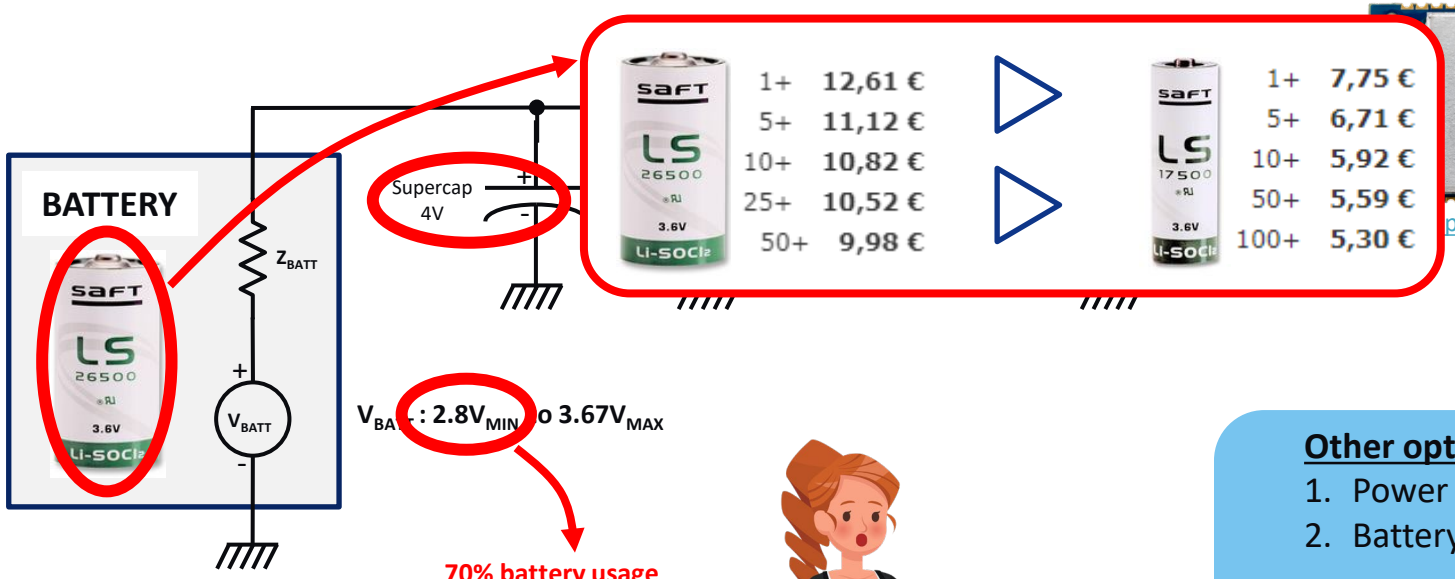
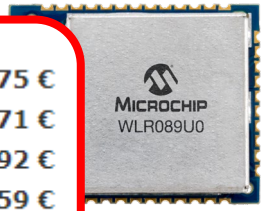
Real Life Example: Smart Water Meter

Total System Solution



1+	12,61 €
5+	11,12 €
10+	10,82 €
25+	10,52 €
50+	9,98 €

1+	7,75 €
5+	6,71 €
10+	5,92 €
50+	5,59 €
100+	5,30 €



p.com/sam-r34-r35

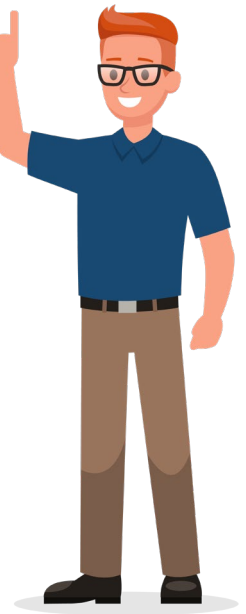
LoRaWAN

TRUST&GO

www.microchip.com/trustgolora

Other option to increase
1. Power efficiency (from 60%)
2. Battery usage (from 70%)

You can also save space and reduce your system cost.

