



Ultra Low Power Integrated Platform for Connectivity and Audio/Voice/Sensing

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www.ceva-dsp.com



IoT Value Chain



Wearables: Main Design Considerations

Implementation Constraints

- ▶ Power Consumption
 - ▶ Battery size and weight limitation
 - ▶ Less frequent/limited charging (e.g. sleep tracker)
 - ▶ Always-on UI, always-connected
- ▶ Form Factor
 - ▶ Highly integrated solution
- ▶ Cost Sensitive
 - ▶ Fewer IPs and smaller die size



Feature Set Considerations

- ▶ User Interface
 - ▶ Limited display/touch-screen (if any)
 - ▶ Always-on voice/gesture control (primary UI in Android Wear)
- ▶ Connectivity
 - ▶ Bluetooth Low Energy (BLE) for sensor and app data communication
 - ▶ A2DP and Hands-Free BT profiles for audio playback and voice calls
- ▶ Sensor Fusion, Contextual Awareness

Ultra-low power, single-core solution for:
Connectivity, Audio, Voice and Sensor Fusion

Power Challenge for Wearables

Under “normal usage”, most of the power is consumed during screen-off use-cases, running:

1. BLE
2. Sensor fusion
3. Always-listening (voice)
4. Always-watching (face, gesture)
5. Audio playback

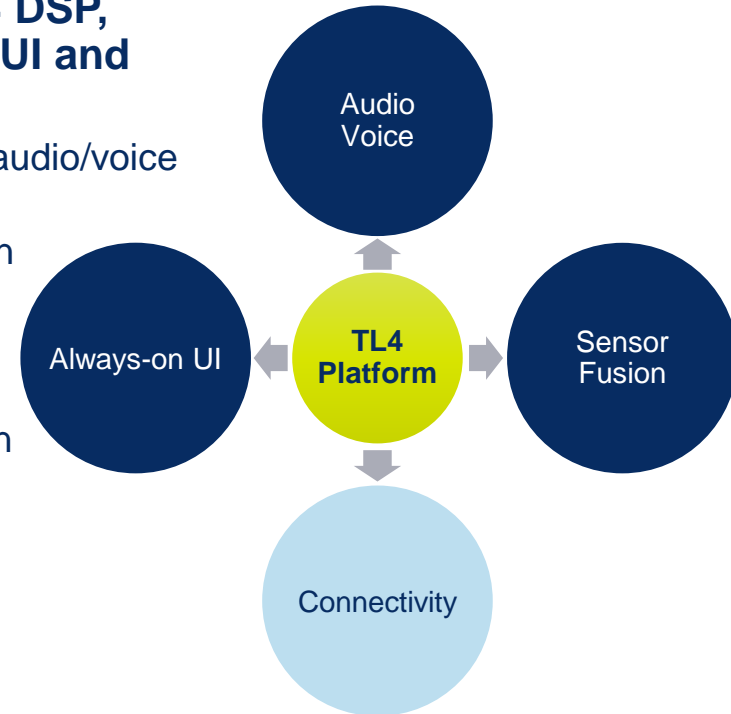
Application	Standard Application Processor	Moto X (Using TI C55 DSP)	Acceptable for a Smartwatch
Voice Activation	~20mA	4.5mA	0.6mA
Wake-on-gesture, wake-on-face	~40mA	N/A	1.1mA
BLE (including RF)	Negligible	N/A	0.03mA
Smartwatch always-on battery life (voice + gesture + face + BLE)*	5 hours	67 hours = ~3 days (voice only)	173 hours = ~7 days

*Assuming 300mAh battery

- ▶ How do we get here? ←
- ▶ Must use an application-specific processor, integrating multiple functions

Solution Overview

- ▶ **A complete solution based on a single TeakLite-4 DSP, handling Audio/Voice, Sensor Fusion, always-on UI and Connectivity**
 - ▶ **Feature rich:** Supporting various connectivity standards, audio/voice functions, always-on UI and sensor fusion
 - ▶ **Smallest die size:** Single core replacing at least 2 cores in alternative solutions
 - ▶ **Ultra-low power consumption:** HW platform including DSP well tuned for such applications
 - ▶ **Integrated and pre-verified** HW platform and SW solution
- ▶ **Serving several key markets**
 - ▶ Wearable devices
 - ▶ Wireless audio (speakers and headsets)
 - ▶ Smart home
 - ▶ Future user-centric IoT devices

