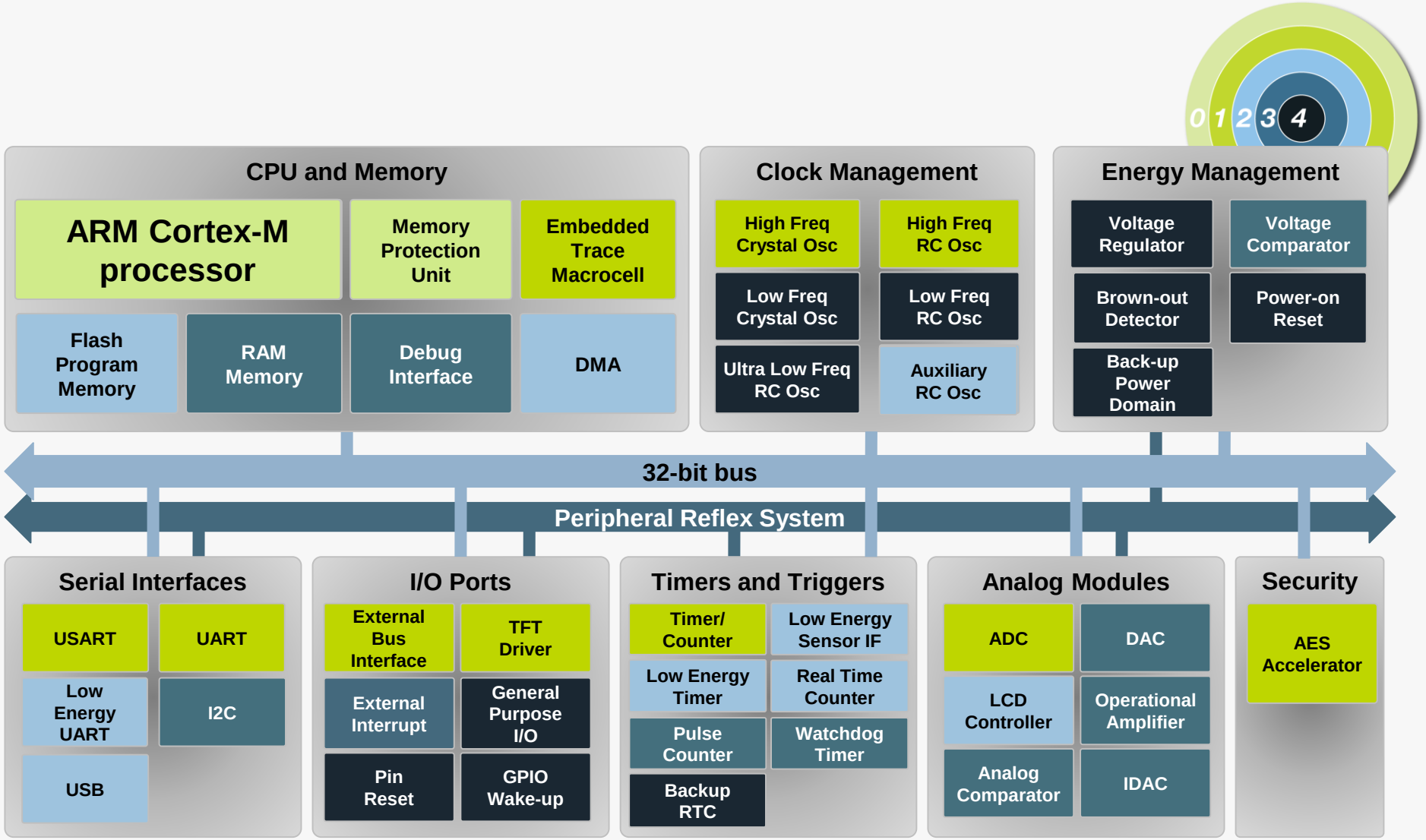
EFM32 Series 0: Energy Optimization

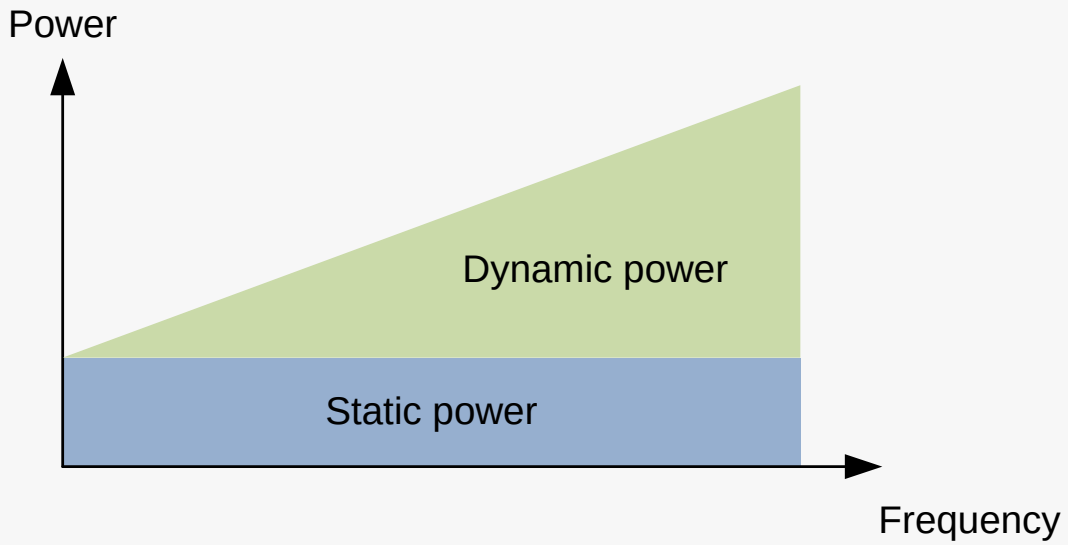
Power domains of EFM32



Available down to:

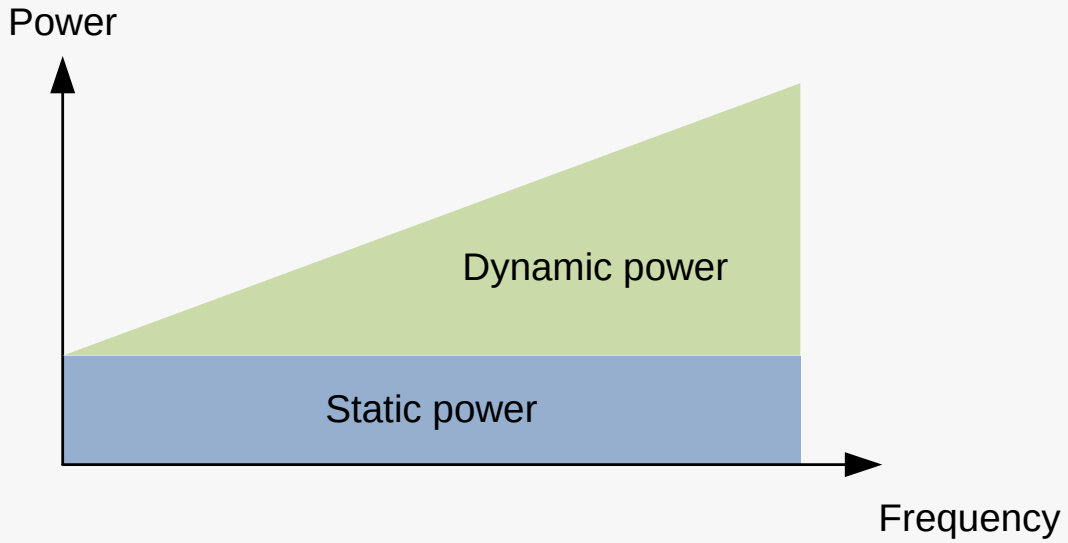
