采用低功耗助手(LPA)技术的英飞凌CYW43012 Wi-Fi蓝牙组合芯片和 PSoC 62 MCU 打造超低功耗的IoT系统设计

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Ultra Low Power IoT System Design with Infineon CYW43012 Wi-Fi BT Combo and PSoC 62 MCU using Low Power Assistant Technique

Presented by: Harris Chan

Agenda

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

CYW43012 Wi-Fi/Bluetooth Radio and PSoC 6 MCUs

CYW43012

§ Ultra-Lower Power 11n/11ac-Friendly™ Dual-Band Wi-Fi and Bluetooth 5.0 for IoT

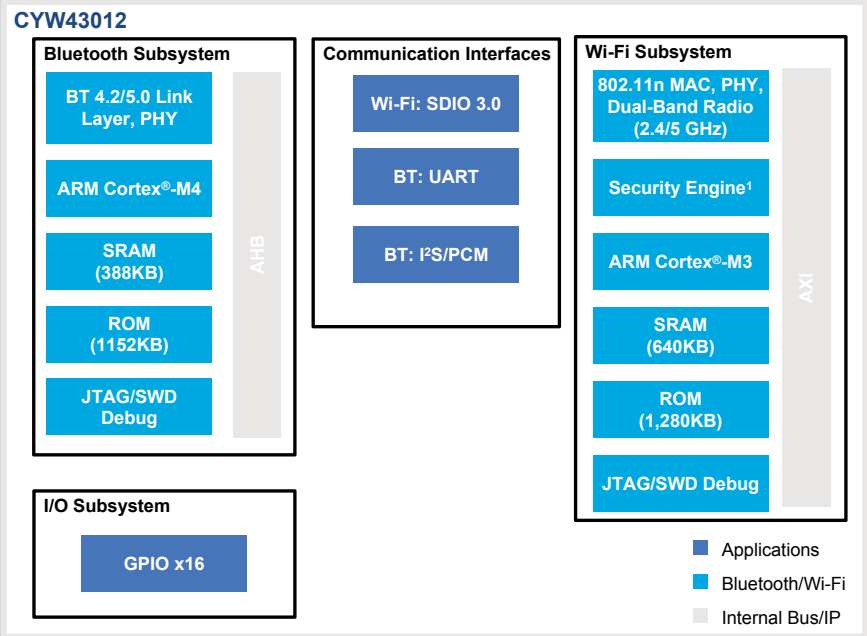
Applications

Ultra-low power applications especially battery powered

Features

- **Ultra-Low-Power Wi-Fi and Bluetooth Combo**
- **802.11n-compliant Wi-Fi**
  - Industry's most widely deployed Wi-Fi IP
  - Up to 72.2-Mbps data rate
  - Dual band (2.4/5 GHz) with on-chip power amplifiers and low-noise amplifiers for both bands
  - SDIO 3.0 interface (up to 50 MBps)
- **Low-power 802.11ac compliance in 5 GHz**
  - 256-QAM support on 20-MHz channels in the 5-GHz band
  - MCS8 enables up to 78-Mbps data rate
- **Bluetooth 5.0 Compliant**
  - All Bluetooth 4.2 optional features and Bluetooth 5.0 2-Mbps LE data rate
  - Class 1 (100 m) and Class 2 (10 m) operation
  - Host controller interface (HCI)-over-UART
- **Packages**
  - WLBGA, WLCSP, FCBGA