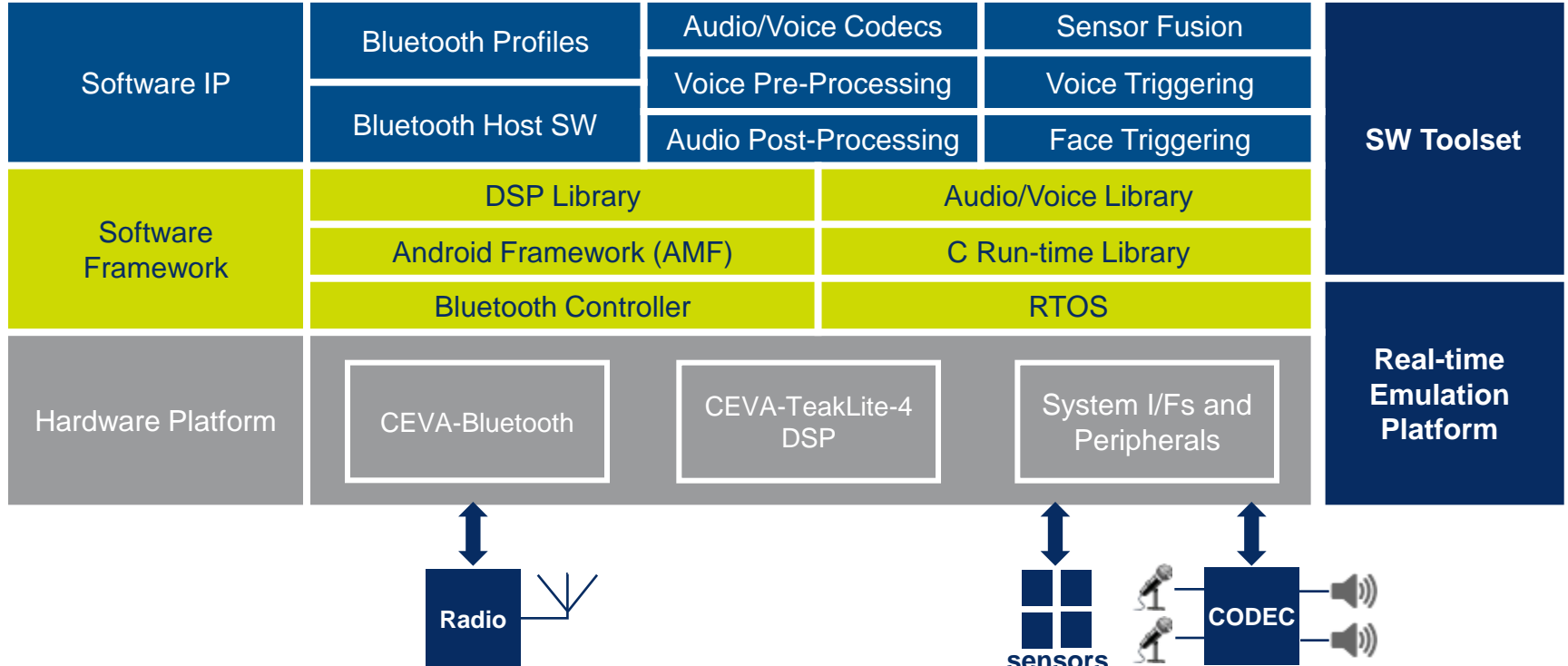


Solution Highlights



- ▶ Covers all Bluetooth, Audio/Voice and Sensor Fusion functionalities
- ▶ Down to 150K gates for the entire integrated HW platform
- ▶ Ultra-low power consumption
 - ▶ <150uW @ 28nm (always-on voice and face triggers + sensor fusion + BLE)
 - ▶ PSU 2.0 - latest generation power scaling technology
 - ▶ Power-optimized 32-bit DSP for control + audio/voice processing
 - ▶ Power-tuned CEVA-Bluetooth IP
 - ▶ Single core eliminates IPC overhead
- ▶ CEVA-TeakLite-4 handles multiple pre-integrated SW modules
 - ▶ Complete Bluetooth stack
 - ▶ Always-on functionality e.g. voice trigger, face trigger
 - ▶ HD audio and voice processing
 - ▶ Audio/Voice pre/post-processing
 - ▶ Sensor fusion (context awareness)
 - ▶ Android Framework (incl. KitKat)
 - ▶ RTOS, libraries
- ▶ Plenty of headroom for customer's proprietary software

