BLE-204

Harnessing Ambient IoT: A Leap Towards Sustainable Connectivity

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SILICON LABS

Agenda

Silicon Labs IoT

Ambient IoT Intro

Focus Application: Asset Tracking

Going Battery-less

Ambient IoT Architectures

Demo

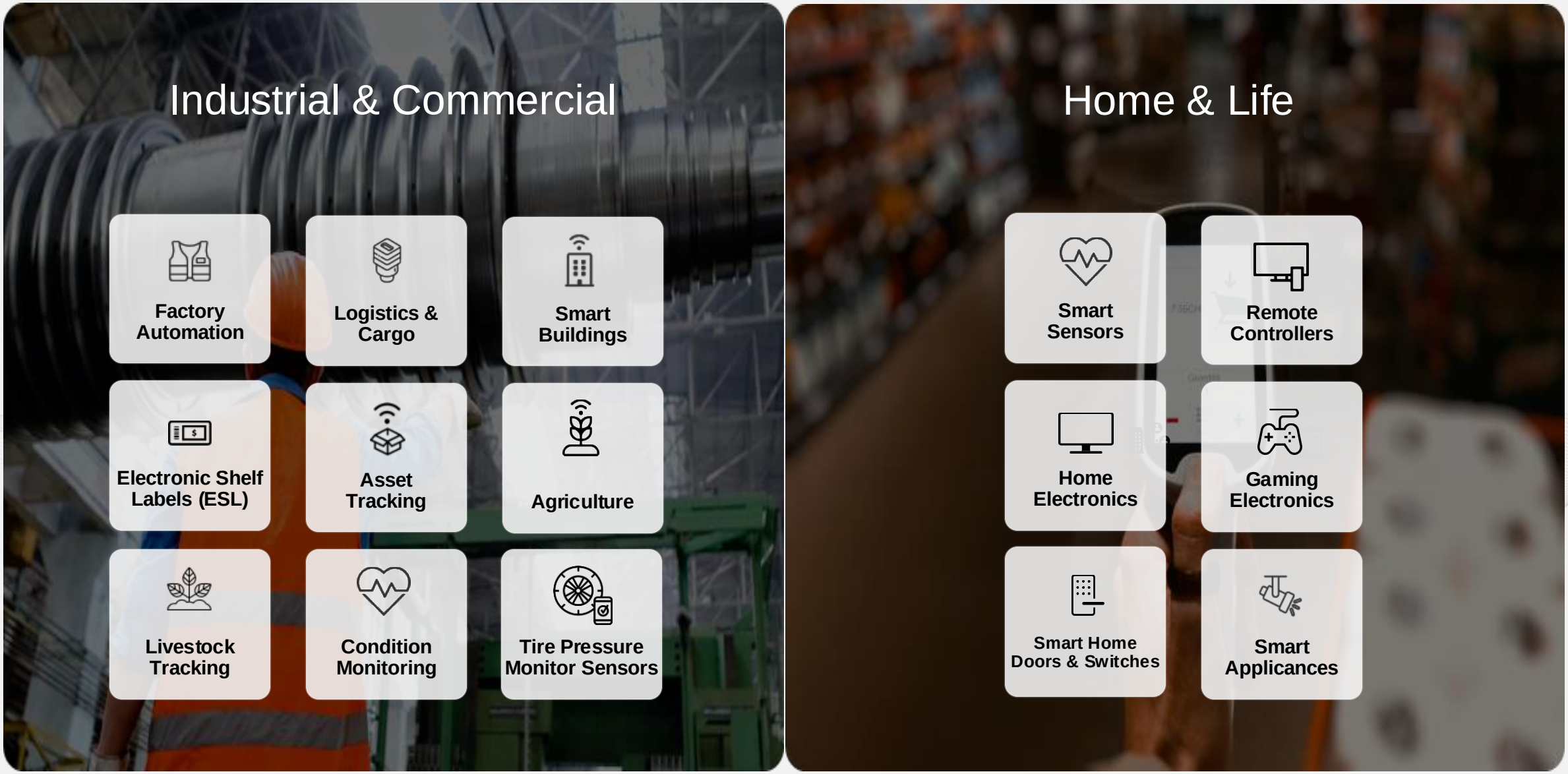
Getting Started with MG22E

Q&A

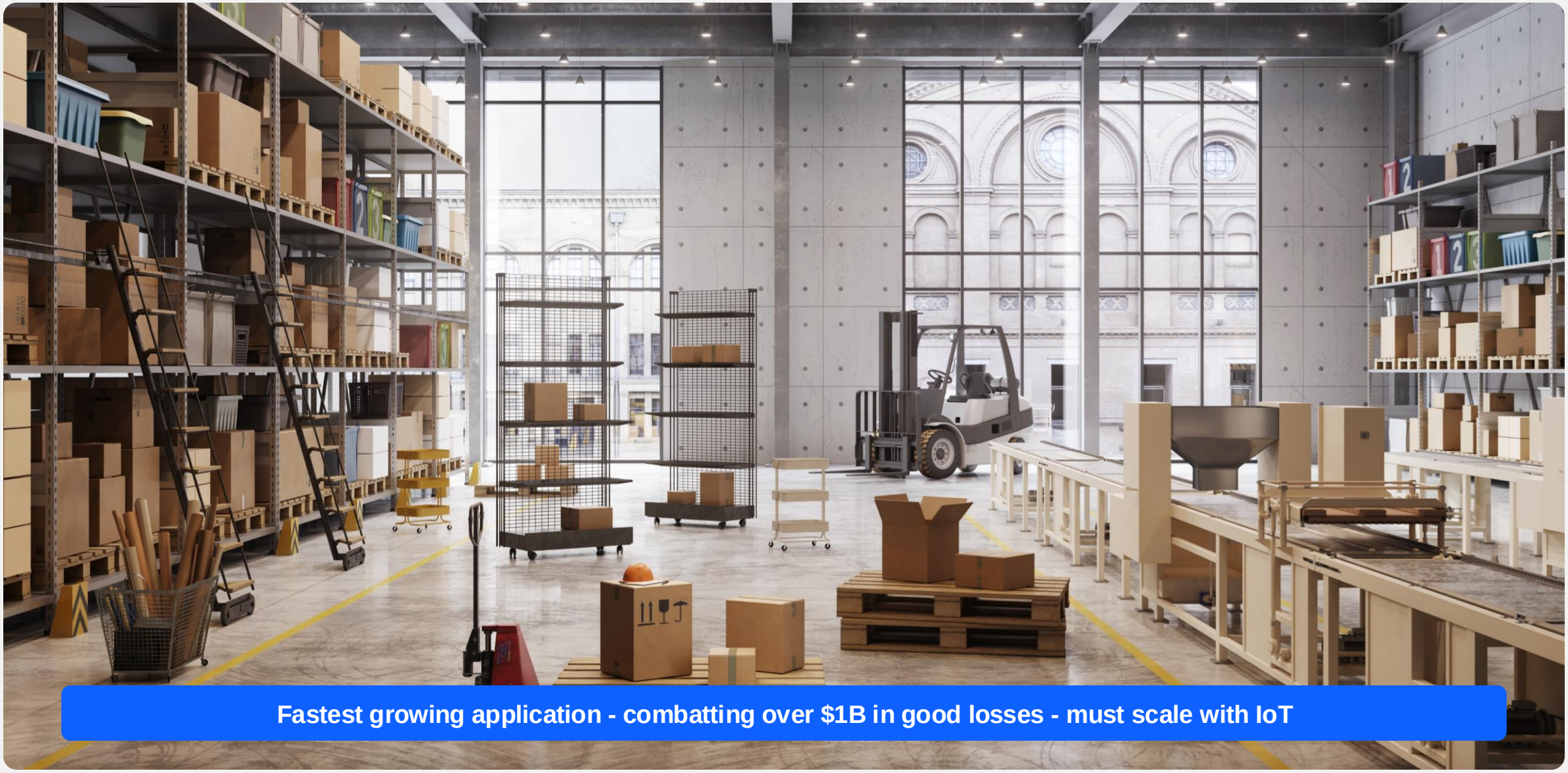
What is Ambient IoT ?