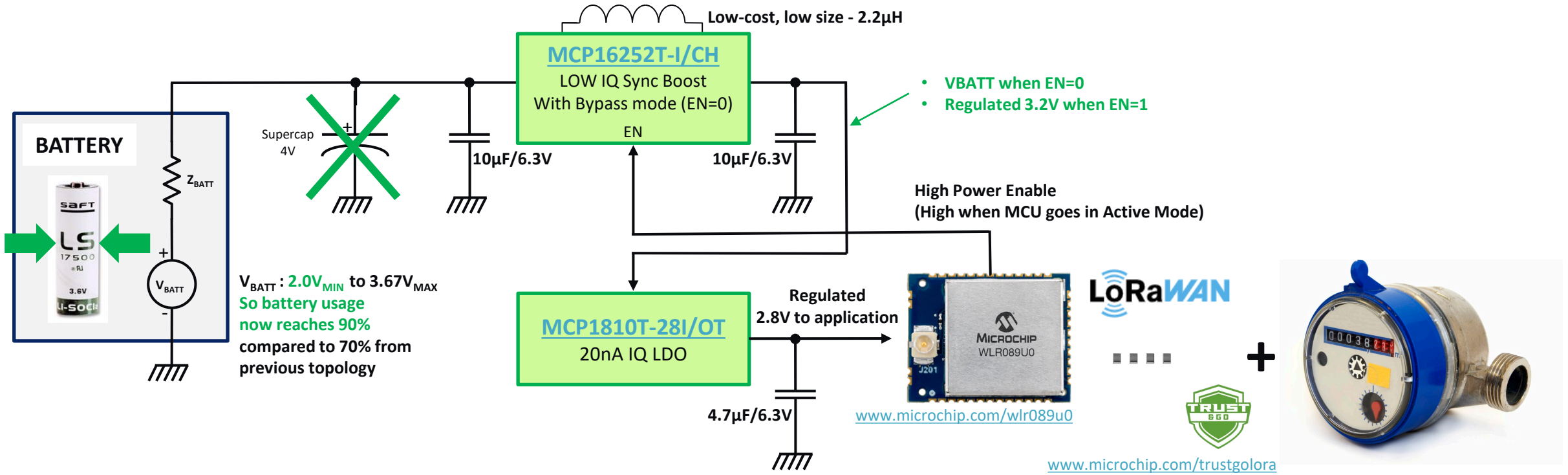


Average efficiency with LDO will be 60% with 10µA standby current, 1µA LDO IQ, 2µA leakage through Supercap.

$$eff = \frac{P_{OUT}}{P_{IN}} = \frac{V_{OUT} \cdot I_{OUT}}{V_{IN} \cdot (I_{OUT} + I_Q)}$$

Real Life Example: Smart Water Meter

Total System Solution



New Efficiency:

- **73% in Sleep Mode**
- **81% in Active Mode**

Battery life is improved by >15% leading to much lower total system cost and smaller system!

Real Life Example: Smart Water Meter

Going the Extra Mile

Option	HW Schematic	Efficiency in Sleep	Efficiency in Active	Total Efficiency	Battery Life	System Cost
Option 1 Initial Demand	MCP1810 Low IQ LDO + Supercap	Best	Good Due to **higher** battery cut-off voltage	Good Due to **higher** battery cut-off voltage	Worst	Worst Due to extra cost from battery and supercap
Option 2 Microchip Proposal	MCP16252 Boost MCP1810 Low IQ LDO	Very Good	Very Good	Very Good	Very Good	Best

This is a great proposal!

This solves our mechanical constraint issue with $$$ saving!!!

We will test it for our project.

Real Life Example: Smart Water Meter

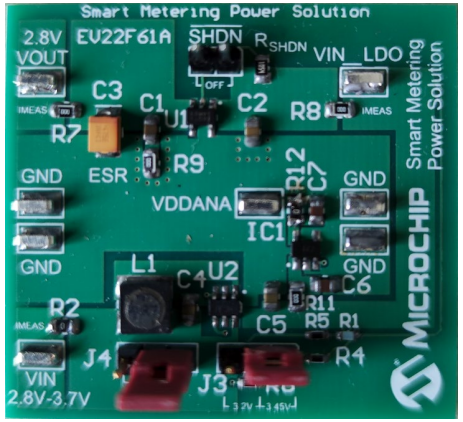
Going the Extra Mile

Option	HW Schematic	Efficiency in Sleep	Efficiency in Active	Total Efficiency	Battery Life	System Cost	Noise
Option 1 Initial Demand	MCP1810 Low IQ LDO + Supercap	Best	Good Due to **higher** battery cut-off voltage	Good Due to **higher** battery cut-off voltage	Worst	Worst Due to extra cost from battery and supercap	Very Good
Option 2 Microchip Proposal	MCP16252 Boost MCP1810 Low IQ LDO	Very Good	Very Good	Very Good	Very Good	Best	Worst

We also improve the system robustness by measuring noise (ripple rejection).

We did the math, simulations and tests.

We now have **more options** for you to consider.