Solution Diagram



CEVA-TeakLite-4 Based Bluetooth



▶ CEVA-Bluetooth

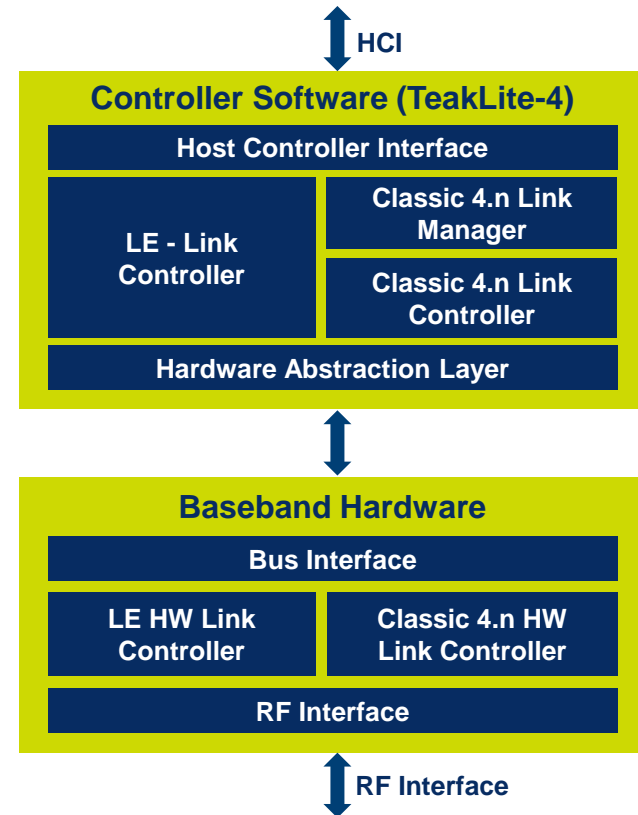
- ▶ Classic Bluetooth (2.1+EDR, 3.0)
- ▶ Low Energy Bluetooth (4.0/4.1) Single/Dual Mode
- ▶ CEVA-Bluetooth BB HW integrated with TL4
- ▶ CEVA-Bluetooth Controller SW stack running on TL4
- ▶ BlueRF for 3rd party Radio

▶ Single Mode

- ▶ Reduced HW/SW footprint for low power & silicon cost
- ▶ CEVA-Bluetooth host SW stack and profile services running on TL4
- ▶ API to licensee's SW stack