Defining Attributes	Harvesting energy from any viable ambient power source				
IoT Hardware Evolution	**New Device Feature Enablement** • Smaller device size and new form factors • Longer maintenance-free field life, including through battery-free devices • Lower cost of hardware	**Function** • Tracking • Monitoring • Identity • Control	**Topologies** • Point-to-point • Mesh • Broadcast	**Trade Offs** • Lower device functionality and configurability • Requires ambient energy source, which produces very small amounts of power	
Applications	Existing and new IoT use cases. Early examples include asset tracking, commercial building automation, condition based monitoring, cold chain monitoring, and home control.				

Ambient IoT Application



Ambient IoT – Focus Application: Asset Tracking



Asset Monitoring – Ecosystem of End Products

Gateways Aggregators	Real-Time Trackers	Short-Range Trackers	Cold-Chain Dataloggers	Energy Harvesting Tags	Disposable Tags
Collects data from shorter-range trackers Sends **data to cloud** customer dashboard	**Real-time location services (RTLS)** via cloud. Measures **environmental data** (motion, temp, condition monitoring, etc.)	**Connects periodically** to a gateway and communicates status. Measures **environmental data** (motion, temp, condition monitoring, etc.)	**Read at the end of the journey** to determine if any alerts were triggered Detects **shocks or drastic temperature changes** throughout.	Constant **beaconing** or data advertisement **between deep-sleep intervals.** Powered from **ambient energy sources** – **dynamically** configurable by energy level	Periodically **scanned manually** at beginning or end of journey. Does not record journey information
					
WiFi: *RS9116* **BLE**: *BG24* **SubGHz:** *FG23*	**WiFi:** *SiW917* **BLE**: *BG22* **SubGHz:** *FG28* **GPS**	**WiFi:** *WF200* **BLE**: *BG22* **SubGHz:** *FG28*	**BLE**: *BG22* **SubGHz:** FG23	**BLE:** *BG22E* **15.4:** *MG22E*	**NFC/RFID**
Vehicle-powered (battery back-up)	**Battery-powered**	**Battery-powered**	**Battery-powered**	**Battery-less**	**Battery-less**

Asset Monitoring – Challenges & Trends

Trends in Asset Monitoring

- Migrating from dataloggers to real-time tracking networks
  - **multiple radio solutions** for long-range and short-range fallback.
- **Hybrid networks** of multiple tracking products
- **Wi-Fi SSID Sniffing** for cloud-based connectionless tracking
- **Bluetooth LE Positioning** (Channel Sounding, AoA, AoD)
- **802.15.4 Mesh** Architectures

- **Energy Harvesting / Ambient IoT**
  - Solar, RF and other energy harvesting for battery-less tracking

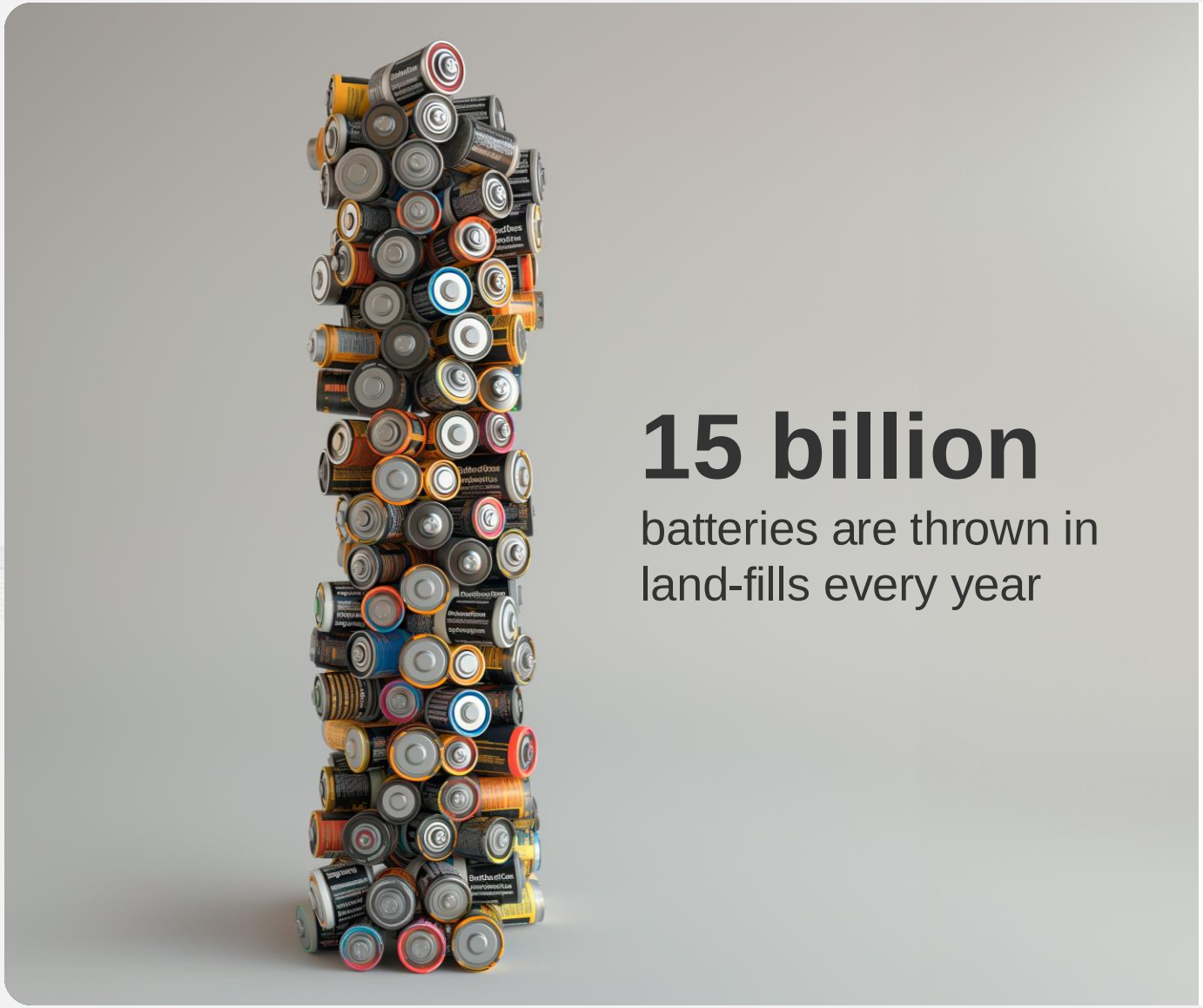
Challenges In Asset Monitoring

- **Battery reliance:**
  - Isolated nodes run on a battery for long periods of time
  - Configurability of sleep, advertisement and connection interval compromised for power

- **Unpredictable RF environments:**
  - Assets are frequently encased in large metal containers
  - Asset frequently travel through very RF-crowded atmospheres causing wireless traffic issues.
  - Asset frequently leave and rejoin multiple networks

The solution to Asset Tracking is *scale*....The challenge with scaling is reliance on batteries!