Real Life Example: Smart Water Meter

Going the Extra Mile

Option	HW Schematic	Efficiency in Sleep	Efficiency in Active	Total Efficiency	Battery Life	System Cost	Ripple Rejection
Option 1 Initial Demand	MCP1810 Low IQ LDO + Supercap	Best	Good Due to **higher** battery cut-off voltage	Good Due to **higher** battery cut-off voltage	Worst	Worst Due to extra cost from battery and	Very Good
Option 2 Our 1st Proposal	MCP16252 Boost MCP1810 Low IQ LDO	Very Good	Very Good	Very Good	Very Good	Best Best Cost	Good
Option 3 Microchip Proposal for Platforming	MCP16251 Boost MIC94310 RippleBlocker™ MIC94062 Load Switch MCP1810 Low IQ LDO	Best	Best	Best Extend RF options to end customers	Very Good	Very Good	Best
Option 4 Microchip Proposal for Best Price + Performance	MCP16252 Boost MIC94310 RippleBlocker™ MIC94062 Load Switch MCP1810 Low IQ LDO	Very Good	Best	Very Good	Best	Best compromise for LoRaWAN™	Best

Option 3 could support more powerful radio allowing platforming (LoRaWAN™/NB-IoT/LTE-M)
Option 4 provides best price / performance / battery life compromise for targeted LoRaWAN radio
Pick the option which best suits you!
Note: Option 1 (starting point of our discussion) was actually the worst option

Summary

- Use a system approach
- Define your power budget
- Select power your source(s)
- Capture the microAmps

Do You Want To Become an IoT Expert?

We've Got You Covered!

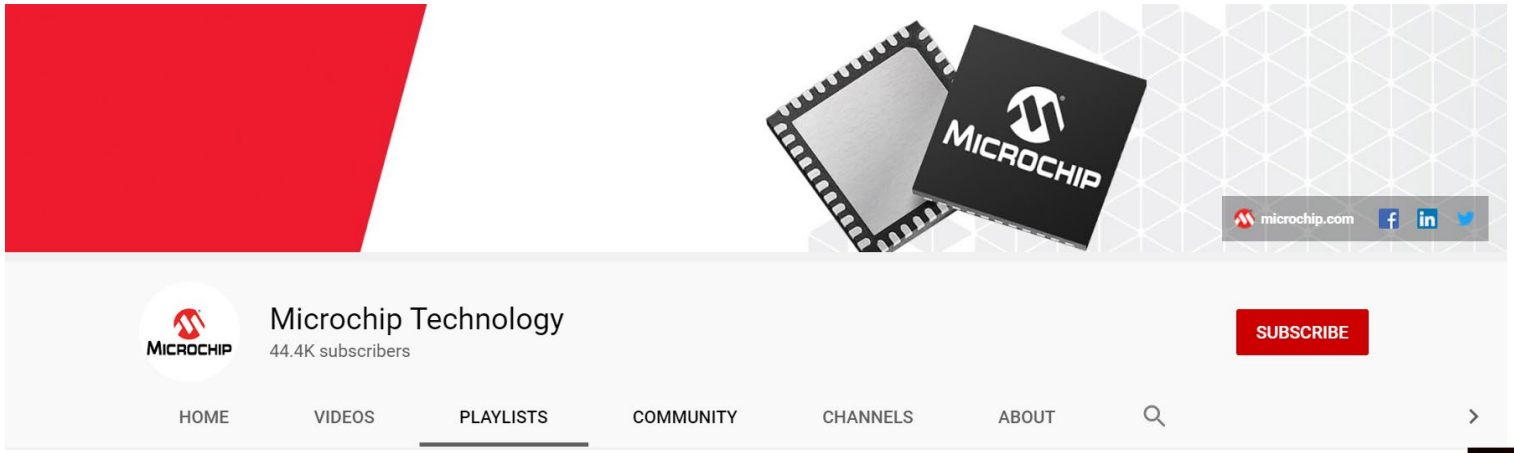
- **Microchip IoT Landing Page**
  - www.microchip.com/iot
- **Github**
  - https://github.com/MicrochipTech
- **Microchip YouTube Channel**
  - www.youtube.com/user/MicrochipTechnology
- **Microchip University**
  - https://secure.microchip.com/mu
- **Design Partner**
  - https://get.microchipdirect.com/design-partner-ecosystem/
- **Design Check: Online Design Review Services**
  - Wireless, Ethernet LAN, PoE, MPU
  - www.microchip.com/design-check-services