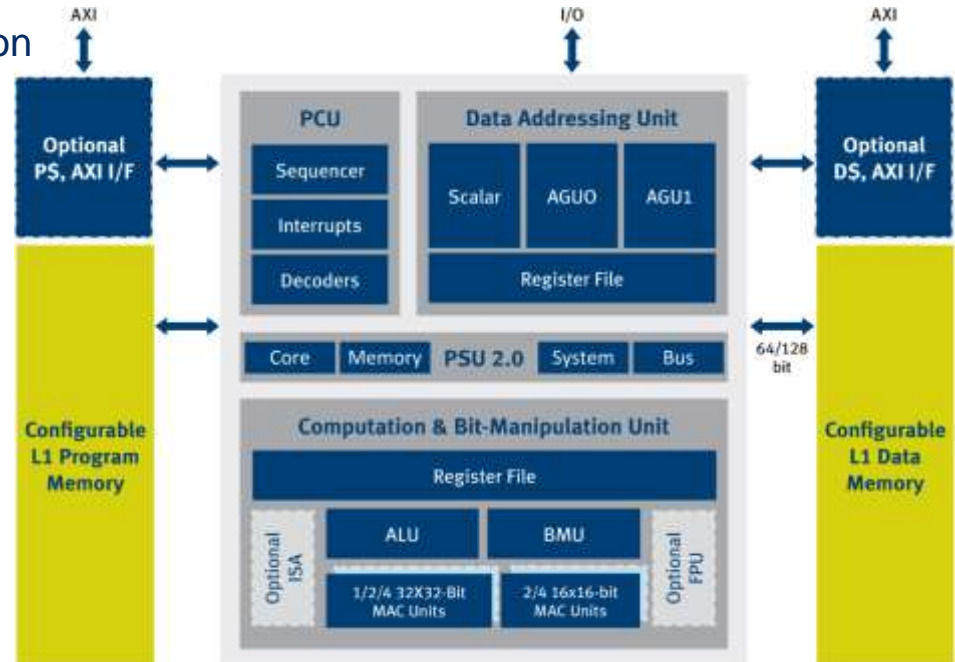
▶ Dual Mode

- ▶ Addition of Low Energy protocol HW & SW to Classic BT
- ▶ CEVA's partners host SW stack and profiles
- ▶ HCI for 3rd party host software



Leveraging CEVA-TeakLite-4 V2 (*)

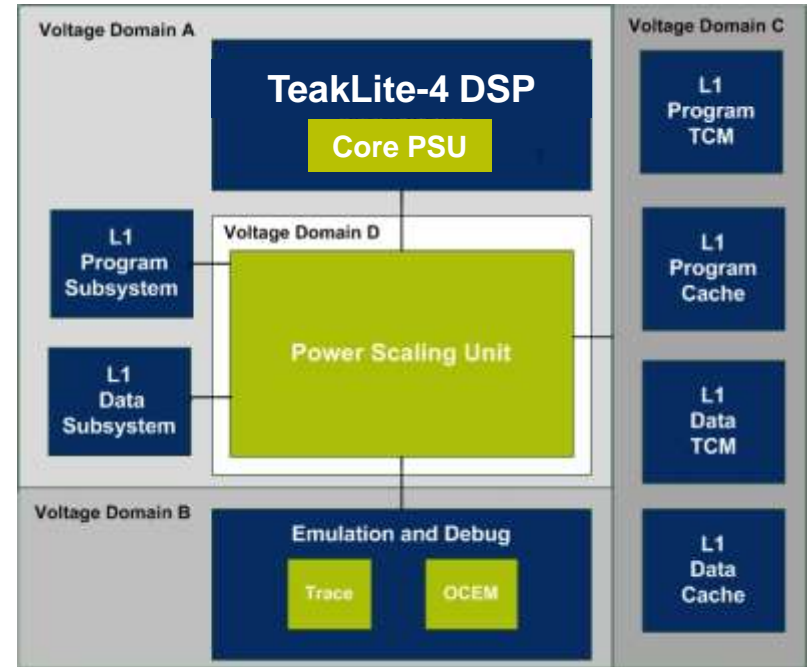
- ▶ New instructions and interfaces
 - ▶ For wireless standards implementation
 - ▶ For audio/voice processing
- ▶ 30% code size reduction
 - ▶ Optimized instruction encoding
 - ▶ Reduced memory silicon area
 - ▶ Reduced power
 - ▶ Improved P\$ utilization and cycle count
- ▶ 20% power reduction
 - ▶ Improved granularity of Power Scaling Unit (PSU)