The Problem with Batteries for IoT



More than 15 billion batteries are thrown in land-fills around the world every year (900,000 tons of hazardous waste)

The average household purchases over 90 batteries annually most have much less than 10-year lifetime

Batteries are slowing down the growth of IoT

- 25 billion IoT devices predicted by 2025 would require 6 million battery replacements every day
- In industrial setting with 1,000 sensors, the annual replacement of over 350 batteries—typically exceeding one per day—incurs significant recurring costs, often surpassing the batteries' own price.
- IoT is compromised when sensor polling rate, payload size, transmission rate and range are lowered due to lack of power.
- Systems need to integrate energy awareness decision making

Battery Regulations

National Electric Code (**NEC**) is introducing **new requirements on battery collection and recycling** as well as mandating the **elimination of batteries** in certain devices.

More and more countries are following the movement (NEC US, NEC Europe, Japan, Australia, Canada)

European Commission – Batteries Regulation

Biden-Harris Administration Announces $62 Million to Lower Battery Recycling Costs Across the Nation

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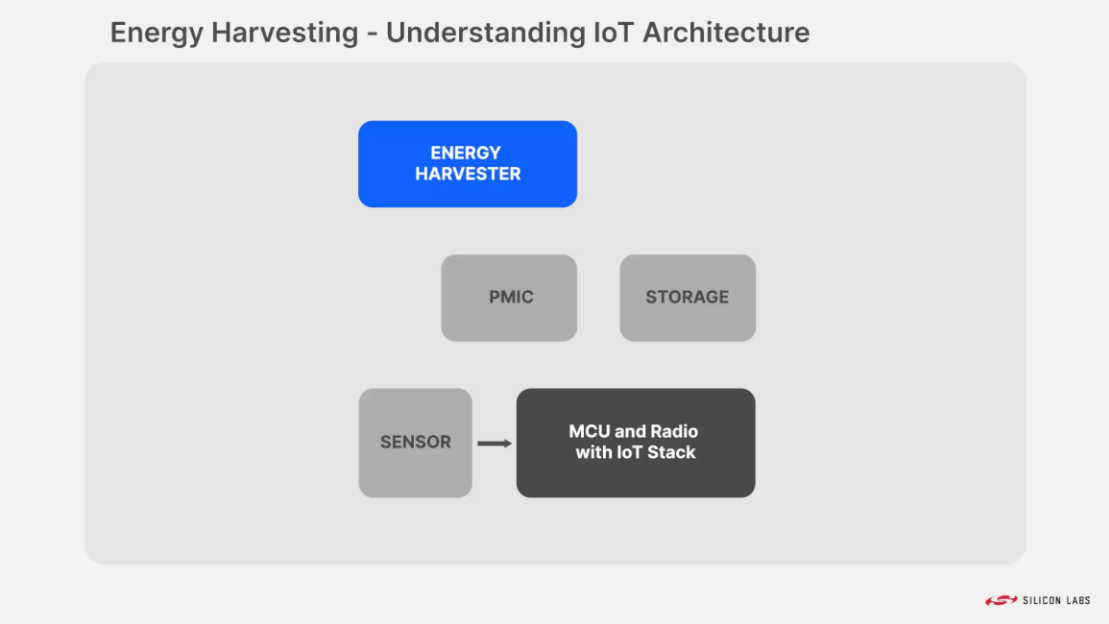
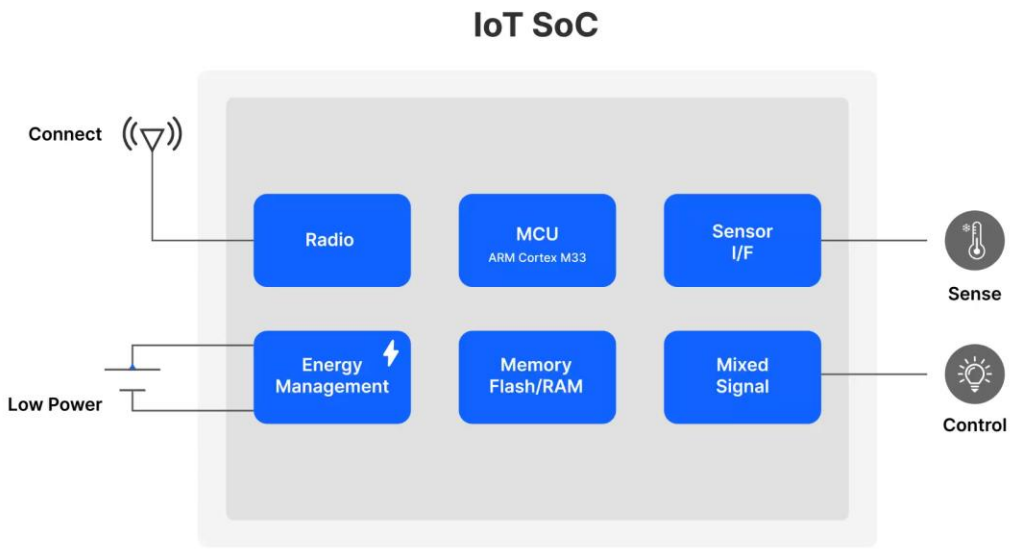
These upcoming regulations impact IoT device design.

This is the beginning of a new era of IoT product development

Understanding IoT Architectures for Energy Harvesting



- **Energy Harvester:** harness ambient energy
- **Storage:** energy bank
- **PMIC:** power management and transformation
- **MCU and Radio:**
  - Application and communication
  - energy-based decision making ; sleep and wake control



The **IoT SoC Platform** is responsible for:

- assessing available energy
- determining when to wake up peripheral systems
- executing system actions...or remain asleep.
- Managing communication payload and transmitting

Introducing EFR32xG22E

Lowest Power, Energy-Efficient Wireless SoC

Wireless SoCs providing Ultra-Low Power suited for deep-sleep **Extended Battery** or **Battery-Less** Applications

Ultra-fast, Low-Energy cold-start

- Power on Reset (PoR) in 8ms
- Consumes less than 150µJ

Ultra-fast, Low-Energy deep sleep wake-up

- EM4 wakeup in less than 1.83ms
- Consumes 16.6µJ in wake-up energy
- 10+ year coin cell battery operation for ultra-low power or extended storage applications

Power-efficient energy mode transition

- Optimized for smooth transitions in and out of energy modes
- Mitigates current spikes or in-rush to prevent harm to batteries or alternate storage

Reliable Wireless and Long Range

- Multiprotocol 2.4 GHz wireless SoC with High-Performance RF
  - Bluetooth LE, Proprietary, Zigbee, and Zigbee Green Power

Pin compatible with xG22 and xG27 SoCs

- Pin compatible QFN32 and QFN40 packages for easy migration and rapid time to market

xG22E: Ideal for Ultra-low Energy, Ambient IoT, and Energy-Harvesting

DIFFERENTIATED FEATURES

Bluetooth® Proprietary zigbee

5x5 QFN40 (26 GPIO), AEC-Q100

4x4 QFN32 (18 GPIO)