CYW43012: 802.11n Dual-Band Wi-Fi and BT 5.0 Ready Combo



Collateral

Datasheet: CYW43012 Available on Web

Software: Available

Availability

Samples: Now **Production:** Now

[1] WPA, WAPI STA, WPA2, AES, TKIP security features

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

RECEIVE

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

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

TRANSMIT

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

LOW POWER

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

50% to **60%** ê 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

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

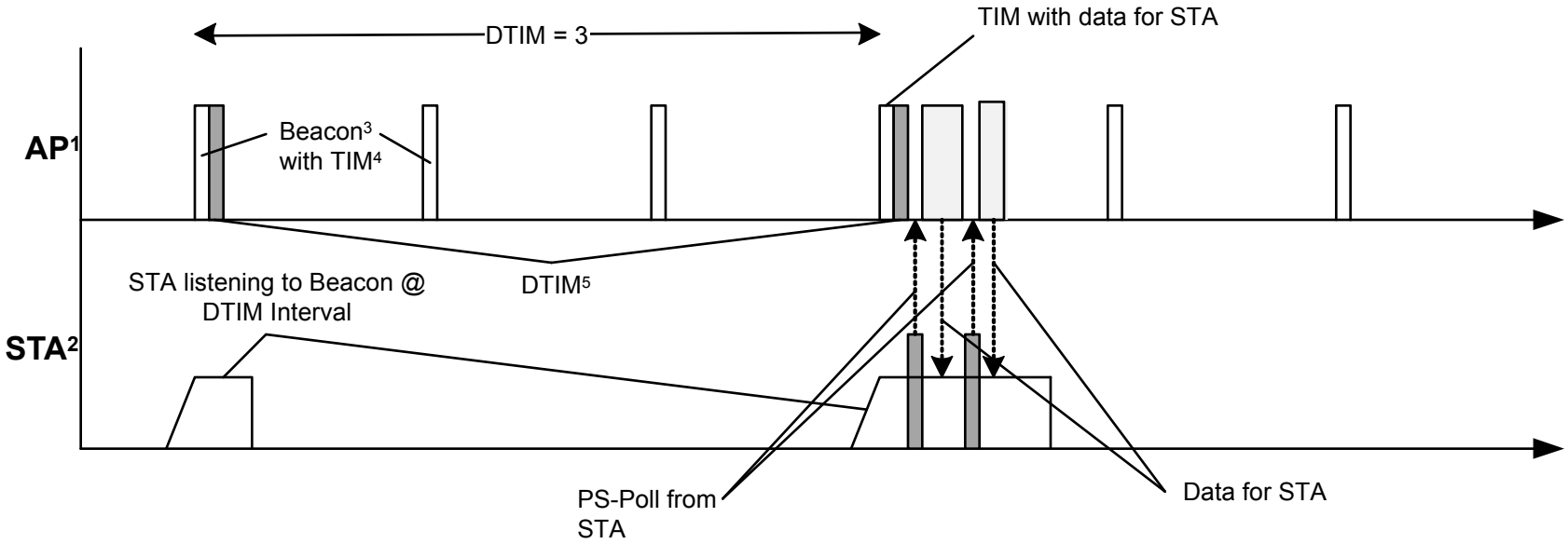
PSoC 6 sets a new, industry-leading low-power benchmark for today's IoT devices

[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

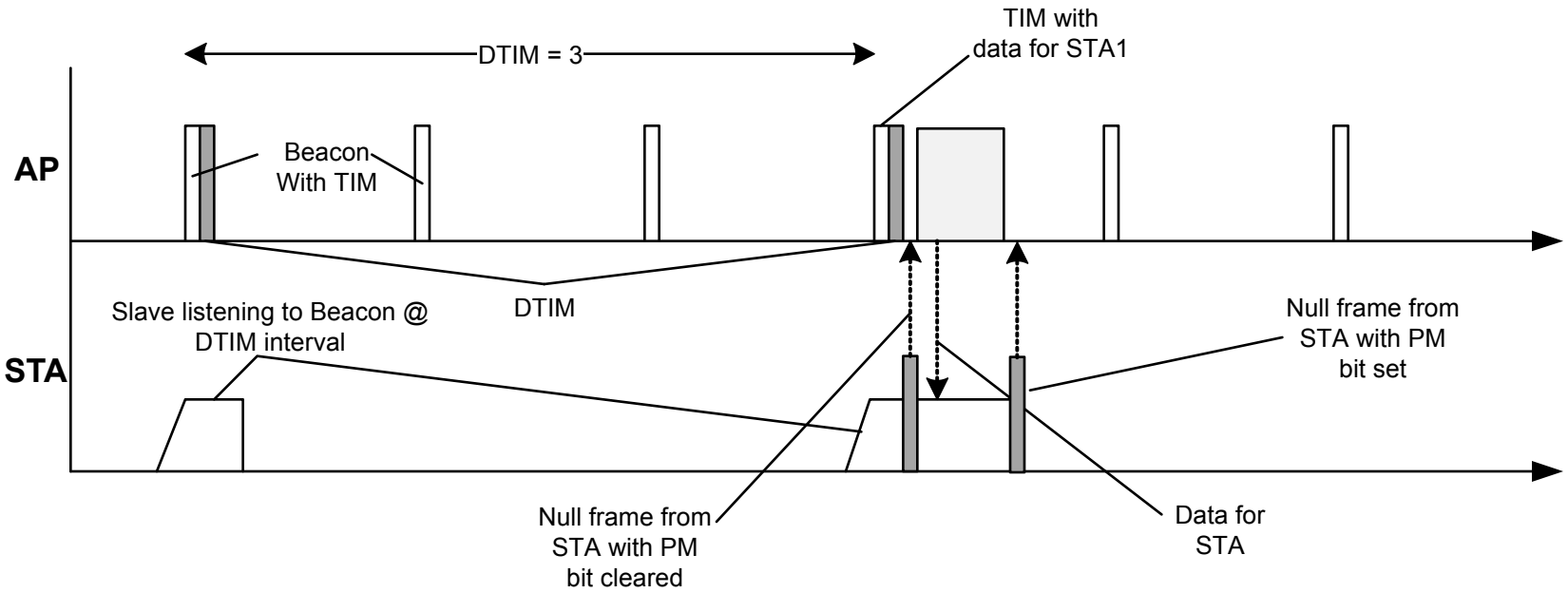
› Power Save with Poll (PS-Poll)