(*) Compared to V1

Enhanced Power Scaling Unit

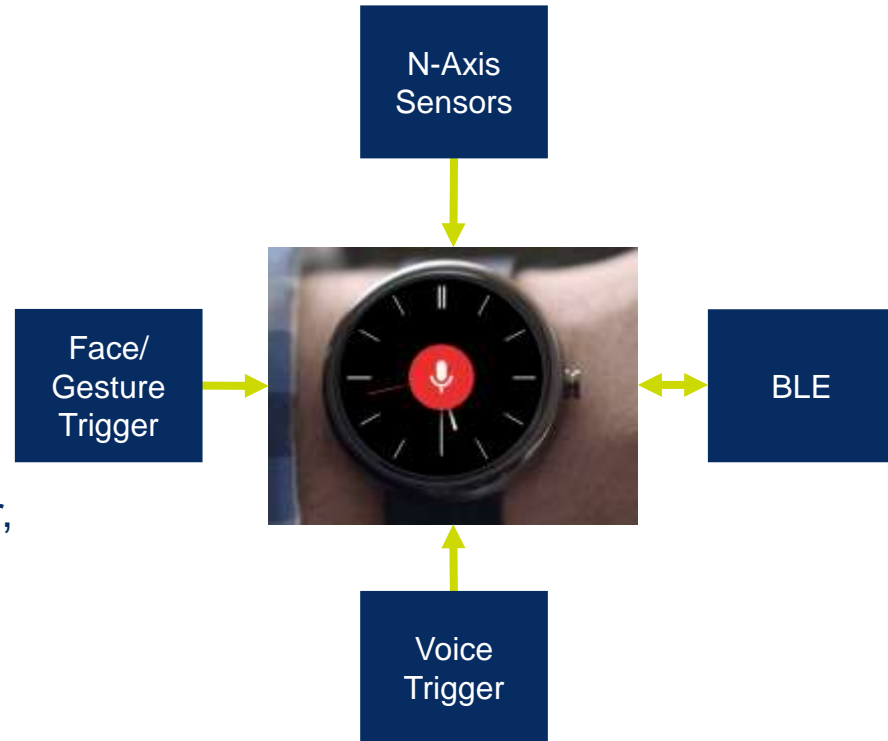
- ▶ Multiple clock sources
 - ▶ DSP Core - internal unit manages the clock automatically
 - ▶ Early in instruction decode pipe stage
 - ▶ Unneeded modules are shut down
 - ▶ Memory subsystem
 - ▶ Data & program memories
 - ▶ Emulation & debug modules
- ▶ Multiple voltage domains
 - ▶ DSP and memory subsystem
 - ▶ Data and Program L1 memories - enables data retention when core is powered off
 - ▶ Emulation & debug modules



Improved Granularity Enables Ultra-Low Power Controlled Both Automatically and by Software

Always-on Triggers and Sensor Fusion

- ▶ **Always listening microphone**
 - ▶ Voice trigger/command, speaker verification
 - ▶ <20uW @ 28nm
- ▶ **Always watching camera**
 - ▶ Face wake-up, gesture, gaze detection
- ▶ **Contextual awareness**
 - ▶ Multi-sensor processing (Accelerometer, Gyroscope, Magnetometer, Barometer, Humidity, Light, Heart Rate...)
- ▶ **Bluetooth Low-Energy (BLE)**
 - ▶ Connectivity and Beacons




Voice and Audio Pre/Post-Processing

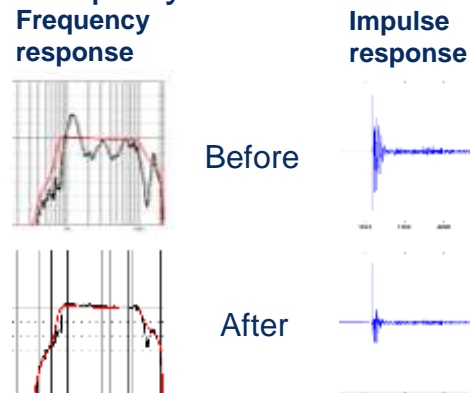
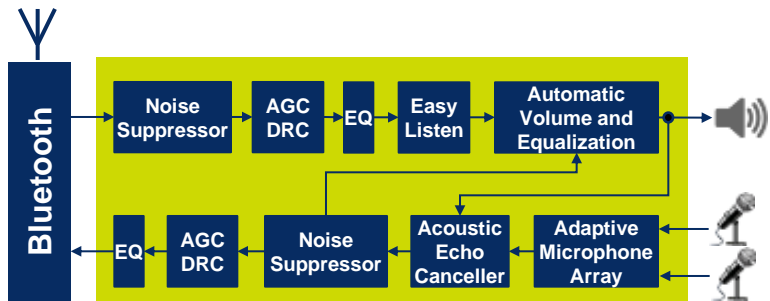
Voice Pre-Processing

- ▶ Alango Voice Capture 
- ▶ AEC
- ▶ NR
- ▶ AGC
- ▶ DRC
- ▶ Dual mic
- ▶ Other 3rd party solutions also available



Audio Post-Processing

- ▶ Dirac Power Sound 
- ▶ Enhanced sound from small speakers
- ▶ Pure and loud sound
- ▶ Maximum bass without distortion
- ▶ Resonances are wiped out
- ▶ Other 3rd party solutions also available