DEVICE SPECIFICATIONS

Efficient, Low-Energy Cold Start
- Boot-up time less than 8ms
- Energy consumption under 150uJ

Low-Energy Deep Sleep wake-up
- Consuming less than 17uJ

Power-efficient energy mode transition
- Optimized to smoothly transition out of energy modes
- Mitigates current spikes or inrush

RFSense with OOK mode
- Ultra low-power receive mode to wake-up MCU from EM2 or EM4
- Results in longer battery life

PLFRCO
- Eliminates need for 32 KHz XTAL and lowers overall system cost

16-bit ADC
- Up to 14-bit ENOB for better analog sensing

High Sensitivity 2.4 GHz Radio
- -Up to +6 dBm TX
- -98.9 dBm RX @ BLE 1 Mbps
- -106.7 dBm RX @ BLE 125 kbps
- -102.3 dBm RX @ 15.4

Efficient ARM® Cortex®-M33
- Operating Frequency: Up to 76.8 MHz
- 512kB Flash, 32kB RAM
- Low Power
- 27 µA/MHz
- 3.4 mA TX @ 0 dBm
- 2.5 mA RX (BLE 1 Mbps)
- 1.4 µA EM2 sleeps
- 0.17 µA EM4

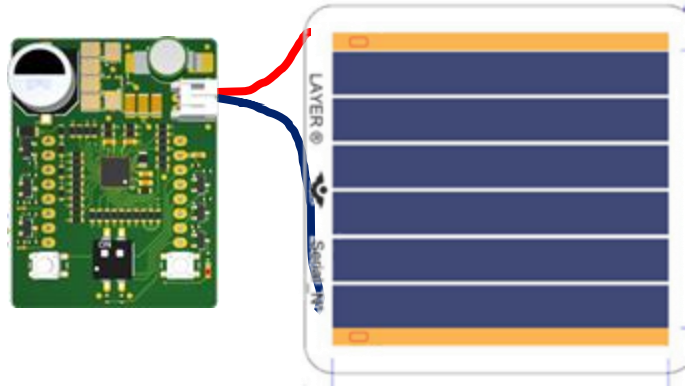
Secure
- Secure Vault Base
- ARM ® TrustZone

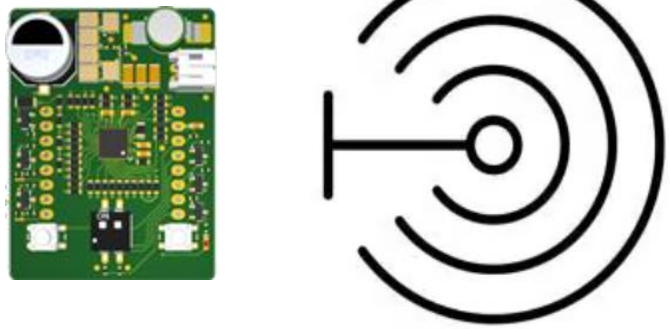
Wide Operating Range
- 1.71 to 3.8 volts
- +125ºC operating temperature

PLFRCO
- 500 PPM LFRCO

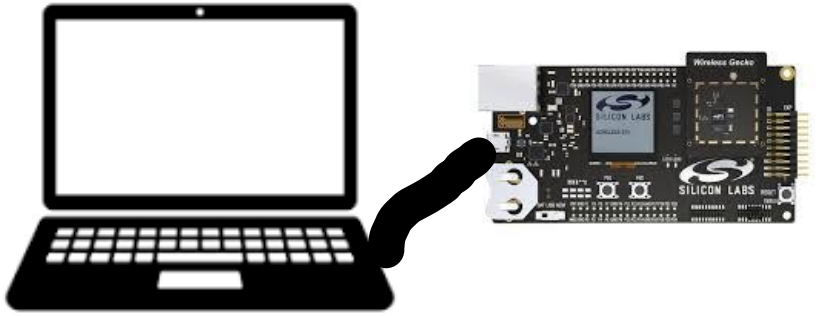
AMBIENT IOT: Battery-less Asset Tracking (PV + RF)

Asset Tag





Gateway



Silicon Labs – WSTK MG24 Radio Board
PC Python script with GUI dashboard

Silicon Labs – MG22E Explorer Kit
Dracula Layer - Energous EN - epeas AEM

Dracula Company Overview

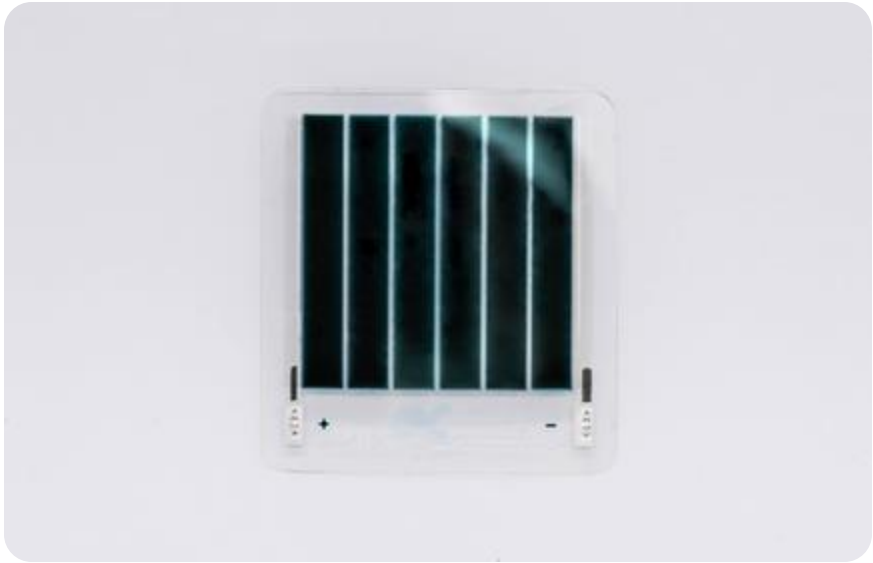
- Pioneering DeepTech and GreenTech since 2012.
- HQ in Valence, France. Team of 39 members.
- Capital raised: €25M
  Strategic investors: Semtech. MGI, ISRA Card
  Financial institutions: BPI France, CDC, EIC grant
- Awards: CES Innovation Award 2021, Solar Impulse, France 2030

Vision: Replace traditional batteries with ambient light as the primary power source, ensuring full energy autonomy for electric devices and paving the way for a greener future.

DRACULA TECHNOLOGIES

LAYER® Replaces Batteries

LAYER® is a thin film offering a flexible solution for low-power devices. It harvests energy from ambient light sources, minimizing costs and environmental impact.



Features

Inkjet Printing
Free-form design for any sensor size & shape

Extreme Low-Light
Optimal performance in sub-500 lux conditions

Organic Photovoltaic technology
No rare earths or heavy metals used

Long Life Span
Durability and sustained performance

DRACULA TECHNOLOGIES

Applications

LAYER powers connected device applications across diverse industry verticals.