[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

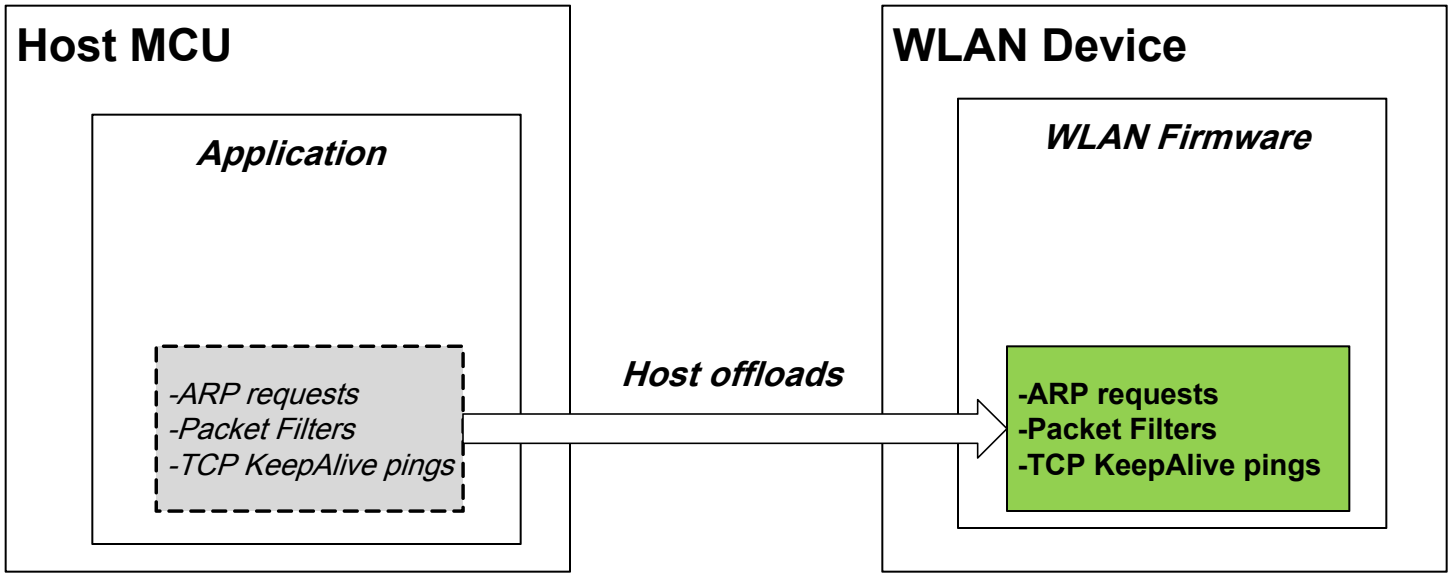
Wi-Fi: IEEE 802.11 Power Save

› Power Save without Poll



Wi-Fi: Host offloads

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

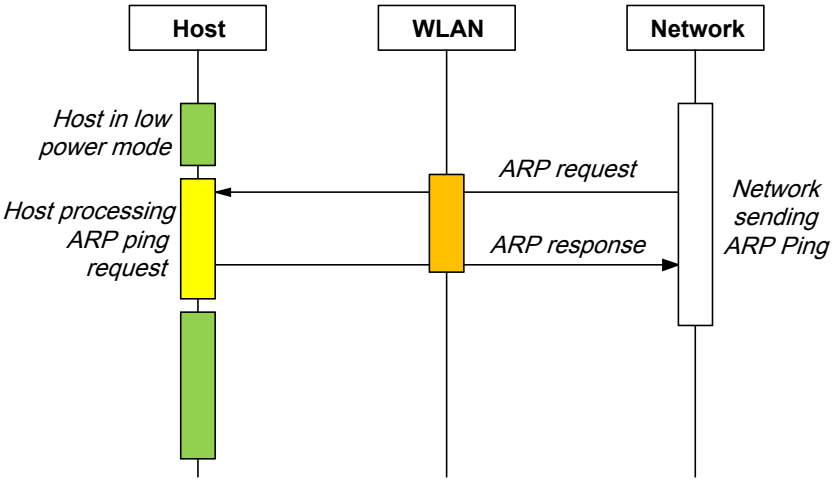


ü **More time for Host in low-power mode**