Wearable Device Requirements

- ▶ Low power audio processing
 - ▶ Audio decoding
 - ▶ Audio encoding
 - ▶ Audio post-processing
- ▶ Low power voice processing
 - ▶ Vocoder
 - ▶ Noise reduction, beam forming
- ▶ Ultra low power always-on
 - ▶ Always-listening voice trigger
 - ▶ Always-watching face trigger
- ▶ BLE/BT4.1 Dual Mode (Bluetooth Smart Ready)
- ▶ Sensor fusion (context awareness)



Example Wearable Use Case: Standby

Smartwatch is on Standby: Always-on UI + Sensor Fusion + BLE

Function		Features
BLE	Baseband HW	CEVA DM Baseband HW
	Controller SW	CEVA DM controller SW
	Host SW	DM Host SW
Always-Watching Camera	Face trigger on DSP	Visidon Face Unlock
Always-Listening Microphone	Voice trigger on DSP	Sensory TrulyHandsfree 3.0
Contextual awareness	Sensor Fusion	Accelerometer/Gyroscope/ Magnetometer/Barometer/ Gesture/Shake



Less than 150uW for Always-on UI + Sensor Fusion + BLE

Example Wearable Use Cases: Voice Call, Wireless Audio

Smartwatch Voice Call using Built-in Speakerphone

Function		Features
Bluetooth V4.0 Classic Mode	Baseband HW	CEVA DM BB HW
	Controller SW	CEVA DM Ctrl SW
	Host SW (HFP)	DM Host SW
Voice Processing	mSBC vocoder	16KHz, Mono
	Pre-processing	Alango Voice Capture, AEC (64ms acoustic echo tail), NR, AGC, DRC
Control	RTOS	

Less than 60MHz and 1.6mW

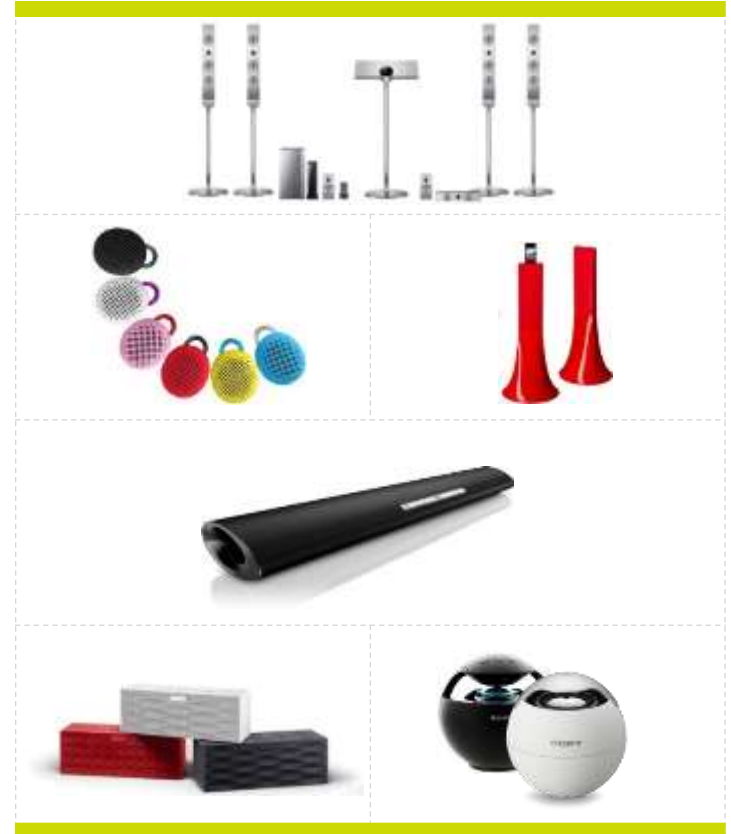
Smartwatch Audio Playback Streamed to BT Headset

Function		Features
Bluetooth V4.0 Classic Mode	Baseband HW	CEVA DM BB HW
	Controller SW	CEVA DM Ctrl SW
	Host SW (A2DP)	DM Host SW
Audio Playback	MP3 Decoder	44.1KHz, 128Kbps
	SBC Encoder	16-48KHz, 96-320Kbps
	Post-processing	Dirac Power Sound
Always-on Microphone	Voice trigger on DSP	Sensory TrulyHandsfree 3.0
Control	RTOS	