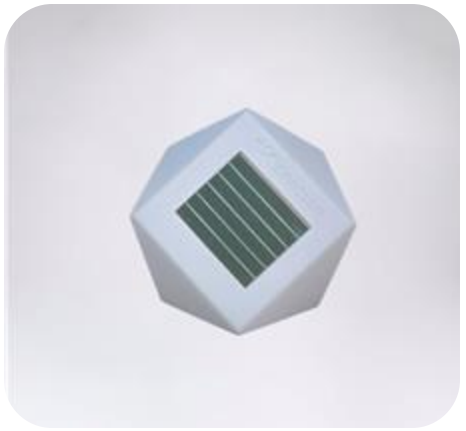
Smart Home & Smart Building

- Monitoring
- Energy Management
- Home Control
- Lighting

Smart Asset Tracking

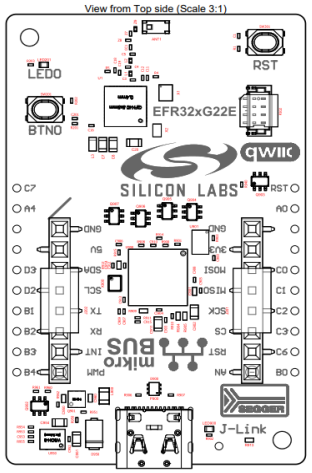
- Cold Chain Monitoring
- Geotagging

Other Low-Power Devices



DRACULA TECHNOLOGIES

HARDWARE: PV Solar Battery-less Asset Tag

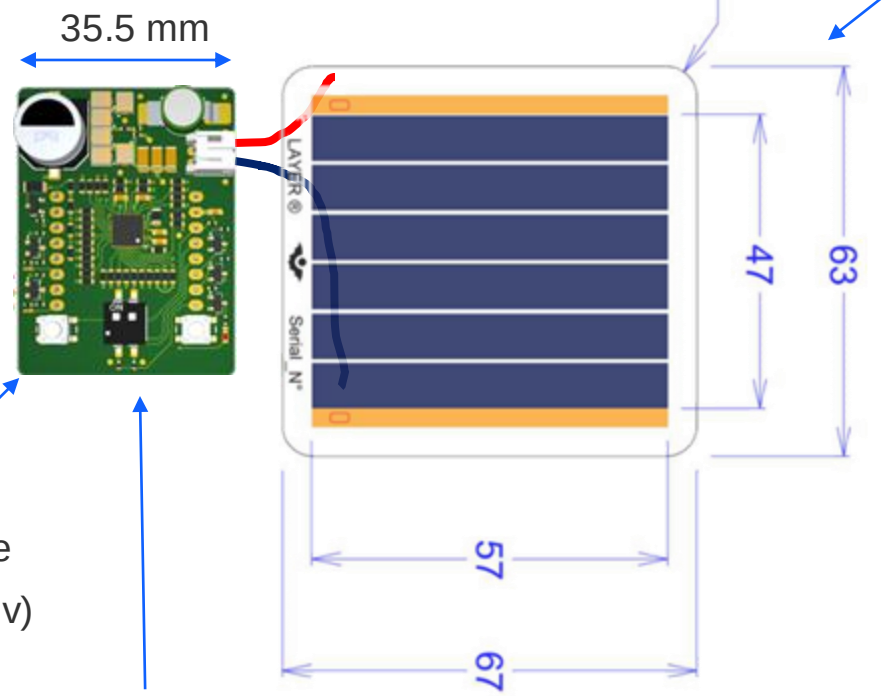


MG22E Explorer Kit

Storage Bank:
4F - 1.4V
220 mF - 3.5V
55 mF - 3.3V

***epeas* PMIC AEM10330**

Pushbuttons + DIP:
Force Advertisement
Force Energy Discharge
Mode selection (EM, Adv)



***Dracula* OPV - Layer**

Explorer Kit Shield

SILICON LABS
e-peas semiconductors
DRACULA TECHNOLOGIES

works with
BY SILICON LABS

Energous is pioneering scalable, over-the-air (OTA) wireless power networks are designed to enable unprecedented levels of visibility, control, and intelligent automation for IoT applications

energous

Energous Enables a New World for IoT

By pioneering scalable, over-the-air (OTA) wireless power networks designed to enable unprecedented levels of visibility, control & intelligent automation for IoT applications

Creating Reliable, Always-on Power Networks

- Provides on-demand access to wireless power, similar to how cell phones provide seamless access to data from anywhere
- Devices stay powered on 24/7/365 – no down time

Improving Operational Efficiencies

- Accurate, real-time and actional data and communication
- Automated energy flow to optimize device performance

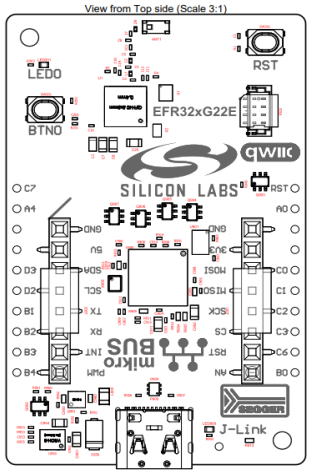
Reducing Costs

- Eliminating need for disposable batteries, wires & cables
- Lowering maintenance costs

Providing Network Flexibility & Mobility

- Network scales with IoT applications

HARDWARE: RF Battery-less Asset Tag

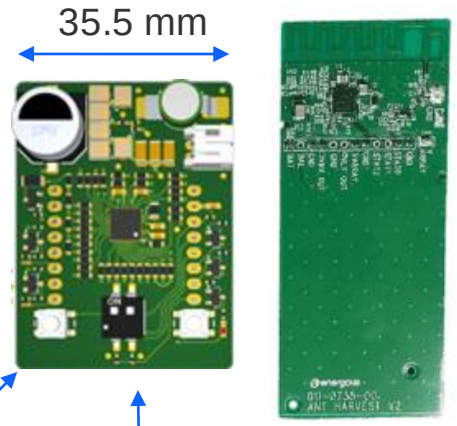


MG22E Explorer Kit

Storage Bank:

NGK EnerCera Li-ion rechargeable battery EC382704P-T

***epeas* PMIC AEM 30940**



Energous PowerBridge EN3210 ; EN4100

Pushbuttons + DIP:
Force Advertisement

Force Energy Discharge

Mode selection (EM, Adv)

Explorer Kit Shield

SILICON LABS

e-peas semiconductors

energous

SOFTWARE: Energy Awareness Decision Making

System will take available (and previous) **energy measurements from storage** and establish energy score

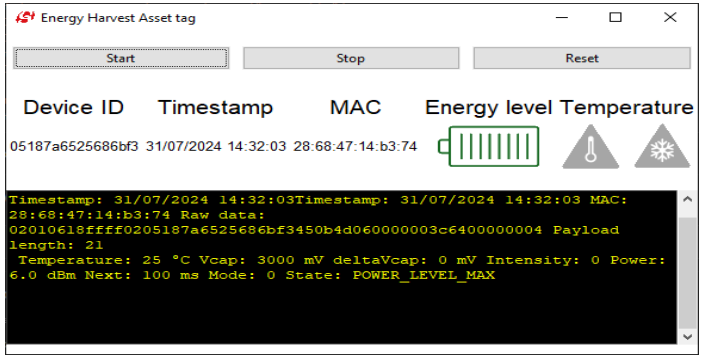
Based on energy levels, system will ***dynamically*** **adjust its operation.**