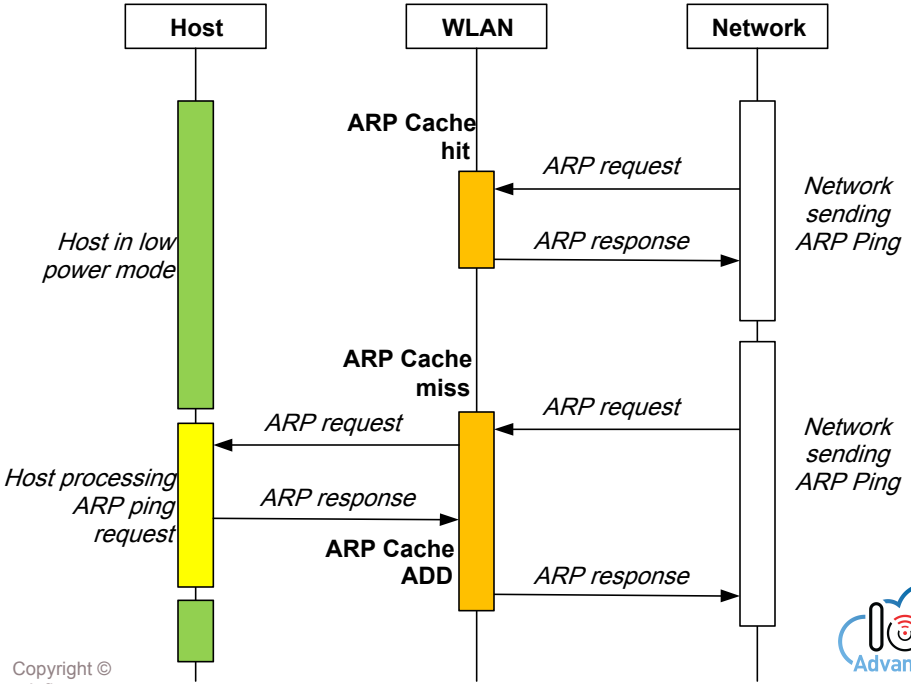
Wi-Fi: ARP offload

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

ARP Ping without offload



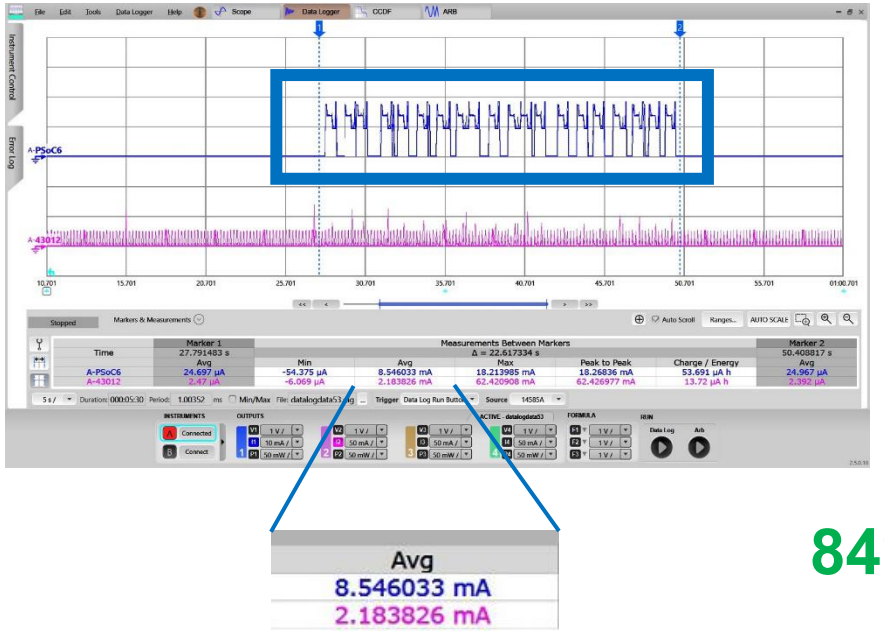
ARP Ping with offload



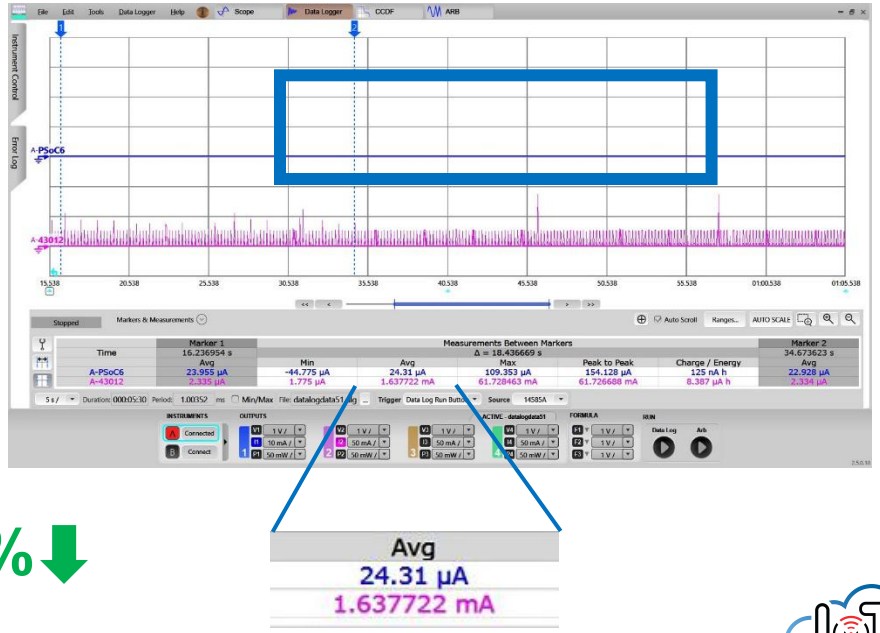
Wi-Fi: ARP offload

› ARP Offload