EM0 (Run Mode)	EM1 (Sleep)	EM2 (Deep Sleep)	EM3 (Stop Mode)	EM4 (Shutoff Mode)

Running fast vs walking slowly



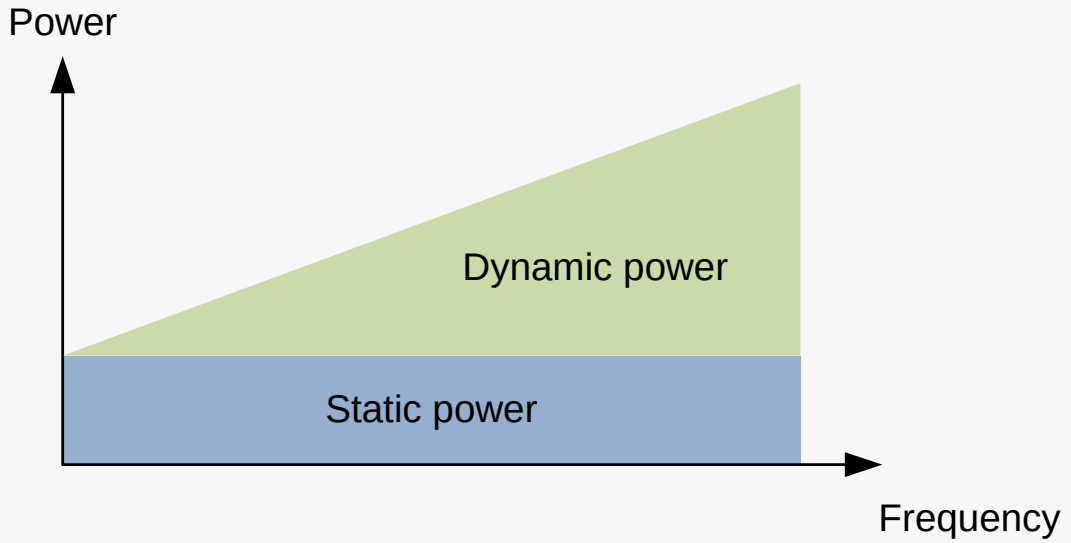
Frequency	EM0 Current
32.768 kHz	38 µA
1 MHz	210 µA
14 MHz	2170 µA
28 MHz	4200 µA