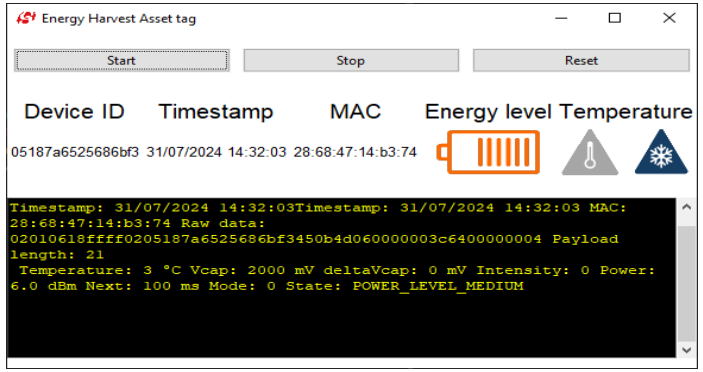
- Payload size
  - FULL: ID, Temperature, Energy (Vcap, Delta VCap), Timing
  - SHORT: ID only
- Transmission power
  - 6 dBm, 3 dBm
- Transmission PHY
  - 1M, 2M
- Number of advertisements and interval
  - Factor of Configuration Mode
- Sleep duration
  - Factor of Configuration Mode

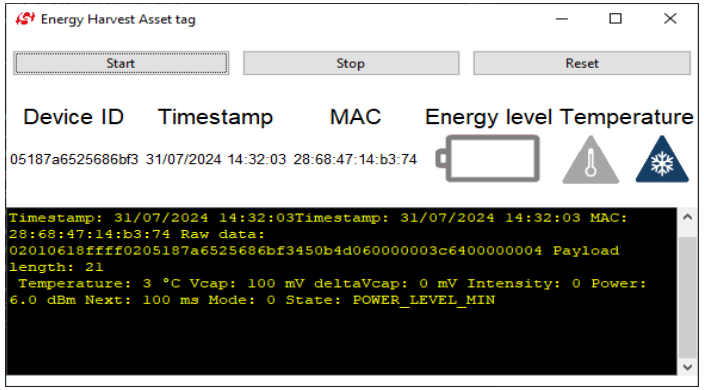
CONFIGURATION MODE	# OF BEACONS ; INTERVAL	SLEEP TIME (min)
MODE 1	3 ; 0.1s	0.5
MODE 2	6 ; 0.2s	1
MODE 3	12 ; 0.5s	2
MODE 4	12 ; 1s	5

ENERGY MODE	TX	PHY	PAYLOAD	BEACONS	SLEEP
MAX	6 dBm	2M	FULL	CONFIG MODE x2	CONFIG MODE/2
HIGH	6 dBm	1M	FULL	CONFIG MODE x2	CONFIG MODE /2
MED	6 dBm	1M	SHORT	CONFIG MODE x2	CONFIG MODE
LOW	3 dBm	1M	SHORT	CONFIG MODE	CONFIG MODE

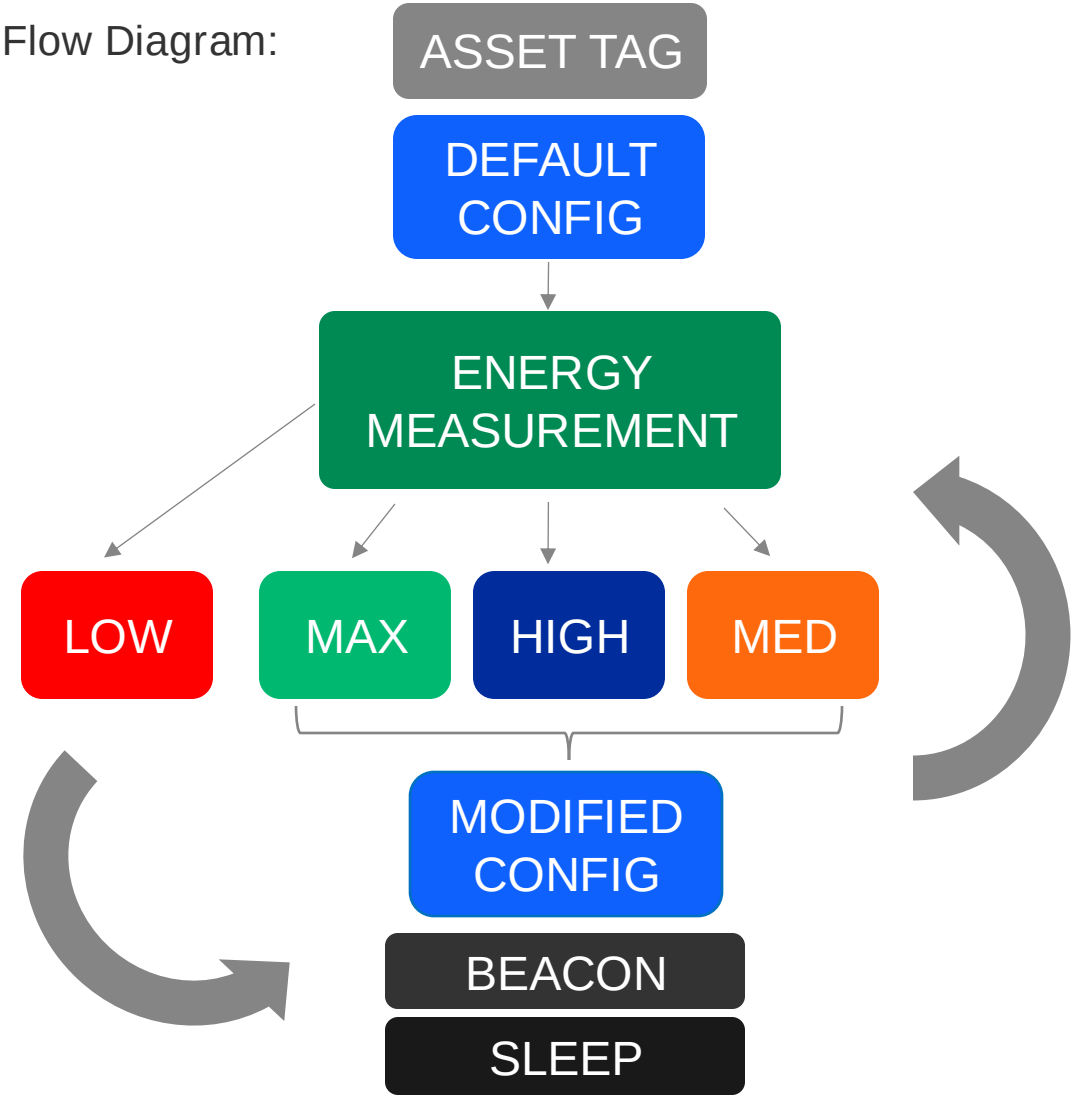
SOFTWARE: Ambient IoT Energy Awareness Dashboard GUI