ARP Ping without offload



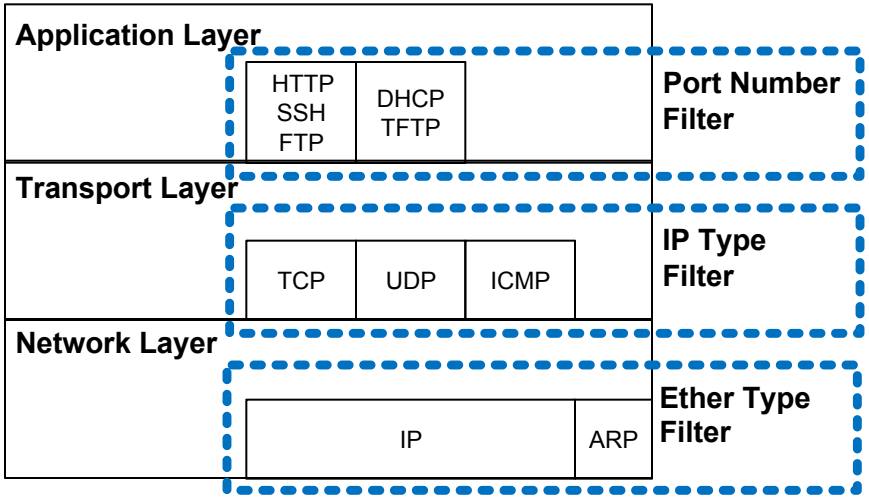
ARP Ping with offload



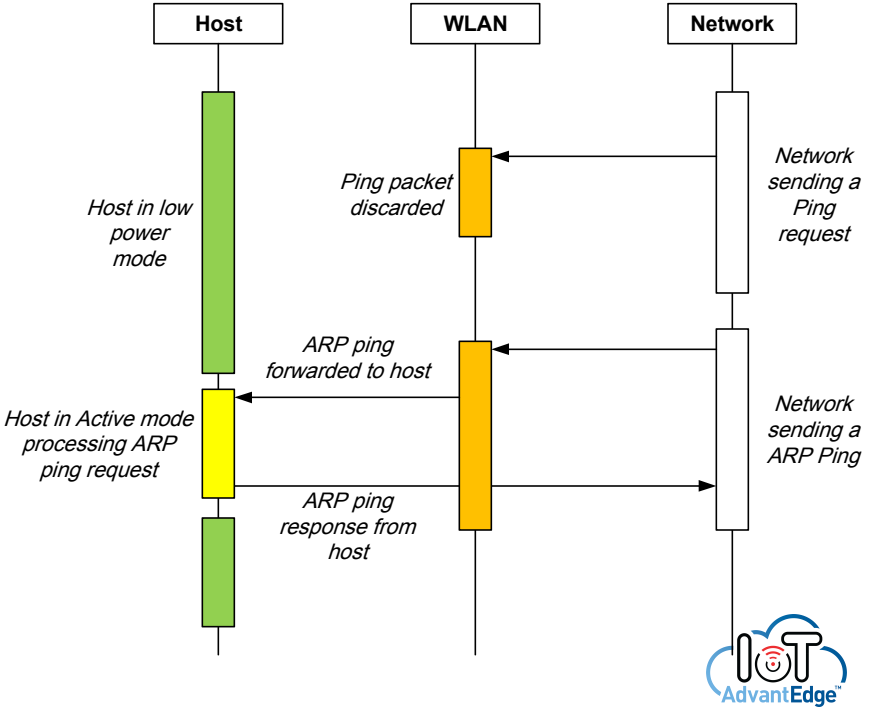
84%⬇

Wi-Fi: Packet Filter Offload

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



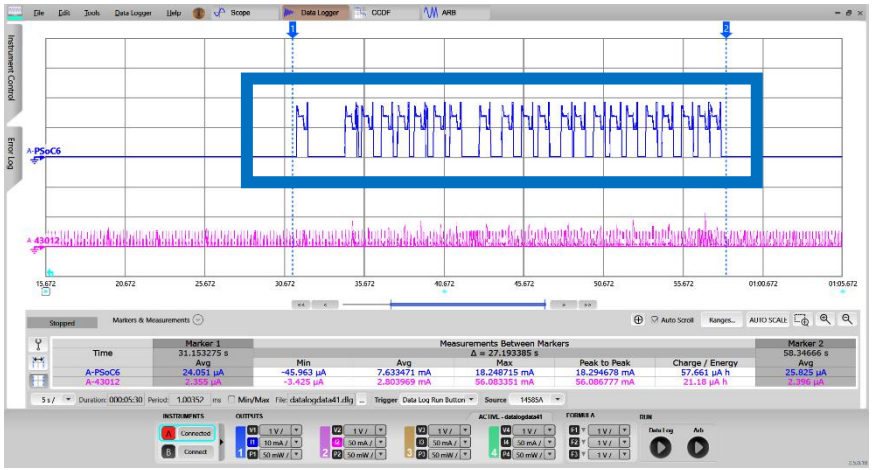
Offload with discard filter for Ping packets