MICROCHIP

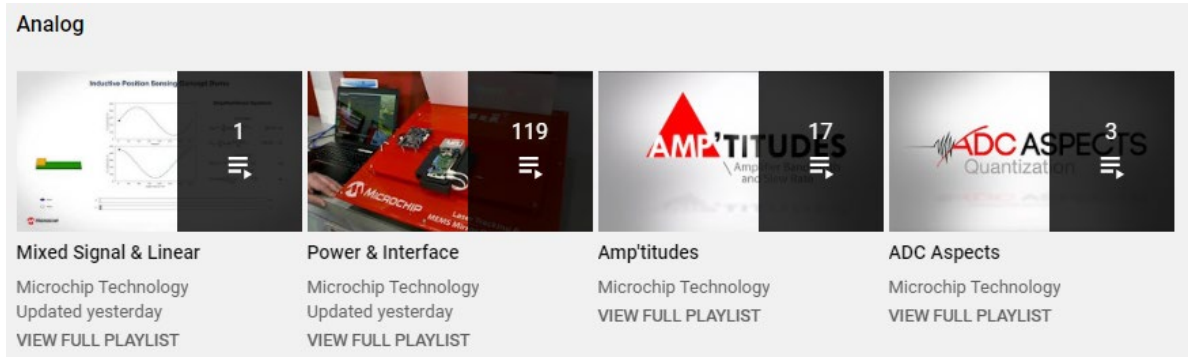
And for Even More…

YouTube Channel

www.youtube.com/user/MicrochipTechnology/playlists



YouTube



Improve Your Circuit Design Experience with the MPLAB® Mindi™ Analog Simulator (34' video)

MICROCHIP

The Challenges We Will Resolve Today

Overcoming Complexity in Connectivity

- **IoT nodes need to be smart and agile**
  - Agile across HW footprints and products
  - Agile across various Cloud platforms
- **Support**

Don’t worry, we've got you covered!

MICROCHIP

1. Comprehensive Portfolio for Sensors

Wireless and Wired Solutions

Wireless

Bluetooth | Wi-Fi® | 802.15.4 (Sub GHz & 2.4 GHz) | LoRa®

Wired

USB | Ethernet | PoE | CAN | RS232 RS485 DALI DMX512

Security

Development Tools Ecosystem

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No One Size Fits All

Agility – Four Real-life Examples

Street Lighting
Market is highly fragmented
Infrastructure may be limited

Position Sensors
Size, cost and power efficiency

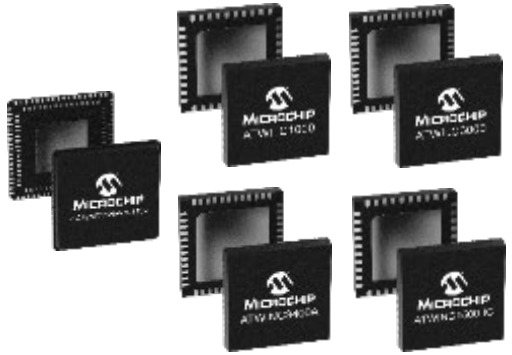
Predictive Maintenance
Complex casing
Maintenance, monitoring, noise interference

Dongle for Diagnosis and FW Upgrade of Secure Industrial Equipment
Wi-Fi®/Ethernet bridge and battery powered
Must be fast and simple, but robust and highly secure, and power efficient

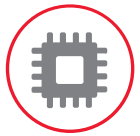
2. Product Agility

Pick the Product Flavor for Your Application

MPU SOM
MPU + Trust&GO + Ethernet PHY + Wi-FI® + BLE



Or go Chip-Down and Discrete with Reference Design and Chip-Down Package from Microchip



Any Core
8, 16, 32-bit
MCU or MPU

Wi-Fi® Controllers
(8 module flavors including BLE)
Link or Network versions
Many antenna options

Security

Standalone Wi-Fi® MCU (4 module flavors)
MCU + Trust&GO + Ethernet MAC + Wi-Fi

NEW

MICROCHIP

2. Product Agility: Going The Extra Mile

Buy, Clone RF Module or Make With IC

Reduced Up-front Investment

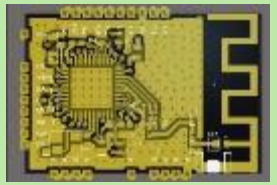
- ✓ Save ~1-year time-to-market
- ✓ Save 50-60 man-months effort
- ✓ Save ~$80K expenses

- ✓ Certified in 7 regions (typical)
- ✓ 2nd sourced critical components
- ✓ Low obsolescence risk
- ✓ REACH, RoHS compliant BoM
- ✓ Up-to-date on regulatory changes
- ✓ RF manufacturing test by Microchip
- ✓ Customizable with external antenna