Running fast vs walking slowly



Frequency	EM0 Current	Time
32.768 kHz	38 µA	854
1 MHz	210 µA	28
14 MHz	2170 µA	2
28 MHz	4200 µA	1

Running fast vs walking slowly



Frequency	EM0 Current	Time	Energy
32.768 kHz	38 µA	854	**1160 µA/MHz**
1 MHz	210 µA	28	**210 µA/MHz**
14 MHz	2170 µA	2	**155 µA/MHz**
28 MHz	4200 µA	1	**150 µA/MHz**

Finish faster and sleep longer!

Energy Modes across EFM32 families

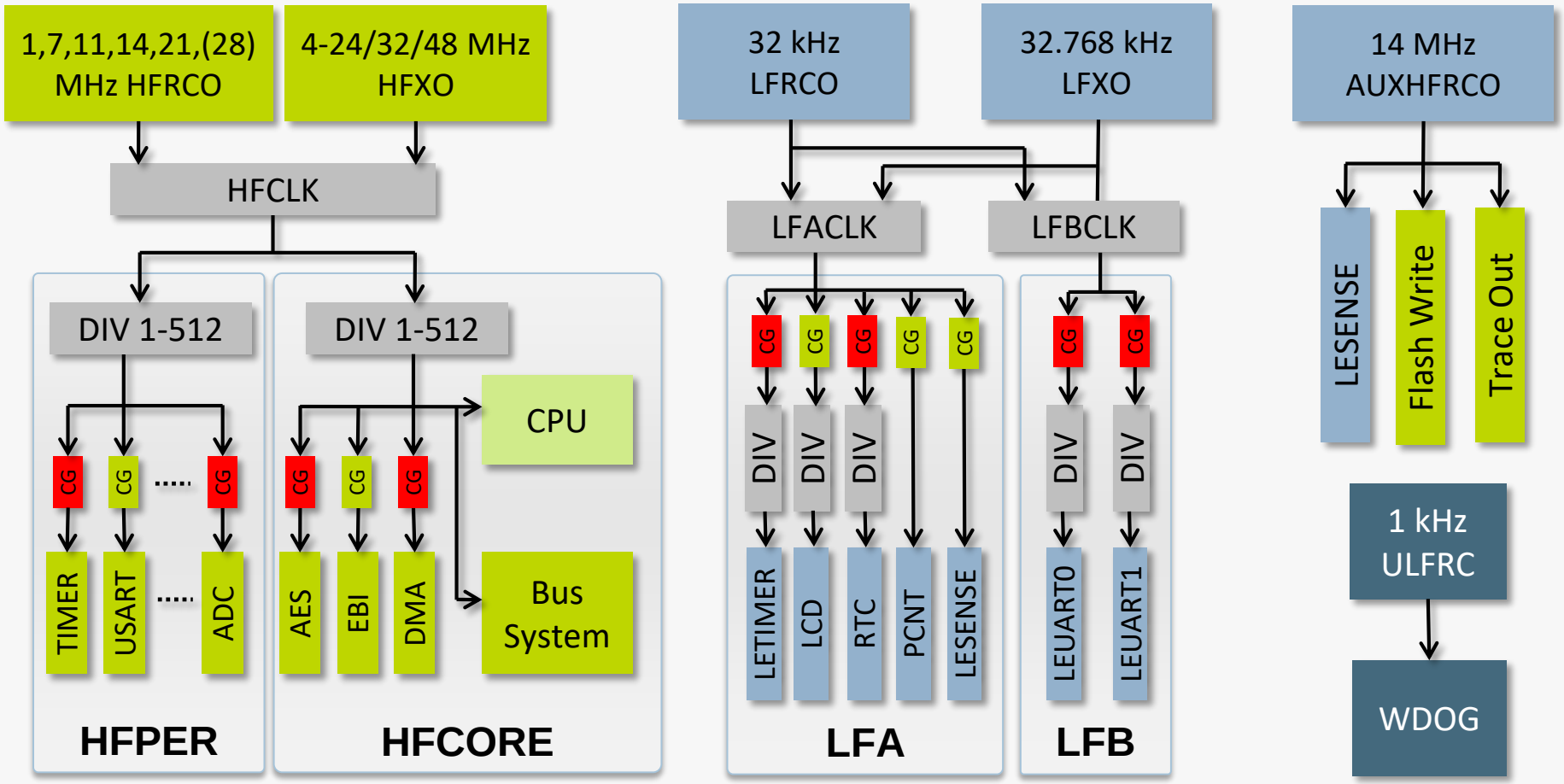
Device	EM0 µA/Mhz	EM1 µA/Mhz	EM2 µA	EM3 µA	EM4 nA	EM4+RTC nA (ULFRCO/LFRCO/LFXO)
EFM32ZG	114	48	0.9	0.5	20	NA
EFM32TG	150	51	1.0	0.6	20	NA
EFM32G	180	45	0.9	0.6	20	NA
EFM32LG	~214[1]	~80[1]	~1.25[1]	~0.84[1]	20	240[2]/310[1]/450[2]
EFM32GG	~214[1]	~80[1]	~2.00[1]	~1.62[1]	20	240[2]/310[1]/450[2]
EFM32WG	225	63	0.95	0.65	20	240[2]/310[1]/450[2]

