RUTRONIK EMBEDDED

TechTalk

Low Power IoT System Design with Infineon Wi-Fi and MCUs

Graham Smith

Agenda

1. Introduction – Low Power in IoT designs
2. Wi-Fi IoT Architectures and Portfolio
3. CYW43012 Radio and PSoC 6 MCU Low Power Features Overview
4. Power Optimization Techniques – Wi-Fi and MCU
5. Low Power Assistant (LPA) library – Overview
6. Demo – Optimizing MQTT Cloud example for Power
7. Getting Started and Resources

Introduction

IoT-AdvantEdge™ Core Strengths

CONNECT

Unfailing connectivity with best-in-class range and interoperability; delivering excellent consumer experience

COMPUTE

IoT-optimized MCU solutions that deliver **security**, **power-efficiency**, and data intelligence at the edge, while enabling engaging human-machine interfaces

CREATE

Flexible, open-architecture platform enabling designers to craft unique, **future-proof** IoT systems from a comprehensive menu of preconfigured building blocks

Complete view of IoT design complexities; Unique ability to offer comprehensive solutions

IoT-AdvantEdge™ Solves Critical IoT Design Problems

Connectivity

Getting products to work seamlessly in a field of multiple wireless technologies; dual-band Wi-Fi and BT

Security

Compliance with emerging privacy and security requirements

HMI

Aesthetically attractive industrial design enabled by state-of-the-art HMI

Low Power

Operating on low power for long periods

Heat dissipation

Addressing environmental issues

Ease-of-Use

Making technology plug-and-play

Behind-the-scenes software updates

Voice commands and other simple interfaces

Integration

Making disparate technologies work together seamlessly

Cloud

Secure, scalable device management with easy on-boarding supporting major platforms or in-house servers

Monetization

Enhanced profitability through reduced support costs

Secure lifecycle management enables feature upgrade/maintenance

Proven, secure, connected, flexible, and robust: Built for the future

Wi-Fi IoT Architectures and Portfolio

Wi-Fi Product Portfolio

Wi-Fi 4 (802.11n)	Wi-Fi 5 (802.11ac)	Wi-Fi 6 (802.11ax)
43364 SB 1x1 11n SDIO	**43455** DB 1x1 11ac + BT5.0 SDIO/SPI	**Coming in 2H'21:** 2x2ax DB + BT5.2
4343W/43438 SB 1x1 11n + BT5.1 SDIO/SPI	**4373 / 4373E** DB 1x1 11ac + BT5.2 USB/SDIO/PCIe	**Coming in 2022:** 1x1ax DB + BT5.2
43439 SB 1x1 11n + BT5.2 SDIO/SPI	**54590** DB 2x2 11ac + BT 5.1 PCIe/SDIO	
43012 **ULP DB** 1x1 11n + BT5.1 SDIO/SPI WLBGA/WLCSP	**54591** DB 2x2 11ac, RSDB, BT5.1 PCIe/SDIO	
43903 SB 1x1 11n + 160-MHz R4	**54907** 1x1ac DB + 320-MHz R4	
43907 1x1 DB 11n + 320-MHz R4		

Wi-Fi +Bluetooth Combos

Infineon's Wi-Fi and Bluetooth combos use production-ready, fully-certified Wi-Fi + Bluetooth combo modules based on both Linux and RTOS based platforms. Many of the Wi-Fi + Bluetooth combos are supported on Infineon's WICED Wi-Fi and ModusToolbox Software Development Kits (SDK) which provide code examples, tools and development support **for easier and faster development.**

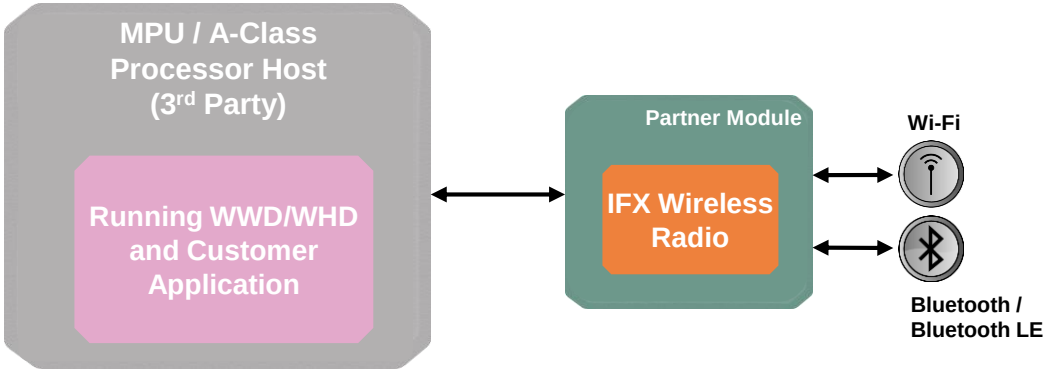
Wi-Fi

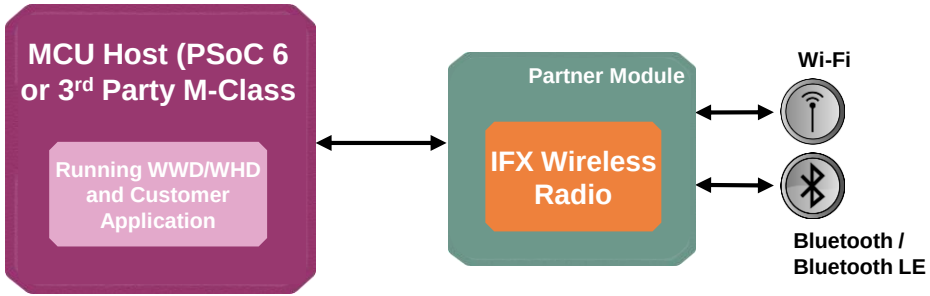
Infineon's Wi-Fi portfolio provides high-performance, flexible connectivity for Linux, Android, and RTOS. Many of the Wi-Fi + Bluetooth combos are supported on Infineon's WICED Wi-Fi and ModusToolbox Software Development Kits (SDK) which provide code examples, tools and development support.

Wi-Fi IoT Device Architectures

Architecture 1

- External Host MCU or MPU running WWD/WHD
- Radio only wireless module





Pros

- Lowest cost partner module option
- Good MCU flexibility

Cons

- Moderate design complexity
- External platform support required

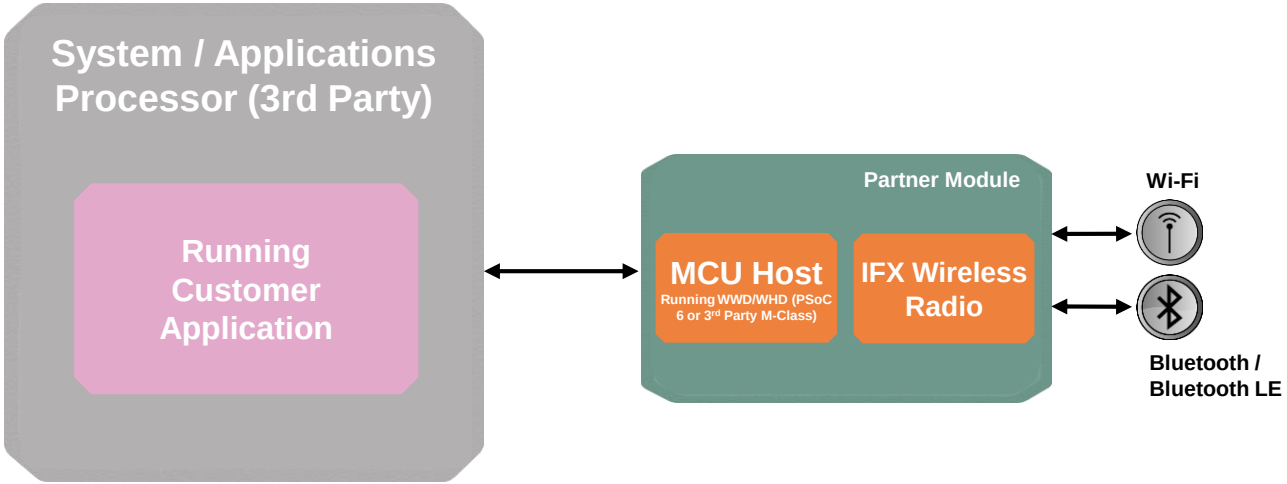
Examples

- Laird Connectivity Sterling-LWB5+ (CYW4373E)
- Murata 1LV (CYW43012)

Wi-Fi IoT Device Architectures

Architecture 2

- System/Applications Processor
- Interfacing with integrated Partner Module containing MCU Host (running WWD/WHD) + Radio