Less than 70MHz and 1.9mW

Wireless Audio Requirements

- ▶ Low power audio processing
 - ▶ Audio decoding
 - ▶ Audio post processing
- ▶ Low power voice processing (speakerphone)
 - ▶ Vocoder, voice pre processing, echo canceller
- ▶ Ultra-low power always-listening voice control
- ▶ BT4.1 Dual Mode (Bluetooth Smart Ready)



Example Wireless Audio Use Case

Function		Features
Bluetooth Classic	Baseband HW	CEVA DM BB HW
	Controller SW	CEVA DM Ctrl SW
	Host SW (A2DP)	DM Host SW
Audio Playback	SBC decoder	16-48KHz, 96-320Kbps
	Post-processing	Auto Volume, DRC, EQ, Bass/Treble Enhancement, Virtual Surround
Always-Listening Microphone	Voice trigger on DSP	Sensory TrulyHandsfree 3.0
Control	RTOS	

BT Speaker A2DP Audio Playback with Always-listening Voice Control

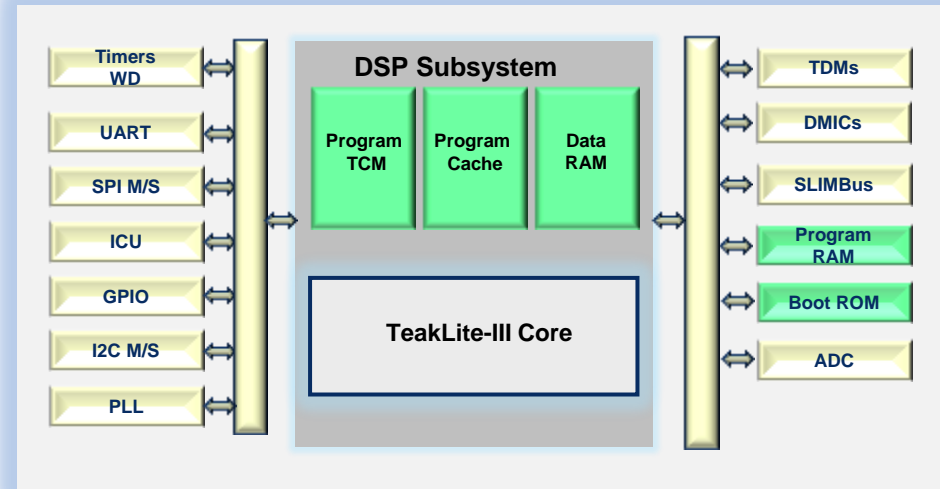


Less than 60MHz and 1.6mW

Chip Example: DBMD2 – Cost Effective, Low Power Audio/Voice Processor for Always-on Functions

DSP Group DBMD2 address all key requirements for always-on functions

- ▶ Utilizes TeakLite-III DSP to provide sufficient processing power
- ▶ Supports different power save modes by turn-off the DSP core and any of the peripherals modules in the chip
- ▶ Enables fast TTM - Complete SW development tools including utilization of on-chip profiler and complete software framework
- ▶ Small form factor (3mm x 3mm)
- ▶ Availability of SW algorithms by DSPG/CEVA/partners
- ▶ Supports various always-on functions including:
 - **Low power voice trigger wake-up (below 2mW)**
 - **Low power voice commands**
 - **Low power sensor–hub functionality**



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Summary



- ▶ IoT and wearables require new system solutions
 - ▶ Requires much more focus on power consumption and cost
 - ▶ E.g., for a smartwatch to run a week between battery charges, 2mA is the limit for always-on (screen-off) use case
- ▶ CEVA's announced TeakLite-4 based integrated platform delivers:
 - ▶ Connectivity, audio, voice, sensing, always-on UI
 - ▶ <150K gates, single-core platform including BT baseband HW
 - ▶ <150uW @ 28nm (always-on voice and face triggers + sensor fusion + BLE)
 - ▶ Can scale for advanced screen-on use-cases with other TL4 cores
- ▶ CEVA partners offer complementary SW solutions
 - ▶ Audio, voice, imaging, pre/post-processing, BT, GNSS, WiFi



THANK YOU

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