[1] Different from datasheet (not confirmed)

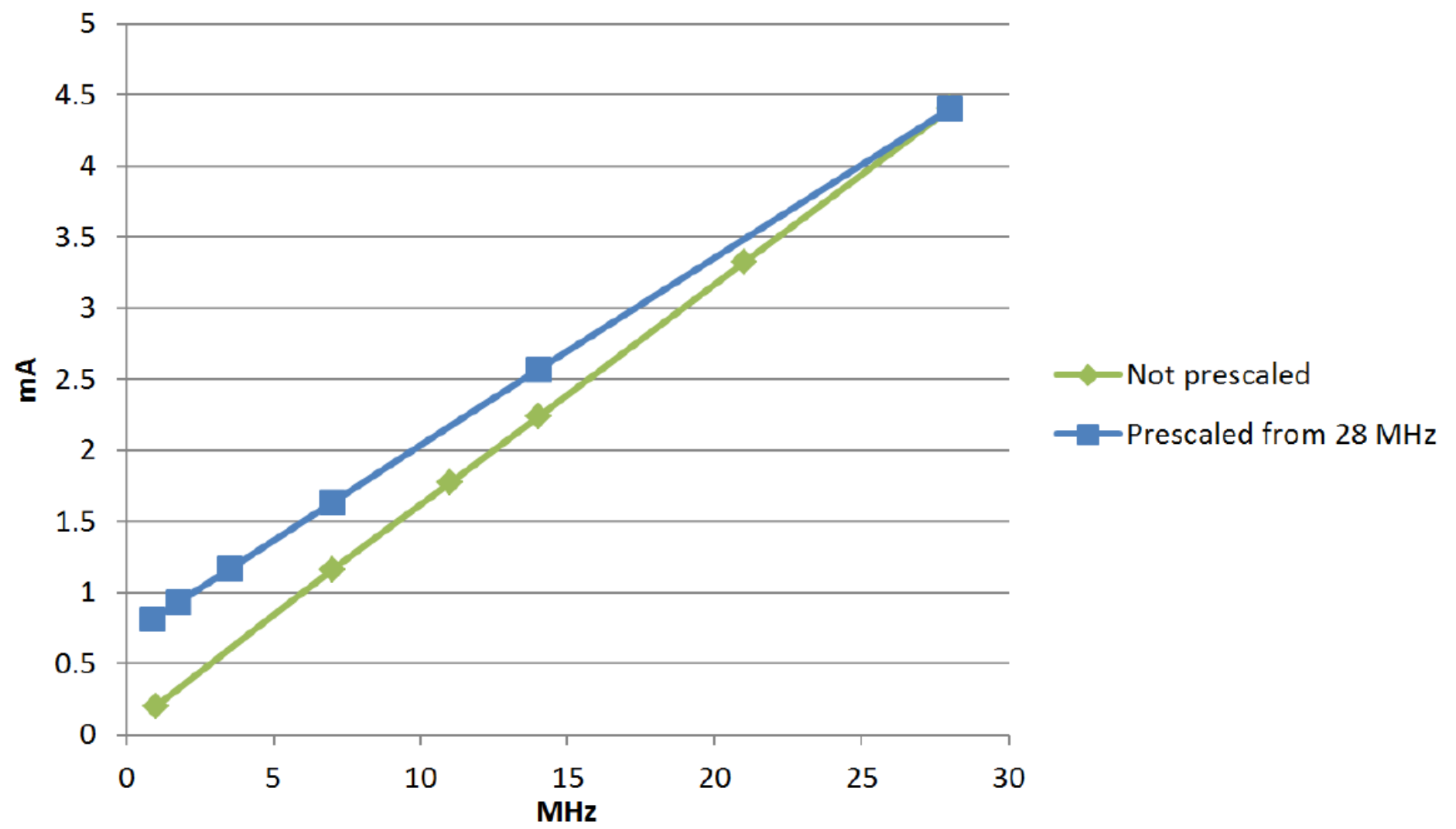
[2] Not in datasheet (not confirmed)