Pros

- Easiest to design in
- Good MCU flexibility

Cons

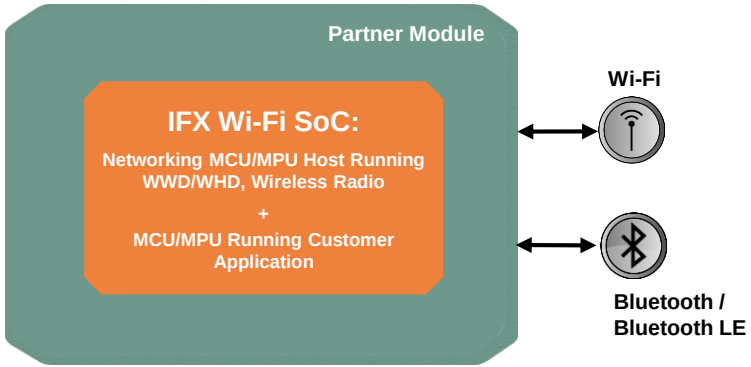
- Highest cost partner module
- Larger module footprint

Examples

- Azurewave AW-CU427 (PSoC 6 + CYW43438)
- Laird Connectivity Sterling-EWB (STM32F412 + CYW4343W)

Architecture 3

- Wireless Partner Module contains single-chip, Infineon Wi-Fi SoC that runs WWD/WHD
- Potentially could be used in Architecture 1 as well with separate



Pros

- Easy to design-in with single chip
- Low cost

Cons

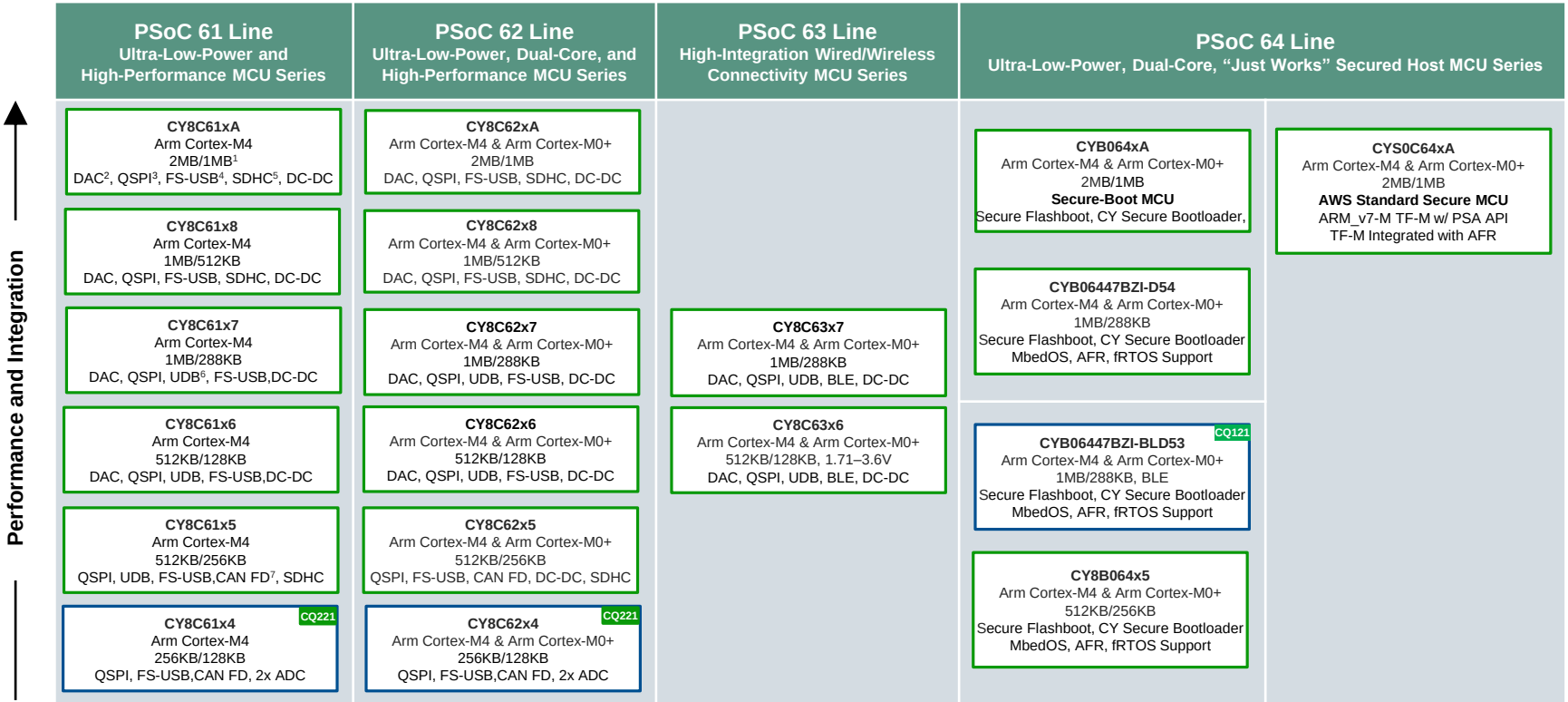
- Potentially limited interfaces and application capability

Examples

- Murata 1PS (CYW54907)
- Murata 1GC (CYW43907)

PSoC 6 MCU Portfolio

Ultra-Low-Power | Flexibility | Hardware-Based Security and Root of Trust



[1] Flash KB/SRAM KB)
[2] Digital to analog convertor
[3] Quad-SPI
[4] Full-Speed USB
[5] Secure Digital Host Controller
[6] Universal digital block – programmable logic
[7] Controller Area Network Flexible Data-Rate

CYW43012 Wi-Fi/Bluetooth Radio and PSoC 6 MCUs

ICW Wi-Fi PL Product Update:
CYW43012 – DB 1x1 11n/11ac + BT 5.2

Key Features / Value Propositions

- 802.11n and 802.11ac-friendly - MCS8 (256-QAM) for 20 MHz channels
- 802.11ac explicit beamformer support
- Best-in-class power consumption in active and power saving modes with MCU offload
- SDIO for WiFi with HCI over UART/SPI or embedded Bluetooth host stack in ROM
- Integrated IPv4/ IPv6 network stack on-chip
- Operating temperature range: -20 to +70C
- Support for both RTOS and Linux/Android (A-Class) host designs

Target Applications

- Wearables, Smart Home products and Portable Audio devices
- All Smart consumer products where maximum Battery Life is required
- IoT Edge Nodes where basic 802.11ac AP/Router compatibility is required

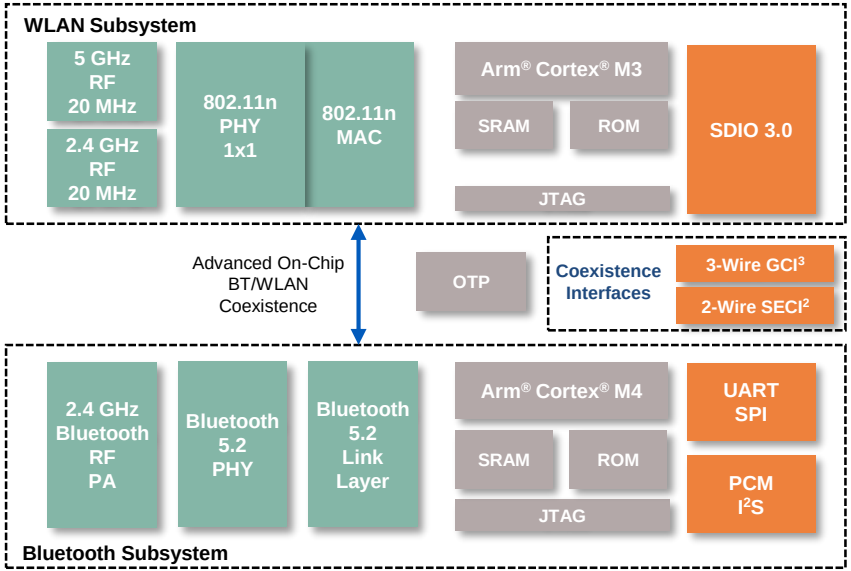
Development Kit

- IFX Kit: CY8CKIT-062S2-43012 (PSoC 62 + Murata 1LV) – Now
- IFX Kit: CYW9P62S1-43012EVB-01 (PSoC 62 + CYW43012 Integr. Module) – Now
- IFX Kit: CY8CKIT-064B0S2-43012 (PSoC 64 Secure Boot + Murata 1LV) – Now
- IFX Kit: CY8CKIT-0640S2-43012 (PSoC 64 AWS MCU + Murata 1LV) – Now
- Embedded Artist Murata 1LV M.2 Module Card (EAR00323, Linux) – Now

Module Availability Update

Azurewave (AW-AM497): Production: Now (Started Jan '21)
Murata Type 1LV (LBEE59B1LV): Production Now (Started Jan '19)

Wireless Connectivity Family | CYW43012



CYW43012 Wi-Fi/BT Radio ULP 28nm Design with Enhanced Deep Sleep

RECEIVE

50% ↓ power consumption than existing 40nm 802.11n products

70% ↓ power consumption than existing 40nm 802.11ac products

TRANSMIT

25% ↓ power consumption than existing 40nm 802.11n products

LOW POWER

80% ↓ Sleep power consumption than existing 40nm 802.11n products

50% to **60%** ↓ Idle & Ready Mode power consumption than existing 40nm 802.11n products

CYW43012 is a game-changer!