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

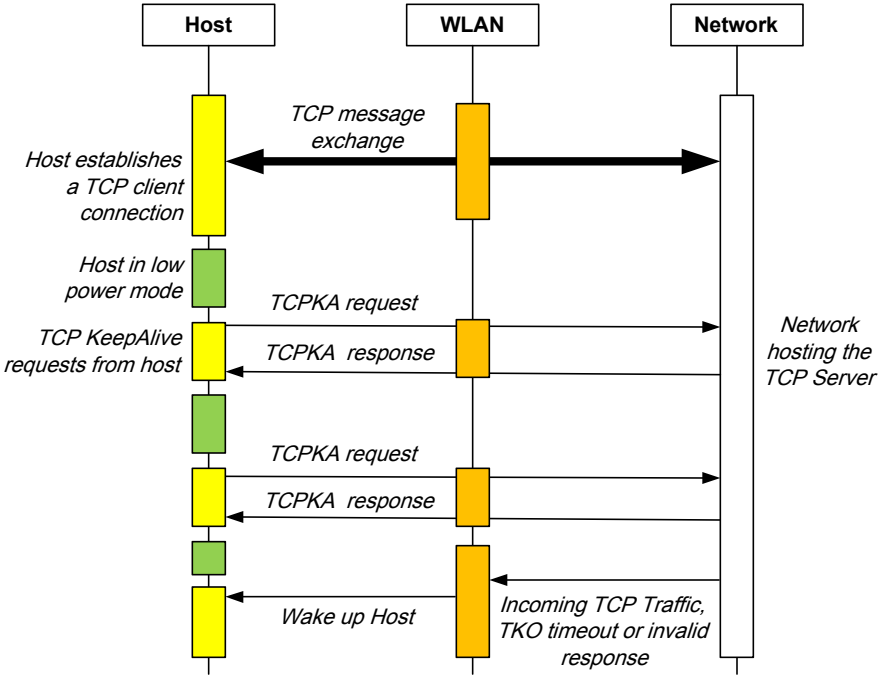
74%⬇

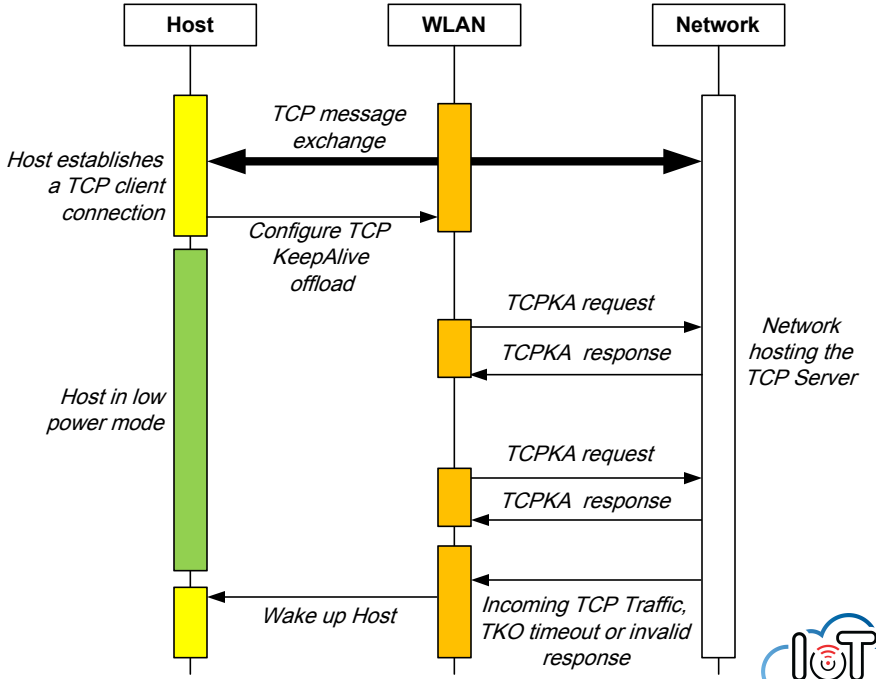
Ping (ICMP) from Network

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

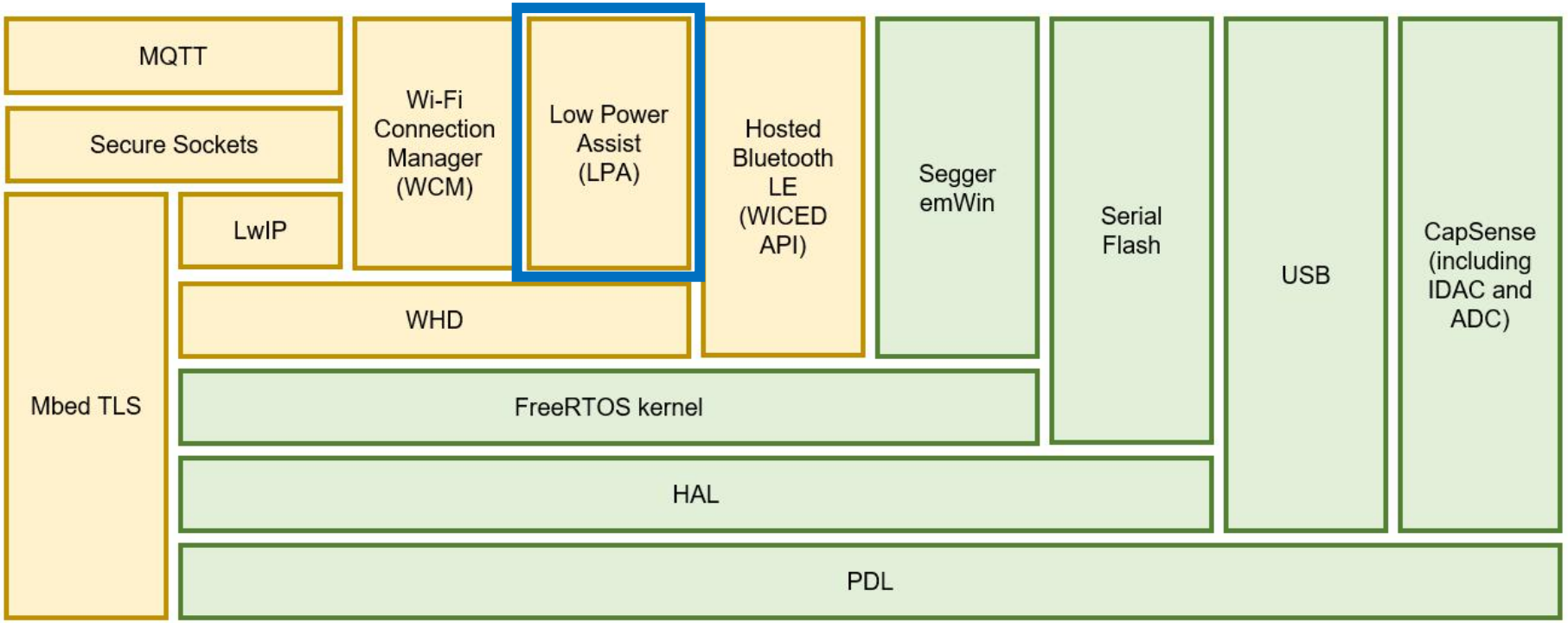
LPA Feature	Description[1]	Power consumption	
		Without LPA	With LPA
Wi-Fi ARP offload	Enable host wake, Enable ARP offload and Suspend network stack	10.6 mA	1.6 mA (84%)
Wi-Fi Packet Filter Offload	Enable host wake and minimal set of filters – ARP, DNS, DHCP, 802.11x security – to establish a Wi-Fi 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