Updated datasheets mid February

Clocks and Oscillators



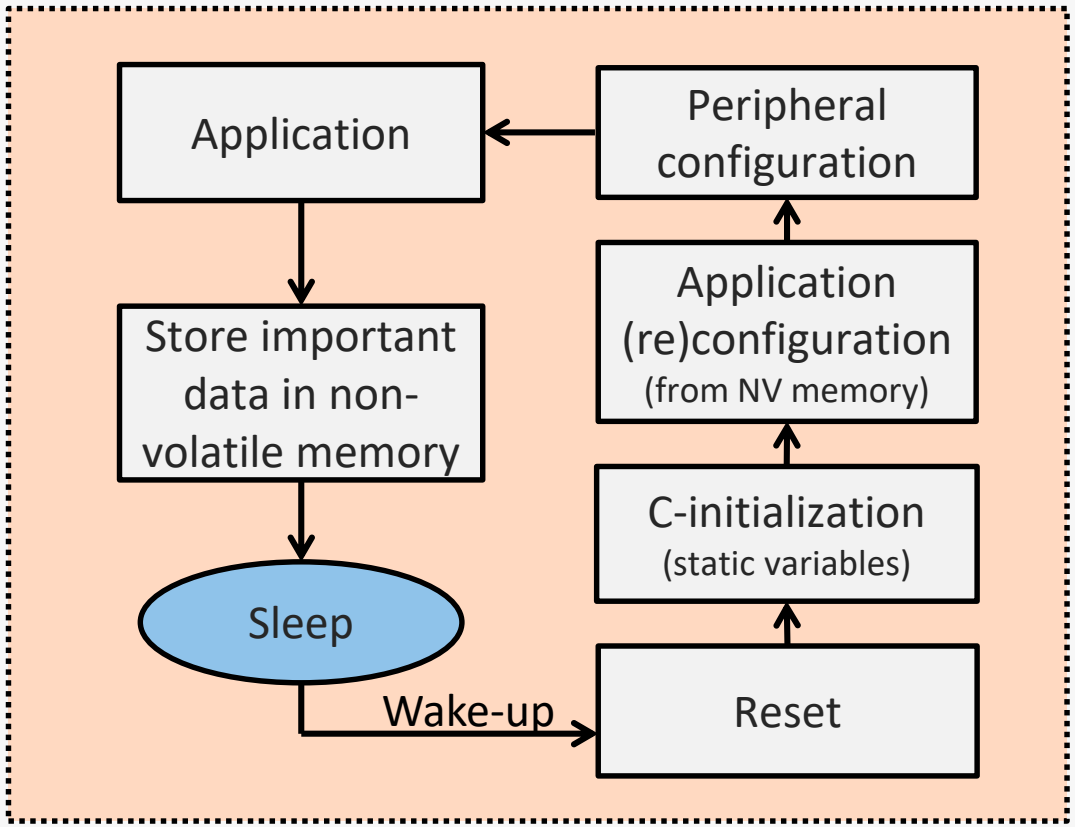
Prescaling power consumption penalty



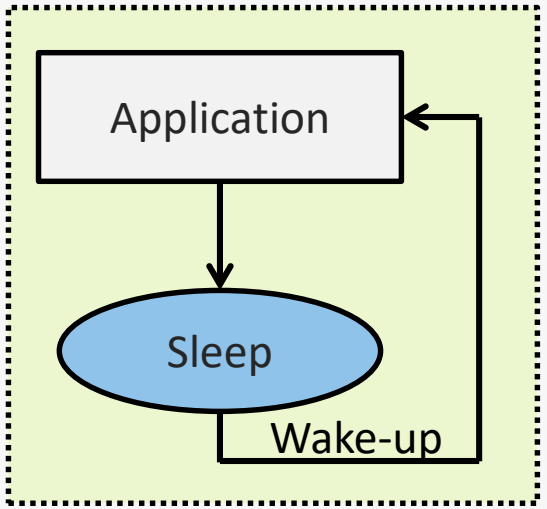
Sleep with and without retention

- Retention of RAM and digital logic
  - Usually higher leakage current

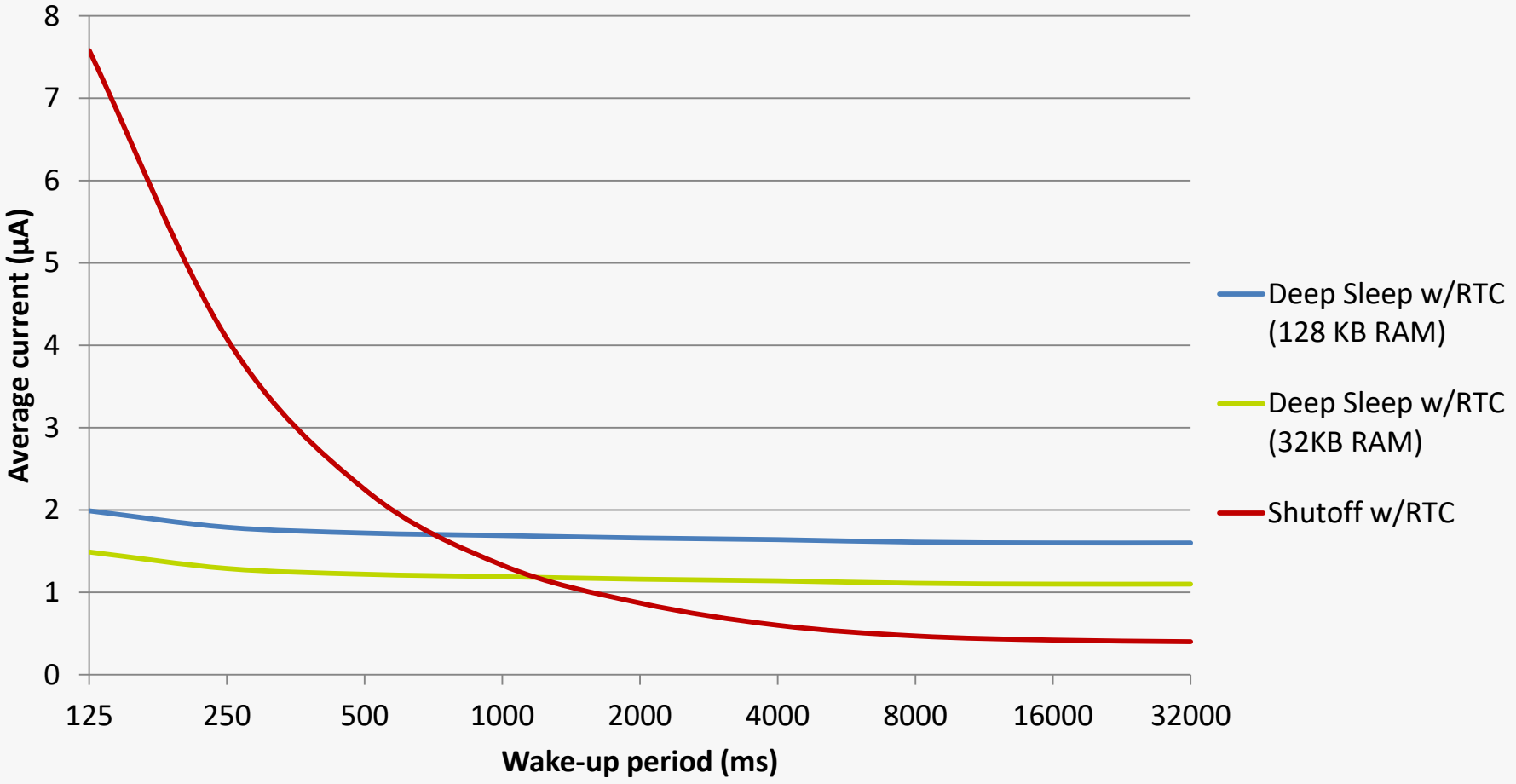