Power Consumption: CYW43012 vs Existing 40nm 11n

~50% power savings in 2.4GHz DTIM 1 & DTIM 3
~46% power savings for 2.4 GHz RX (MCS7)
~28% power savings for 2.4 GHz TX (MCS7)

		CYW4343W			CYW43012		
		VBAT (3.6 V) mA	VDDIO (1.8 V) µA	Total Power Consumption from Battery (mW)**	VBAT (3.6 V) mA	VDDIO (1.8 V) µA	Total Power Consumption from Battery (mW)**
	Radio Off	0.0035	0.08	0.013	0.0012	0.3	0.005
	SLEEP, IEEE Power Save, Inter Beacon	0.0058	80	0.181	0.003	88.0	0.187
	2.4GHz DTIM 1	1.05	74	3.928	0.447	93.0	1.795
	2.4GHz DTIM 3	0.35	86	1.432	0.156	88.0	0.738
WLAN 2.4G	Rx MCS7 HT20	41	12	140.4	21	375	76.350
WLAN 2.4G	Tx MCS7 HT20 18dBM	260 (15 dBm)	15	936.0	187	1400	676.000
WLAN 5G	Rx MCS7 HT20	—	—	—	21.5	770	78.940
WLAN 5G	Tx MCS7 HT20 18dBM	—	—	—	265	1600	957.200

**Assuming 3.6V VBAT direct from battery and 1.8V VIO from a 90% efficiency external buck connected to 3.6V battery

ICW MCU PL Product Update: PSoC 6-2MB (CY8C62xA)

Key Features / Value Propositions

- High-performance PSoC 6 device ideal as an IoT Host MCU. Large on-chip memory (2048 KB Flash, 1024 KB SRAM) with dual core CPU for running Edge Compute + Secure + Cloud connected applications
- Features 2 Secure Digital Host Controllers that can be configured as a SDIO interface to be used with Infineon Wi-Fi/Bluetooth Combo Radios (CYW4343W/8, CYW43012 currently with more coming)
- Industry leading CapSense as well as Dedicated Audio processing hardware blocks
- Up to 102 GPIOs. 16 Smart I/Os to integrate external digital logic.

Target Applications

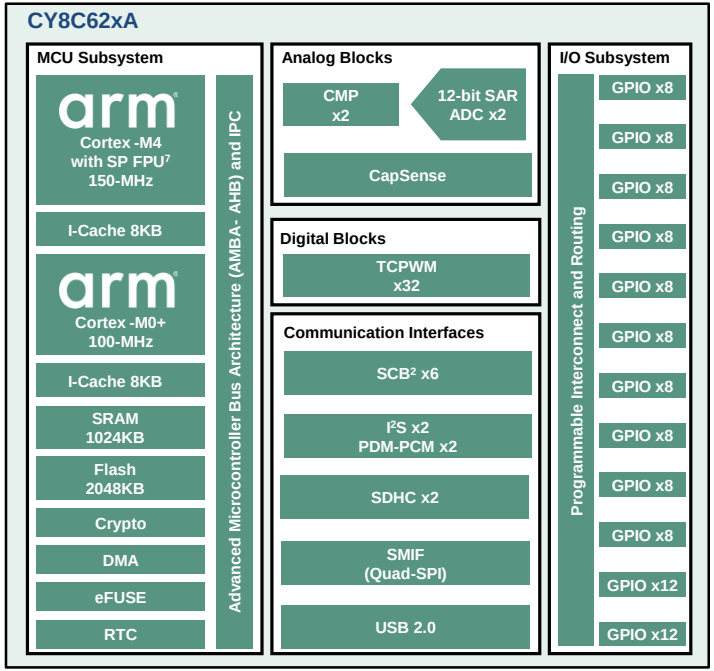
- Smart Home, Wearables, IoT Gateways
- Home Appliance HMIs, Audio Processing,
- Potential applications where Wi-Fi and Sensor Fusion and/or ML is required

Development Kit

- PSoC 62 + CYW43012 Pioneer Kit (CY8CKIT-062S2-43012)
  - Arduino compatible headers – connect to sensors, graphics shields
  - CapSense touch buttons and slider
  - External Excelon F-RAM nonvolatile memory
  - PSoC 62 hosts the low power CYW43012 radio in the Murata 1LV module

Availability Update

Silicon Production: Now → (started April '20) **Kit Production:** Now → (started 2019**)**



PSoC 6: Purpose-Built for the IoT

Emerging IoT devices require increased processing and security without a power or cost penalty

Infineon's PSoC 6 portfolio bridges the gap between application processors and standard microcontrollers

- 150-MHz and 100-MHz dual-core Arm® Cortex®-M4 and Arm Cortex®-M0+ ultra-low-power 40-nm architecture
- Industry-leading ultra-low-power design that consumes as little as 22-µA/MHz in active power mode[1]
- Best-in-class flexibility with wired and wireless connectivity options, software defined peripherals and industry-leading CapSense®
- Integrated, hardware-based Trusted Execution Environment (TEE) with secure data storage

*Linked terms are defined in the Glossary

[1] Power specifications are based on the Arm Cortex®-M4 CPU

PSoC 6: Ultra-Low-Power IoT Solution

Power Mode	Current Consumption	Code Execution	Digital Peripherals Available	Analog Peripherals Available	Clock Sources Available	Wake-Up Sources	Wake-Up Time
Active (M4)	5.82-mA @ 150-MHz (LP[1]) 1.43-mA @ 50-MHz (ULP[2])	Yes	All	All	All	-	-
Active (M0+)	3.43-mA @ 100-MHz (LP) 0.75-mA @ 25-MHz (ULP)	Yes	All	All	All	-	-
Low-Power Active (M4)	380-µA @ 8-MHz	Yes	All	All	8-MHz IMO[3]	-	-
Deep-Sleep	7.0-µA	No	WDT[4], SCB[5]	Comparator, POR[6], BOD[7]	32-kHz ILO[8]	Comparator, GPIO, WDT, DS-SCB	10-µs, 100-µs[9]
Hibernate	300-nA	No	No	Comparator, POR	No	Comparator, GPIO, RTC	500-µs

The PSoC 6 MCU Architecture[10] reduces energy consumption without sacrificing performance with:

- Dynamic voltage and frequency scaling enabling both performance- and power-critical processing
- A dual-core architecture, where the Cortex®-M0+ can be used as an offload engine for power efficiency, allowing the main Cortex®-M4 core to sleep
- An ultra-low-power system, where the Cortex®-M4 consumes 22-µA/MHz and the Cortex®-M0+ consumes 15-µA/MHz