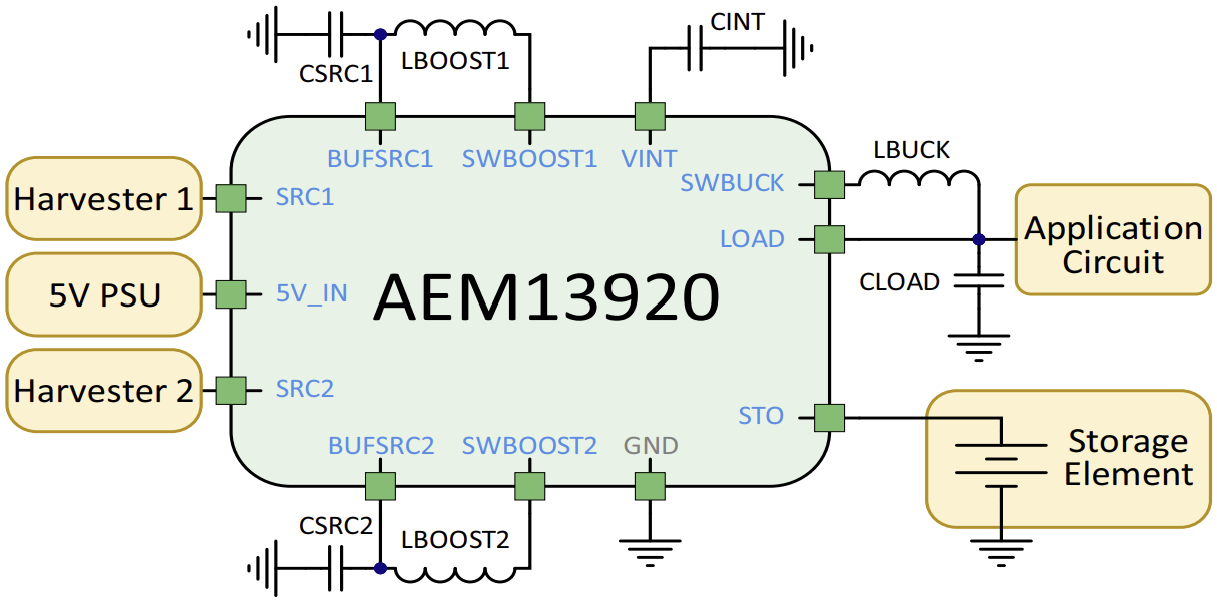


Flow Diagram:



Demo

e-peas Company overview



e-peas semiconductors

AEM13920

- e-peas is specialized in ultra-low power electronics for Energy Harvesting.
- e-peas products key feature is highest energy conversion efficiency.
- We offer a wide PMIC Product range covering “all” IoT energy harvesting sources.
- e-peas customers benefit from a wide ecosystem of raw energy sources and storage elements.
- Developers get development support through components architectures, EVKs, design support with FAEs and AEs teams.
- e-peas has Worldwide presence
- Give power to IoT products with a focus on SMART SENSOR, REMOTE CONTROL UNITS, PC PERIPHERALS, ELECTRONIC SHELF LABELS, WATCHES and WEARABLE DEVICEs

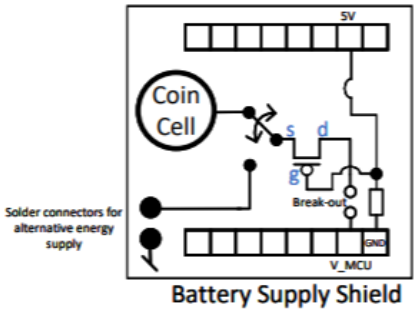
Getting Started with EFR32xG22E – Energy Harvesting Shields Explorer Kit

NEW Explorer Kit: redesigned to minimize leakage and isolation of debugger circuit

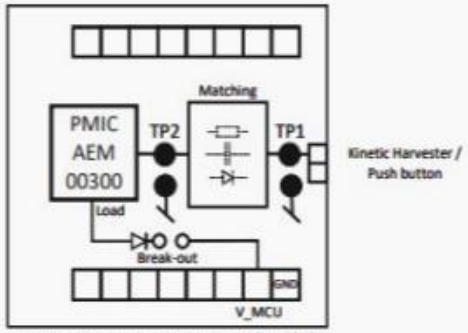
BRD8200

AVAILABLE - Q4 2024

Shield #1 for alternative battery technologies and storage options with measurements



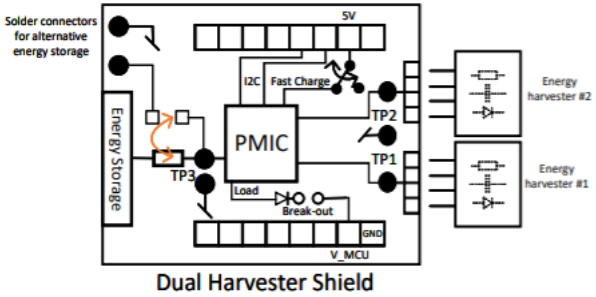
Battery Supply Shield



Kinetic Harvester Shield

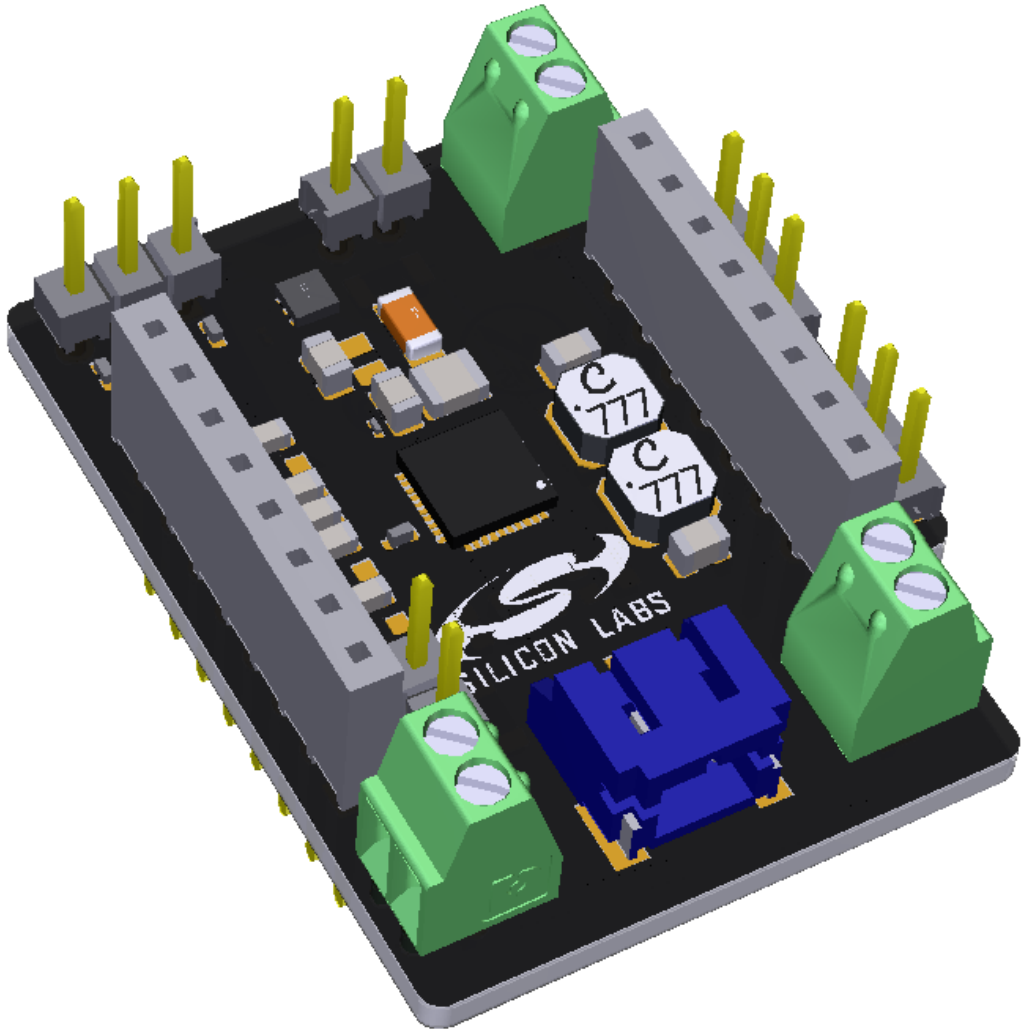
Shield #2 dedicated for evaluating kinetic/pulse harvest generators with measurements.