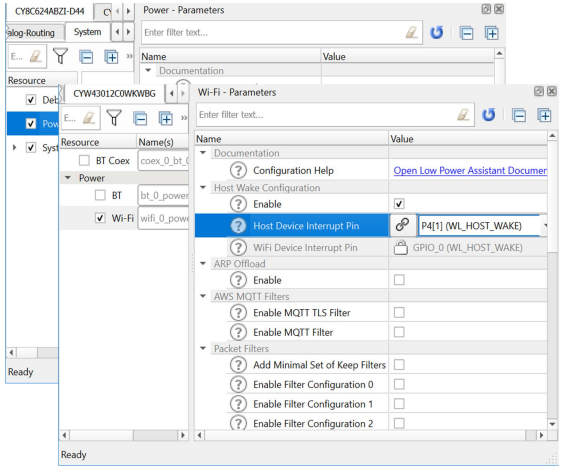
ModusToolbox® AnyCloud Stack



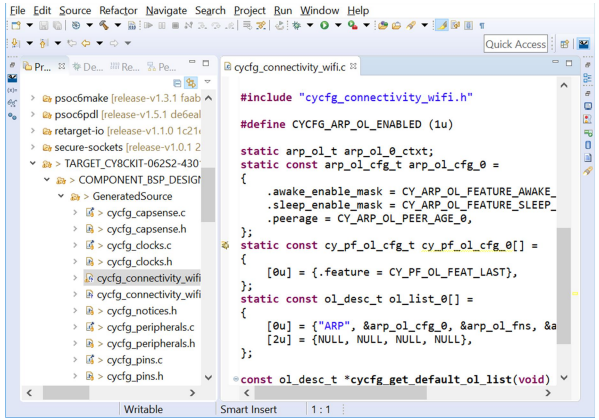
LPA: Overview

- 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
  - LPA v2.0.0 and ModusToolbox 2.1
- 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

Getting Started

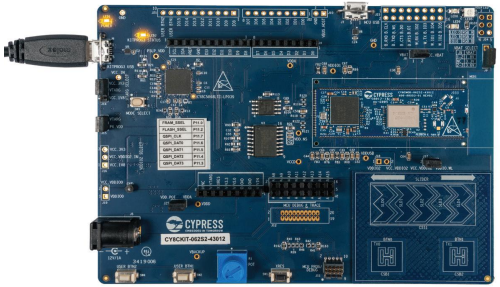
+

+ AnyCloud Stack – LPA, MQTT..

+ Code Examples

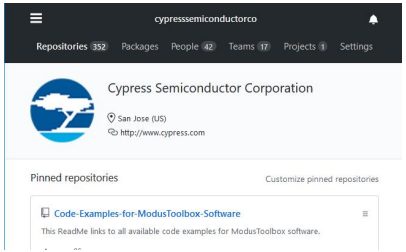
+ Design Application Notes

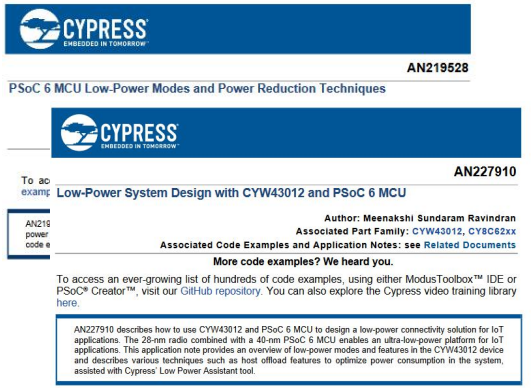
Murata Type 1LV module



PSoC® 62S2 Wi-Fi BT Pioneer Kit

GitHub





Resources

Action	Link
Order a Kit From Mouser	PSoC® 62S2 Wi-Fi BT Pioneer Kit Murata Type 1LV module
Download the App Note	Low Power System Design with CYW43012 and PSoC 6 MCU
Learn About the Products	PSoC 6 MCU (silicon available @ Mouser) CYW43012 Wi-Fi/Bluetooth Radio (module available @ Mouser) IoT-AdvantEdge: Power Efficient Solutions Page
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Q&A

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