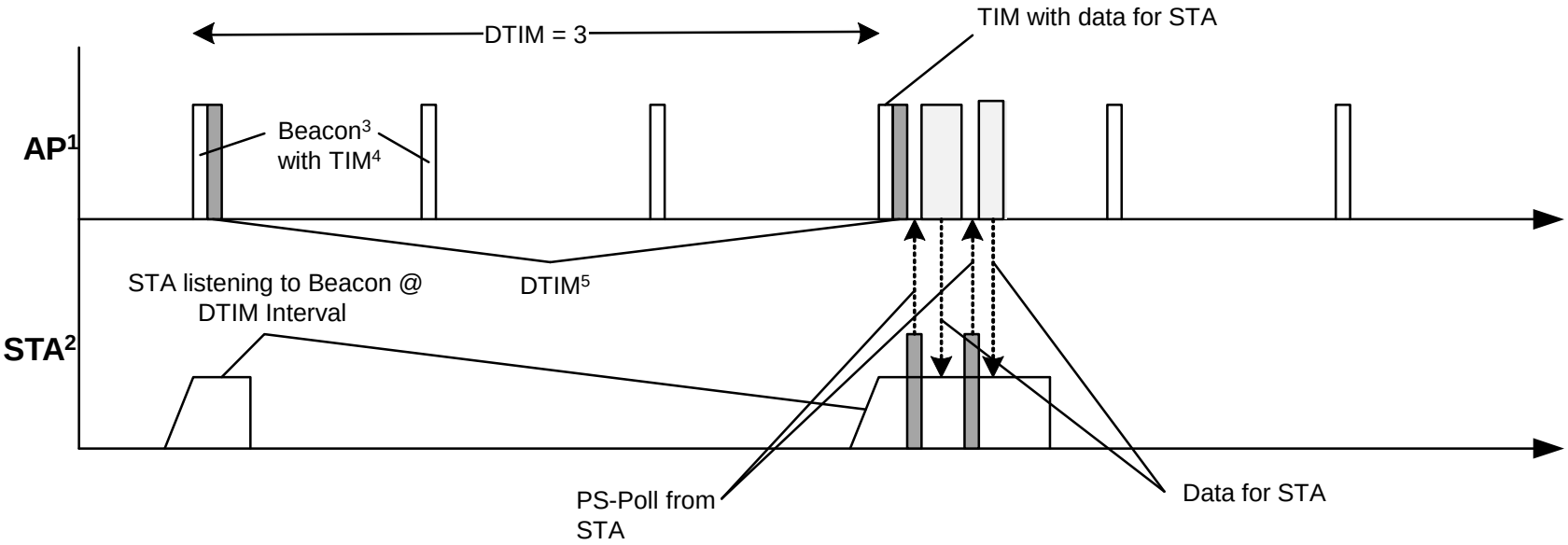
PSoC 6 sets a new, industry-leading low-power benchmark for today's IoT devices

[1] Low-power active mode (1.1-V operation)
[2] Ultra-low-power active mode (0.9-V operation)
[3] Internal main oscillator
[4] Watchdog timer serial communications block
[5] Serial communications block
[6] Power-on-reset
[7] Brownout detect
[8] Internal low-speed oscillator
[9] Low-power active and active modes, respectively
[10] Built on a 40-nm ultra-low-power process, providing the lowest power, most flexibility, and most secure architecture for the IoT

Power Optimization Techniques

Wi-Fi: IEEE 802.11 Power Save

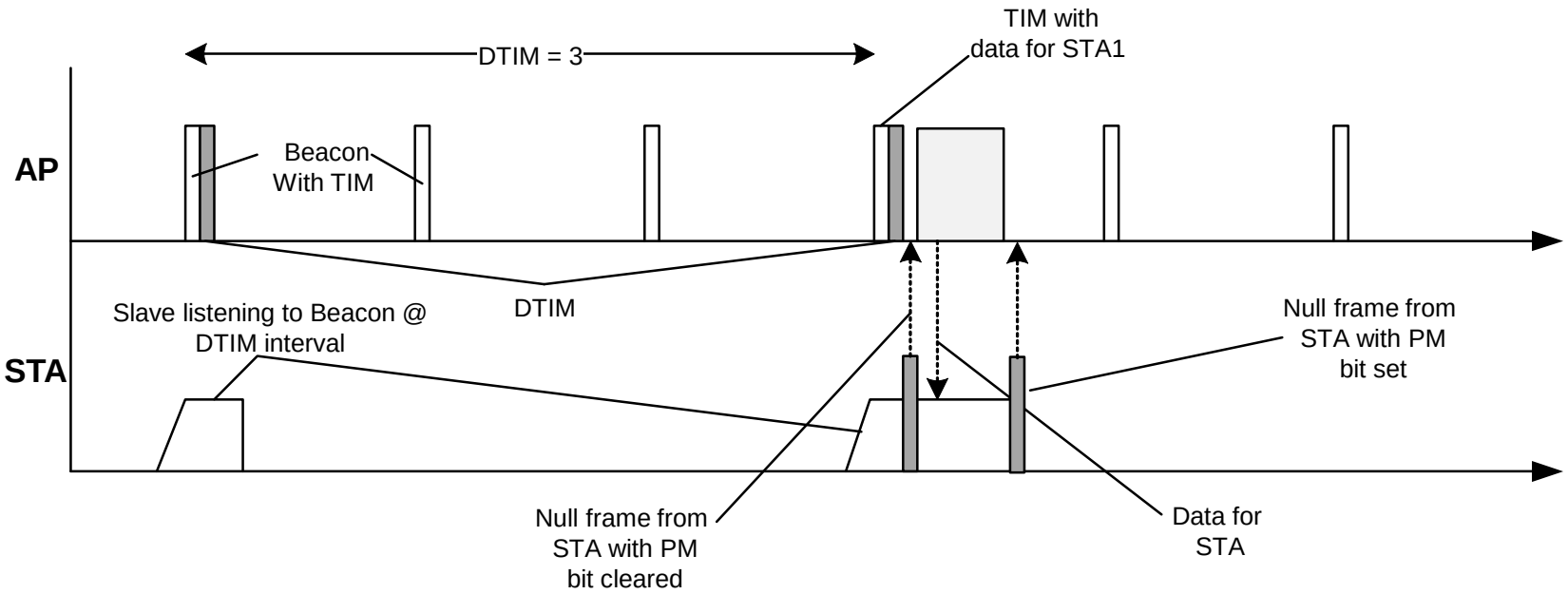
› Power Save with Poll (PS-Poll)



[1] Access Point provides infrastructure for other Wi-Fi devices to connect to a wired network
[2] Station is any device capable of using Wi-Fi protocol
[3] Beacon is a periodic frame (102.4 ms) transmitted by the AP broadcasting the network capabilities and traffic information
[4] Traffic Indication Map in a beacon frame indicates whether a station has data buffered for it or not
[5] Delivery TIM in a beacon frame indicates whether the presence of multicast or broadcast data for the STAs in the network