Sleep without retention



Sleep with retention



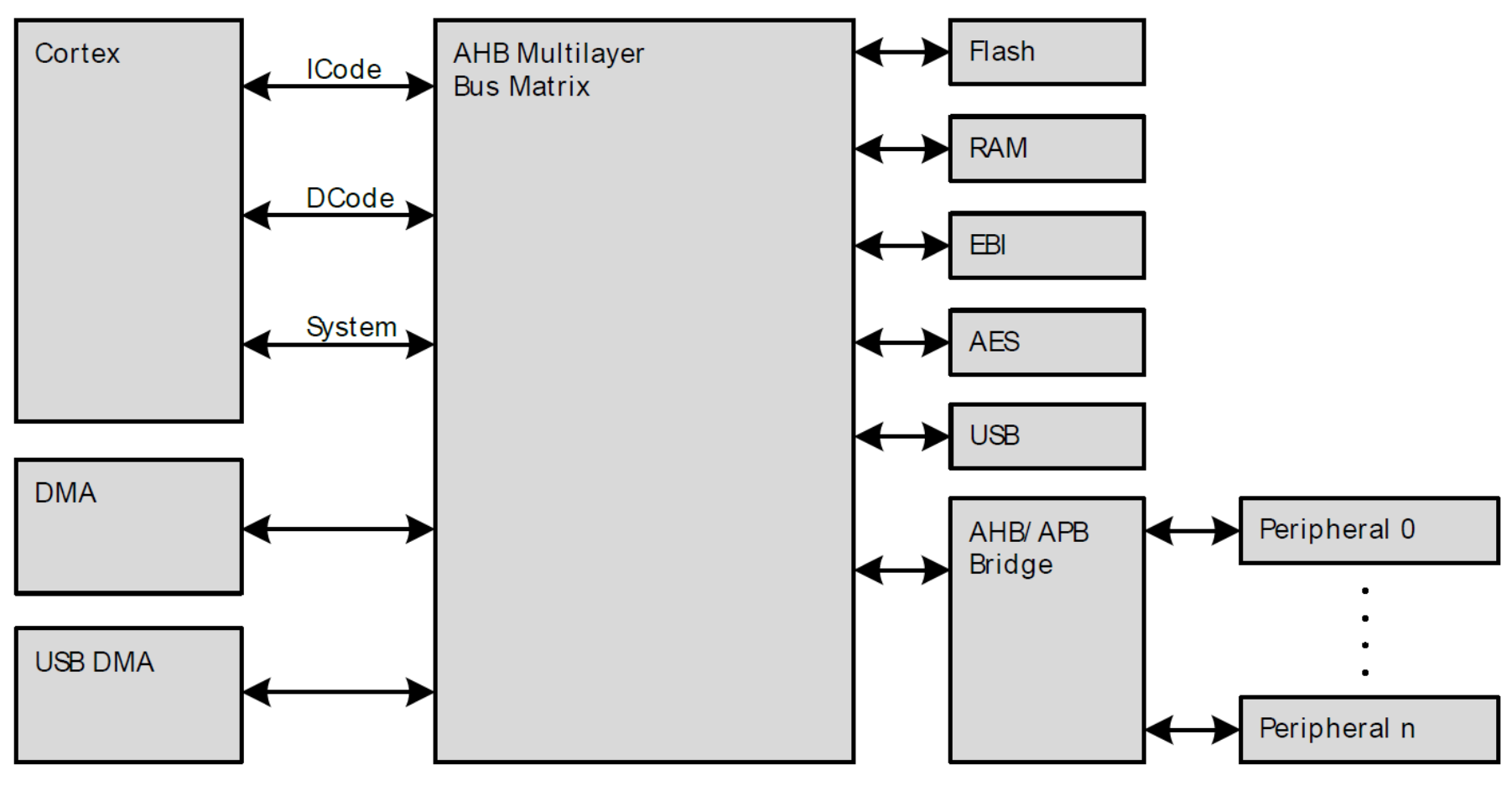
The power of retention



Saving power with instruction cache

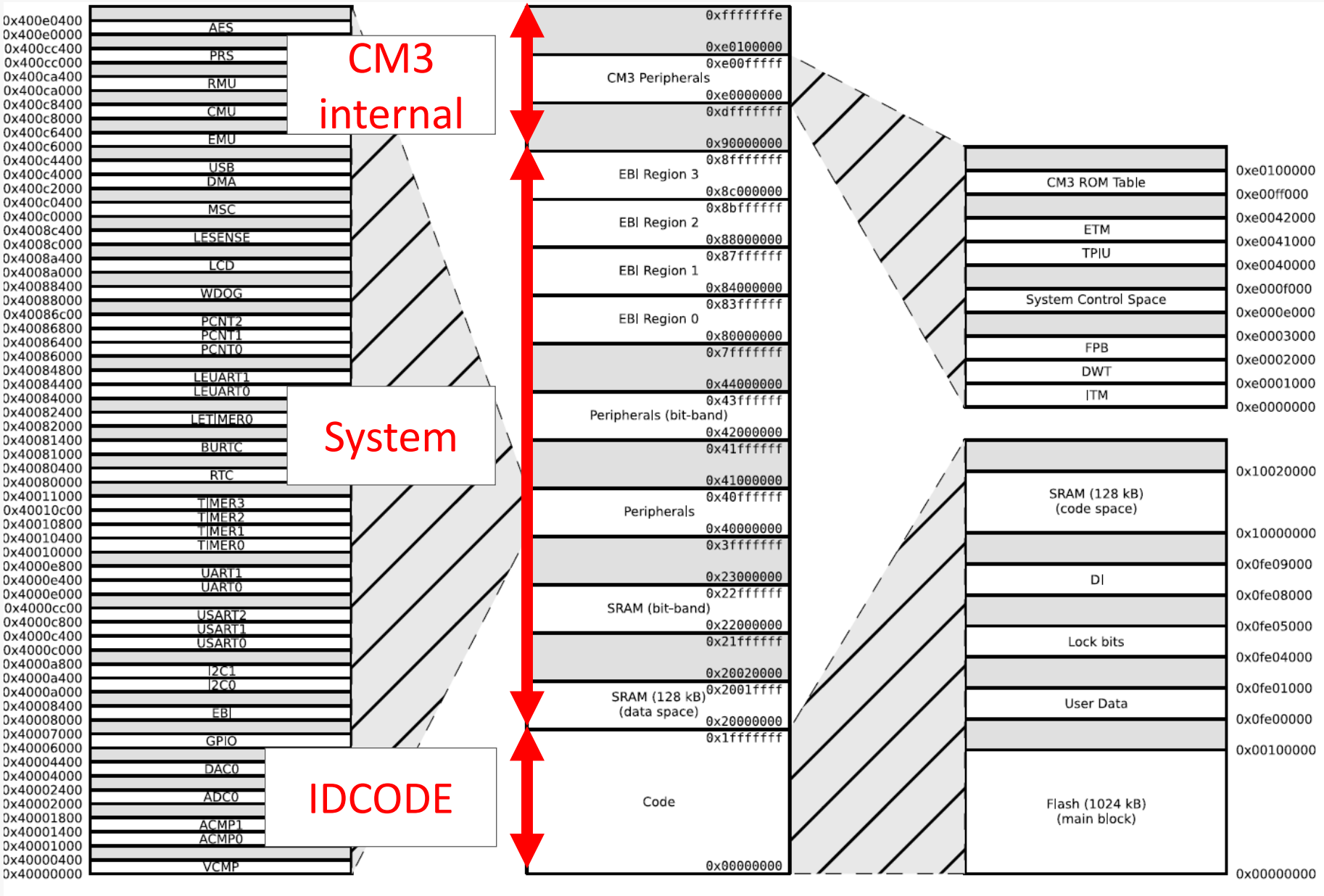
- All parts except EFM32Gs include a 512 byte instruction cache
  - Previously accessed instructions are automatically stored in in cache
  - Lower power and zero wait-states for previously read instructions
  - Cache hits examples:
    - EEMBC ULPBench: 91%
    - EEMBC Coremark: 90%
    - Prime: 100%
  - Cache-hit counter in Memory System Controller
- Data accessed through external bus interface can also be cached
  - Great power/speed savings can be acheived