Buy Certified RF Module

Microchip RF Module

- ✓ Save ~6-7 months time-to-market
- ✓ Save ~40 man-months effort
- ✓ Save ~$30-$40K expenses



Build-your-own Clone Module

Microchip RF IC with
Microchip Chip-Down Package

- ✓ Reuse module across products
- ✓ 100% leverage of Microchip BoM, PCB
- ✓ Some leverage of Microchip certification
- ✓ Tools to aid RF manufacturing test
- ✓ 3rd party CM ecosystem available

Full Custom

Microchip RF IC with
Microchip Chip-Down Reference Design Package

- ✓ Tools, Collateral for all stages in product life-cycle
- ✓ Strict layout guidelines for important sections
- ✓ Support through Wireless Check Service

Lower Unit Cost

Decreased Time to Market

MICROCHIP

How Microchip Makes It Possible

Chip-Down Reference Design Package Option

- Click Through License
- Design Files of Module
- Design Files of Eval Board
- Hardware Design Guidelines
- Wireless Design Guidelines
- Wireless Check Service

- Validation Tool
- Reference Gain tables (If needed)
- Antenna Pattern for PCB and Report

- Certification Tool
- Certification Guidelines

- Production Test Support Tool
- Production Guidelines
- Calibration Procedures

MICROCHIP

3. System Agility

From Hardware to the Cloud

HW with FW Libraries

Any Core

My Sensor Node

My Cloud

aws

Azure

TLS

Google Cloud Platform

LoRaWAN

Any Cloud

Any Connectivity

Join Session 3 to find out more about Cloud Connectivity and our Secure Solutions

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3. System Agility

Made Easy and Robust with Harmony!

Sensitive Data

Sensitive Environment

Reliable Execution

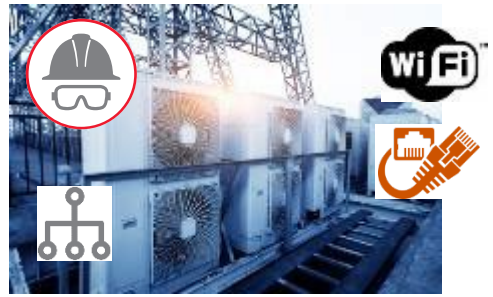
Trusted Execution

= Industrial IoT

Vehicle ECU (Engine Control Unit)

On-site Maintenance

Industrial Water Heater for Hospital



Air Conditioning Monitoring and Control for Hotels

MICROCHIP

3. System Agility

WFI32E01: Industrial Standalone Wi-Fi® MCU

- **High performance 32-bit PIC32 MCU with rich peripherals set**
  - 200 MHz CPU with DSP/DMA (CoreMark score of 710)
  - Wi-Fi® 802.11 b/g/n
  - 10/100 Ethernet, UART/SPI/I²C/SQI/I²S™, CAN, CAN-FD, USB FS
  - Touch and 12-bit dual ADC

- **Superior robustness and security by design**

AEC | MPLAB HARMONY | 25 YEARS MISRA | IEC 60730 Class B | MPLAB CODE COVERAGE | Certification

aws | Google Cloud Platform | Azure | Any Cloud | TRUST&GO | Wi Fi ALLIANCE WPA3 | TLS

- **Rich ecosystem and resources to develop your application in no time**

MICROCHIP

4. Support Matters

- **Design Check Online Design Review Services**
  - Online design review services provide a new “Value Added Service” support case
  - Customer benefits from best practices from Microchip experts
- **Going 1 step further with Microchip GitHub**

Check Services

www.microchip.com/checkservices

Our Local Team is here for you!

MICROCHIP

Conclusion

We have Solutions Made Easy for You

- **“Massive IoT” is deploying fast but also evolving fast!**
- **Success in IoT requires Agility and an End-to-End System Approach**
- **Microchip has a comprehensive wireless and wired portfolio**

Do You Want To Become an IoT Expert?

We've Got You Covered!

- **Microchip IoT Landing Page**
  - www.microchip.com/iot
- **Github**
  - https://github.com/MicrochipTech
- **Microchip YouTube Channel**
  - www.youtube.com/user/MicrochipTechnology
- **Microchip University**
  - https://secure.microchip.com/mu
- **Design Partner**
  - https://get.microchipdirect.com/design-partner-ecosystem/
- **Design Check: Online Design Review Services**
  - Wireless, Ethernet LAN, PoE, MPU
  - www.microchip.com/design-check-services

MICROCHIP

Thank You