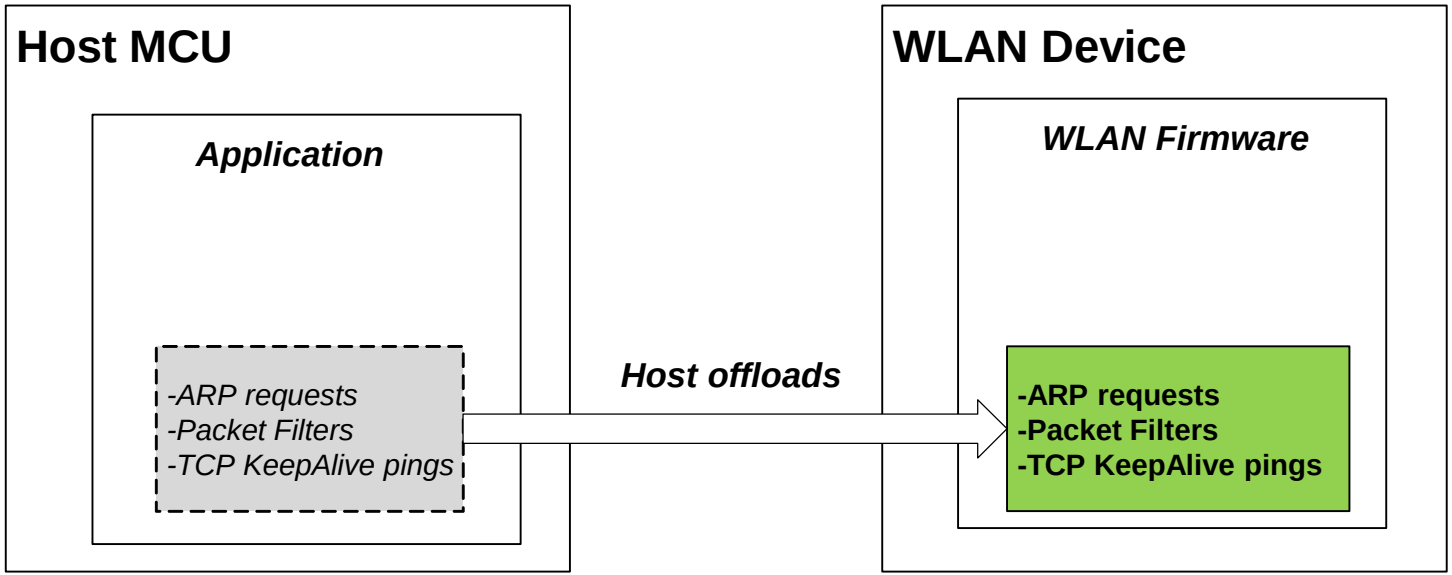
Wi-Fi: IEEE 802.11 Power Save

› Power Save without Poll



Wi-Fi: Host offloads

› Functionalities executed by WLAN device (CYW43012) on behalf of host

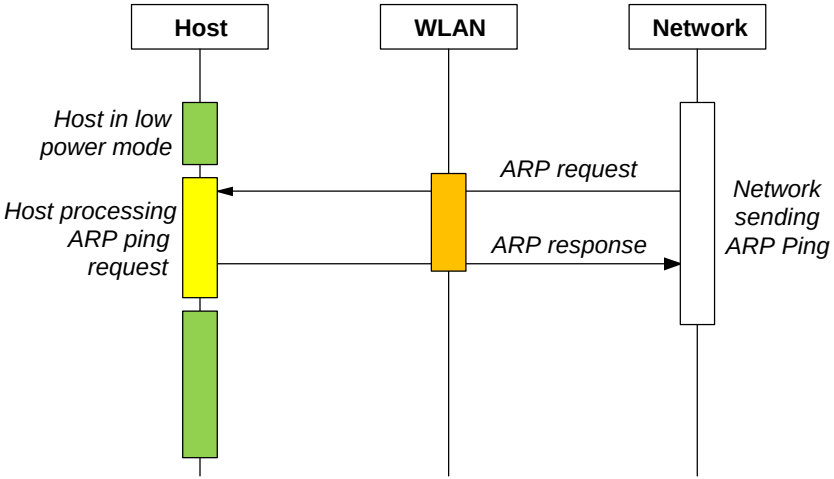


✓ **More time for Host in low-power mode**

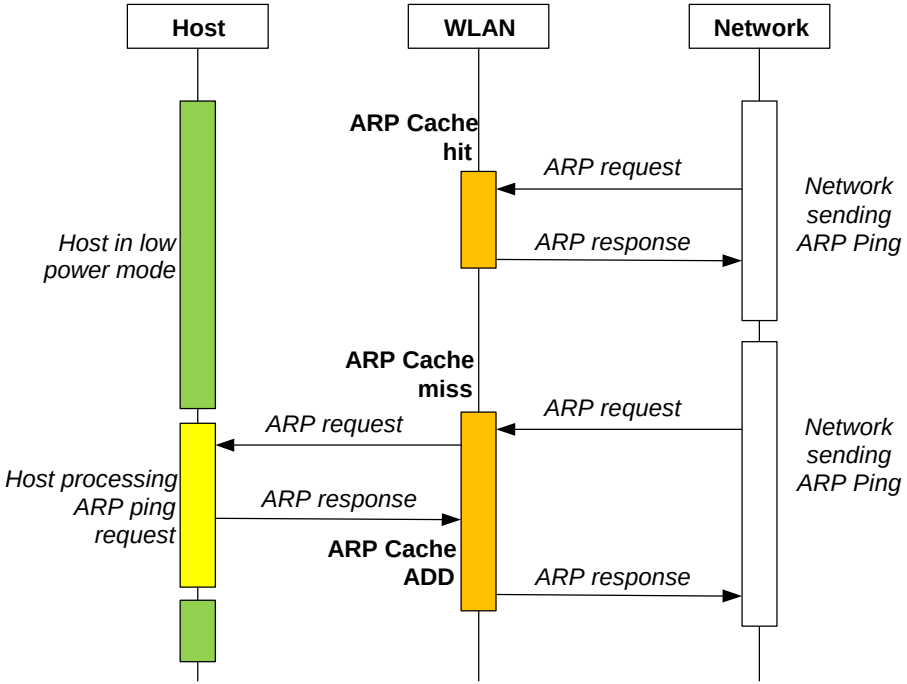
Wi-Fi: ARP offload

› **Address Resolution Protocol (ARP)** – Maps device IP address to its MAC address