Shield #3 for dual harvest sources (PV, Thermal, Vibration, bricks) with measurements



Dual Harvester Shield

Dual Harvest Shield



The shield is preconfigured with GPIO default for safer use conditions.

It accommodates direct connection of Photovoltaic cells.

- Or other harvesters with I/F board

It also accommodate direct connection of storage element (Solder header or JST).

- Please refer to Absolute maximum rating documentation.

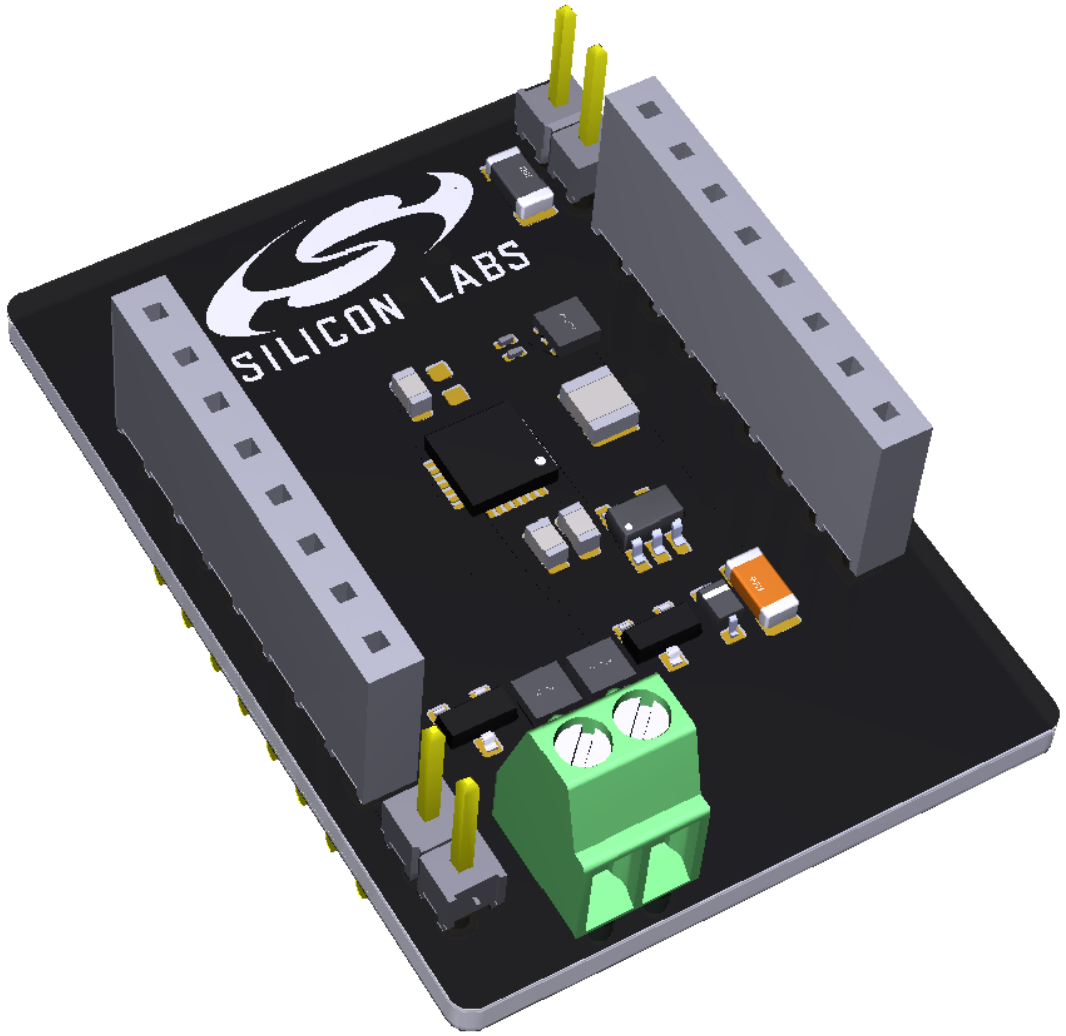
Support additional Mikroe stacking.

Optional 5V from mother board USB input allows fast charger connection.

Break-out points are available to insert amp-meter and measure voltage at storage element and harvester inputs.

I2C bus to / from host EFRxG22e allows host MCU to reconfigure PMIC on-the-fly .

Kinetic Shield



It is preconfigured with GPIO default for optimal use conditions.

It accommodates direct connection of ZF microelectronics kinetic harvester.

An optimized SMD buffer storage element is populated on board.

Impedance matching and rectifier allow push and release action to capture more energy if needed.

Break-out points are available to measure voltage at storage element and harvester inputs.

GPIO settings allow for Setting application voltage.

Silicon Labs Delivers Ambient IoT

Applications

Logistics & Cargo | Asset Tracking | Condition Monitoring | Electronic Shelf Label (ESL) | Smart Building | Home Electronics

Silicon Labs Technology (in-house or via partners)

Technology

Connect | Bluetooth | Proprietary | mioty alliance | Wi Fi CERTIFIED | Wirepas

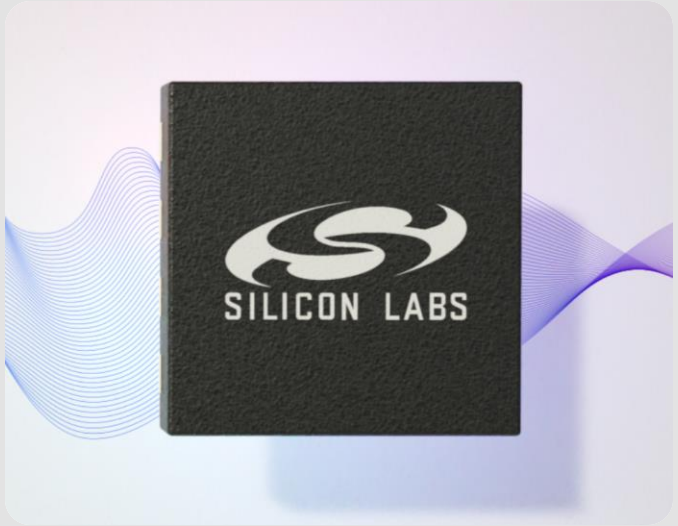
Series 2 Wireless SoCs

Hardware

BG22E | BG27 | SiW917 | FG23

Silicon Labs hardware and software technology solutions enable Ambient IoT

Why Standards-Based Wireless Mesh Networks?



EXPLORE SILABS OFFERINGS

Visit our webpage to learn more about Energy Harvesting, SiLabs offerings, and for a one-stop destination for all we have to offer!

Visit site

WORKS WITH 2023

Watch our WorksWith 2023 session and Tech Talk on Energy Harvesting by an industry expert.

WW23

TechTalk

ADDITIONAL RESOURCES

Read our blogs to learn more about our power optimized SoC and Ambient IoT.

SiLabs xG22E

Ambient IoT

Q & A