ARP Ping without offload



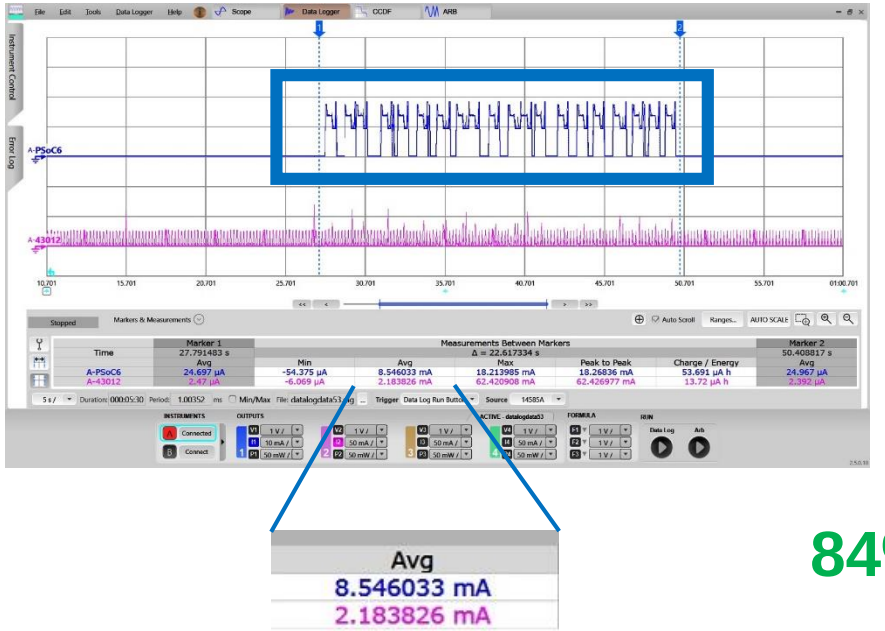
ARP Ping with offload



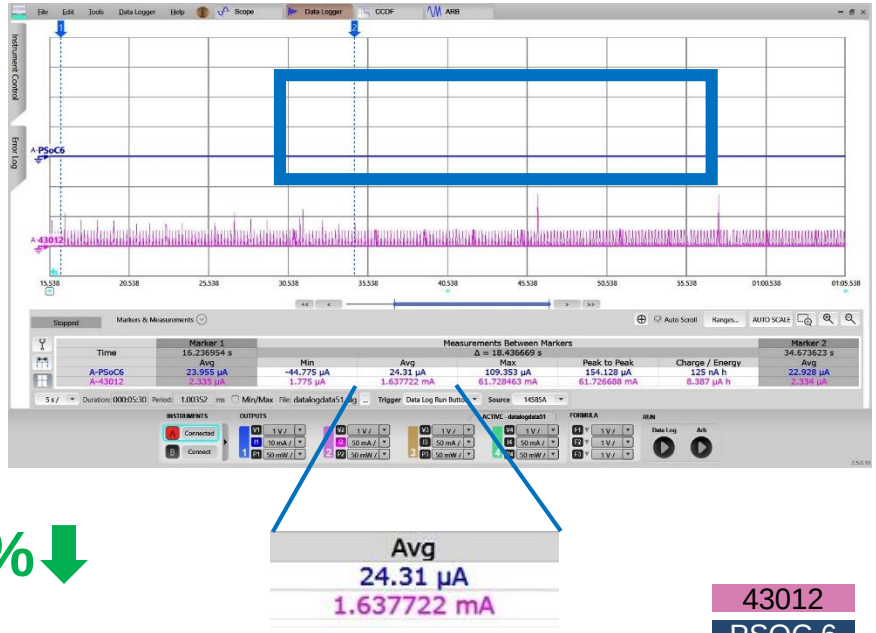
Wi-Fi: ARP offload

› ARP Offload

ARP Ping without offload



ARP Ping with offload

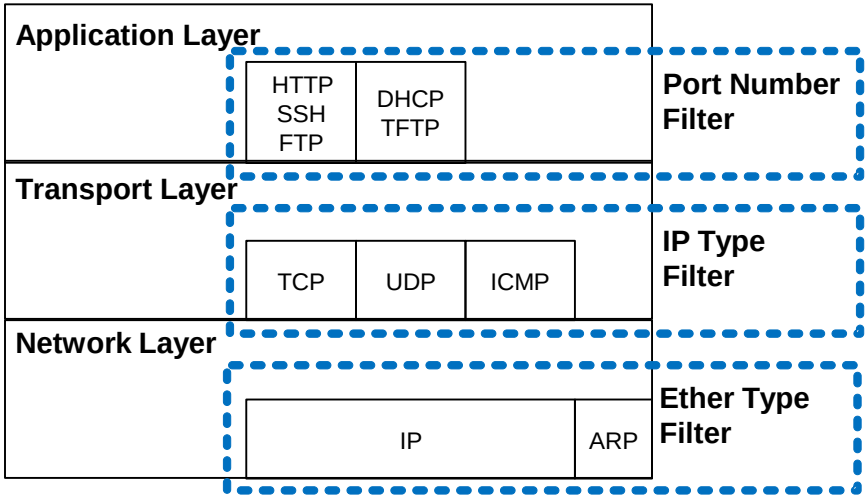


84%⬇

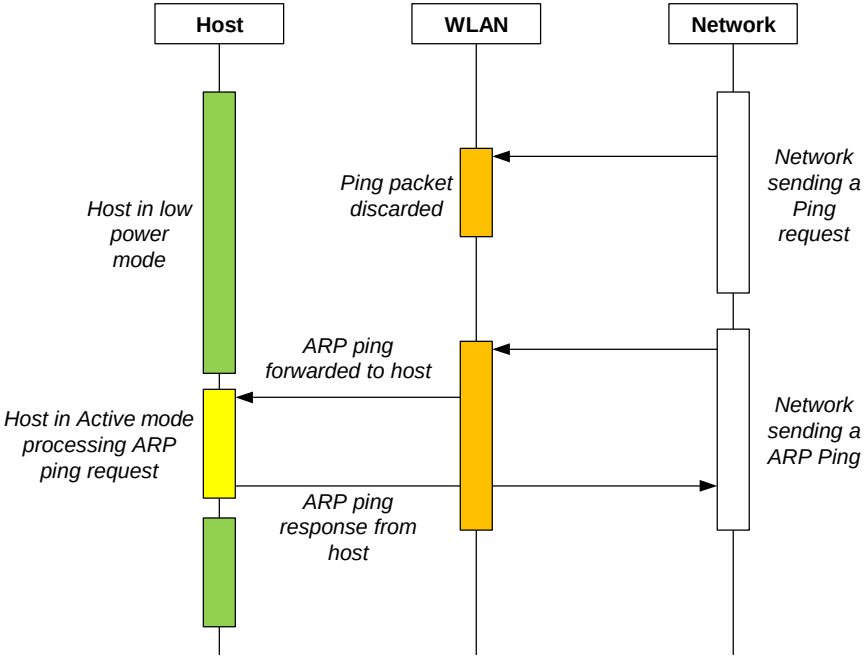
43012
PSOC 6

Wi-Fi: Packet Filter Offload

› **Packet Filter** – Block unwanted network traffic



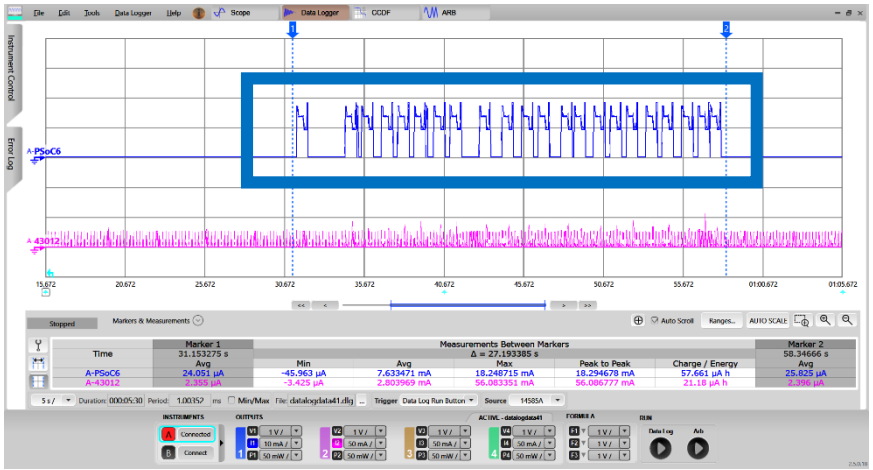
Offload with discard filter for Ping packets



Wi-Fi: Packet Filter offload

› Packet Filter – with minimal filters enabled (DHCP, ARP, 802.11x, DNS)

ARP Ping from Network



Host wakes up to service the request

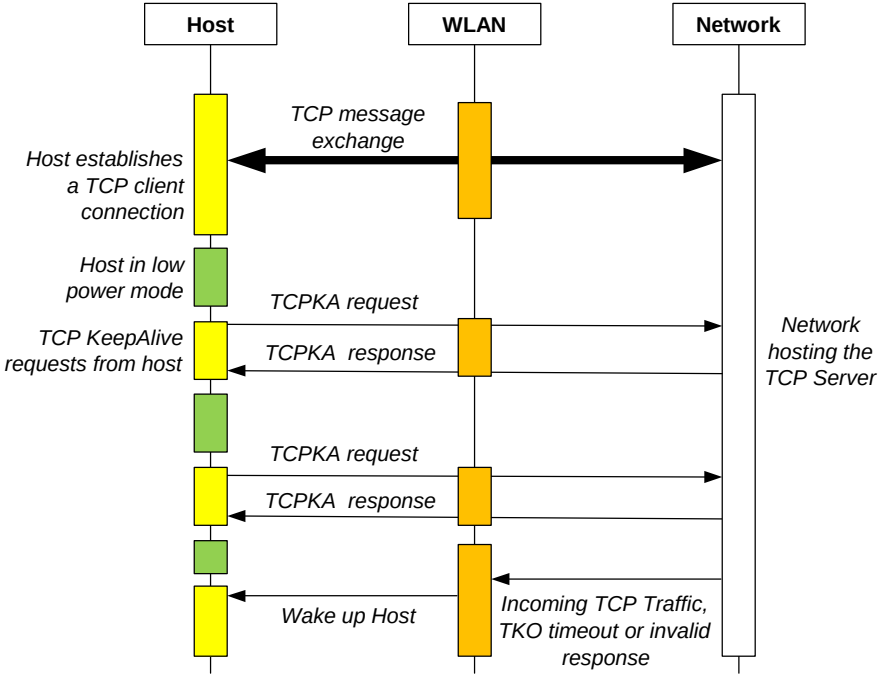
74%⬇

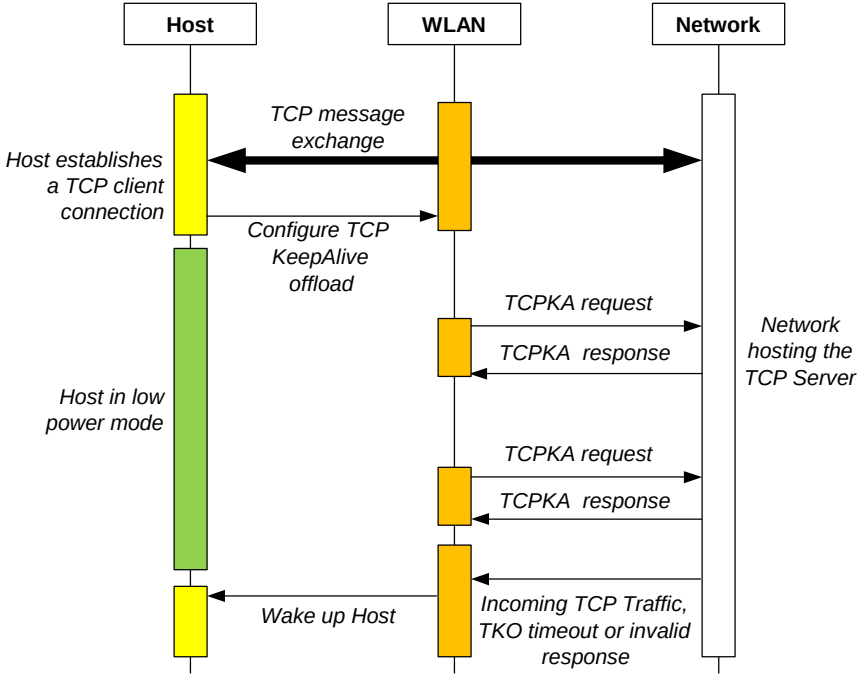
Ping (ICMP) from Network

Host does not wake up during ping requests

Wi-Fi: TCP Keep Alive

› **TCP Keep Alive** – Maintain active TCP connection without interrupting the host





LPA: Performance Data

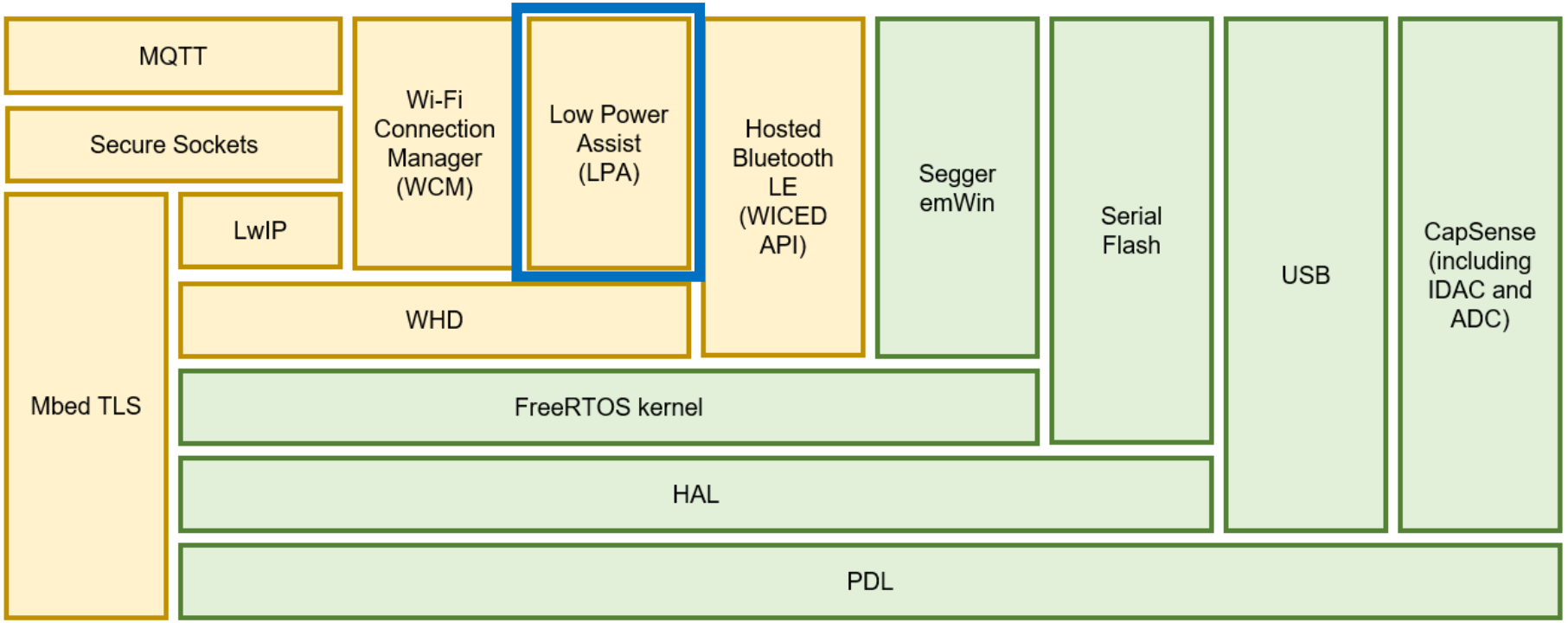
LPA Feature	Description[1]	Power consumption	
		Without LPA	With LPA
Wi-Fi ARP offload	Enable host wake, Enable ARP offload and Suspend network stack	10.6 mA	**1.6 mA (84%)**
Wi-Fi Packet Filter Offload	Enable host wake and minimal set of filters – ARP, DNS, DHCP, 802.11x security – to establish a Wi-Fi connection	7.7 mA	**2.0 mA (74%)**
Wi-Fi TCP Keep Alive Offload	Enable host wake and TCP KeepAlive Offload with a Keep Alive interval of 3 seconds	19.5 mA	**3.3 mA (83%)**

[1] All use mbed-os-example-wifi code example for adding the particular LPA feature

AWS IoT example – 80%

Low Power Assistant

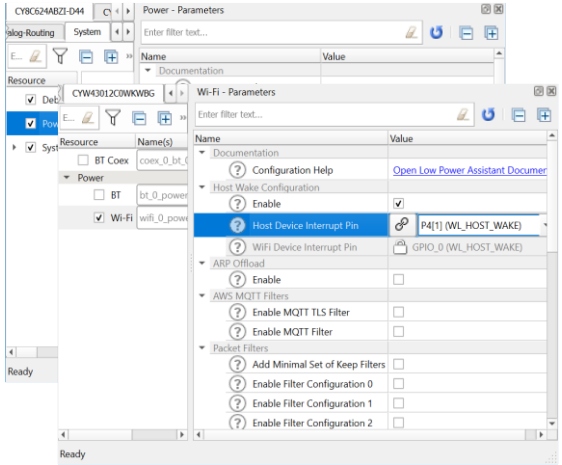
ModusToolbox® AnyCloud Stack



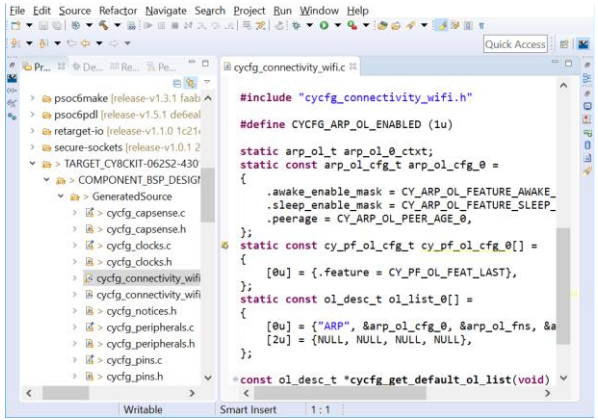
LPA: Overview

- Self-aware firmware that detects configurations automatically and enables appropriate low-power features without any additional API calls from the user
- Supports multiple platforms such as Mbed OS and FreeRTOS (AnyCloud)
- GUI-based configuration for ease of use
- Supports low-power configuration for PSoC 6 MCU, Wi-Fi and BT

Using ModusToolbox Configurator



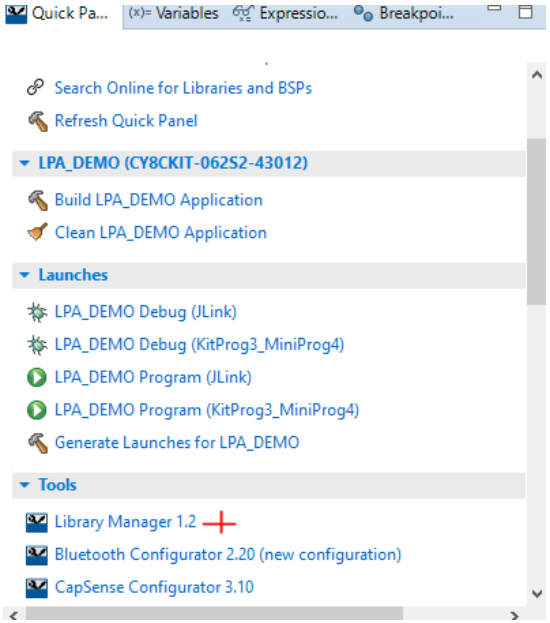
Using Code

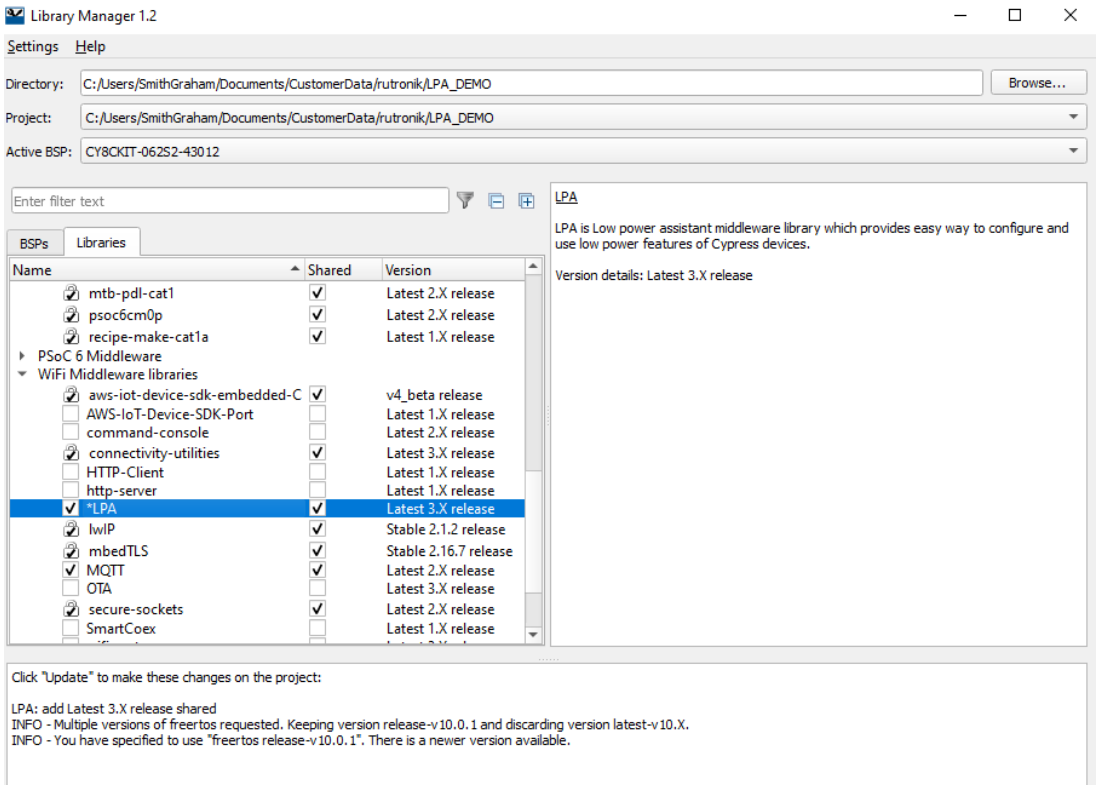


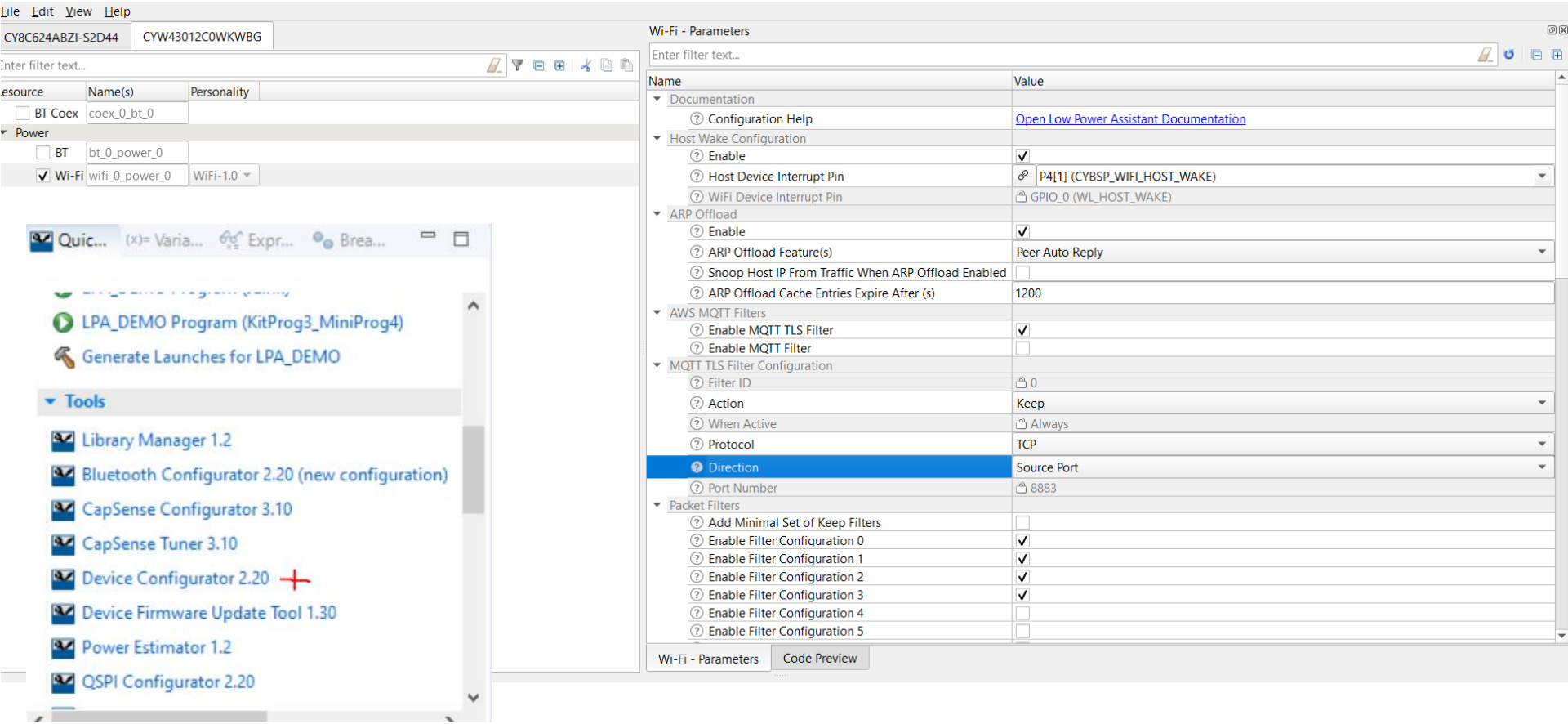
LPA: Features

- Supported features –
  - MCU Low Power
  - Wi-Fi and Bluetooth Low Power
  - Wi-Fi Address Resolution Protocol (ARP) Offload
  - Wi-Fi Packet Filter Offload
  - Wi-Fi TCP Keepalive Offload
- AnyCloud 1.0 support and later
  - LPA v2.0.0 and ModusToolbox 2.1 and later
- Mbed OS support
  - LPA v1.0.0 and Mbed OS 5.14.2 or later
- Provides Quick Start Guide for features supported

LPA Walkthrough Demo


Quick Pa...
(x)= Variables
Expressio...
Breakpoi...
Search Online for Libraries and BSPs
Refresh Quick Panel
LPA_DEMO (CY8CKIT-062S2-43012)
Build LPA_DEMO Application
Clean LPA_DEMO Application
Launches
LPA_DEMO Debug (JLink)
LPA_DEMO Debug (KitProg3_MiniProg4)
LPA_DEMO Program (JLink)
LPA_DEMO Program (KitProg3_MiniProg4)
Generate Launches for LPA_DEMO
Tools
Library Manager 1.2
Bluetooth Configurator 2.20 (new configuration)
CapSense Configurator 3.10


Library Manager 1.2
Settings
Help
Directory:
C:/Users/SmithGraham/Documents/CustomerData/rutronik/LPA_DEMO
Browse...
Project:
C:/Users/SmithGraham/Documents/CustomerData/rutronik/LPA_DEMO
Active BSP:
CY8CKIT-062S2-43012
Enter filter text
BSPs
Libraries
Name
Shared
Version
mtb-pdl-cat1
Latest 2.X release
psoc6cm0p
Latest 2.X release
recipe-make-cat1a
Latest 1.X release
PSoC 6 Middleware
WiFi Middleware libraries
aws-iot-device-sdk-embedded-C
v4_beta release
AWS-IoT-Device-SDK-Port
Latest 1.X release
command-console
Latest 2.X release
connectivity-utilities
Latest 3.X release
HTTP-Client
Latest 1.X release
http-server
Latest 1.X release
*LPA
Latest 3.X release
lwIP
Stable 2.1.2 release
mbedTLS
Stable 2.16.7 release
MQTT
Latest 2.X release
OTA
Latest 3.X release
secure-sockets
Latest 2.X release
SmartCoex
Latest 1.X release
LPA
LPA is Low power assistant middleware library which provides easy way to configure and use low power features of Cypress devices.
Version details: Latest 3.X release
Click "Update" to make these changes on the project:
LPA: add Latest 3.X release shared
INFO - Multiple versions of freertos requested. Keeping version release-v10.0.1 and discarding version latest-v10.X.
INFO - You have specified to use "freertos release-v10.0.1". There is a newer version available.



Getting Started

+

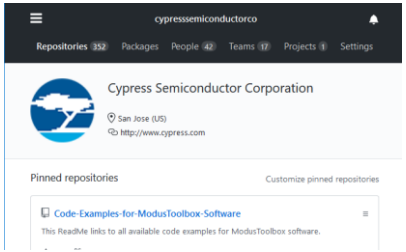
+ AnyCloud Stack – LPA, MQTT..

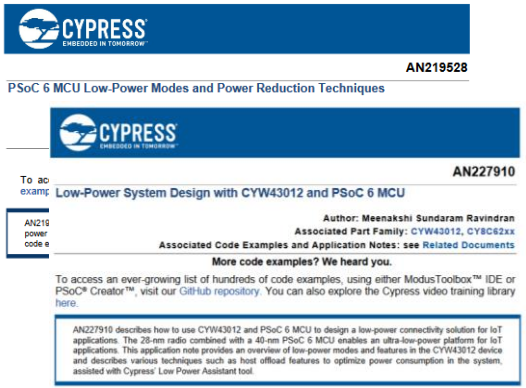
+ Code Examples

+ Design Application Notes

Murata Type 1LV module

PSoC® 62S2 Wi-Fi BT Pioneer Kit





Resources

Action	Link
Download the App Note	Low Power System Design with CYW43012 and PSoC 6 MCU
Learn About the Products	PSoC 6 MCU CYW43012 Wi-Fi/Bluetooth Radio IoT-AdvantEdge: Power Efficient Solutions Page
Get the Software	ModusToolbox 2.2 Software Environment Low Power Assistant Library
Download Code Examples	AnyCloud LPA examples Mbed OS LPA examples
Join the Infineon Community	Community home page

Q&A

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