EFM32 Bus System



- Icode and Dcode busses are combined into 1

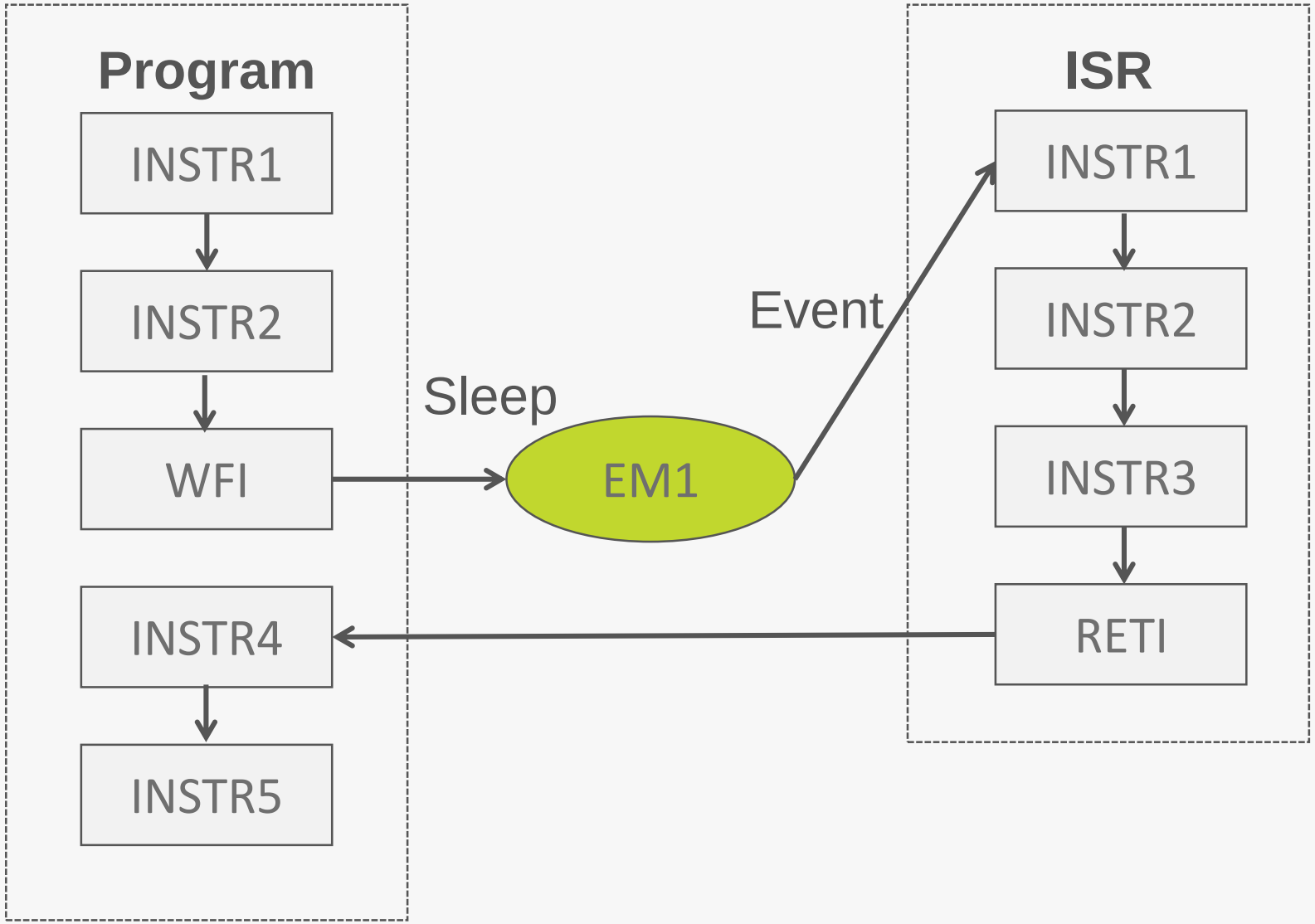
EFM32 Memory Map



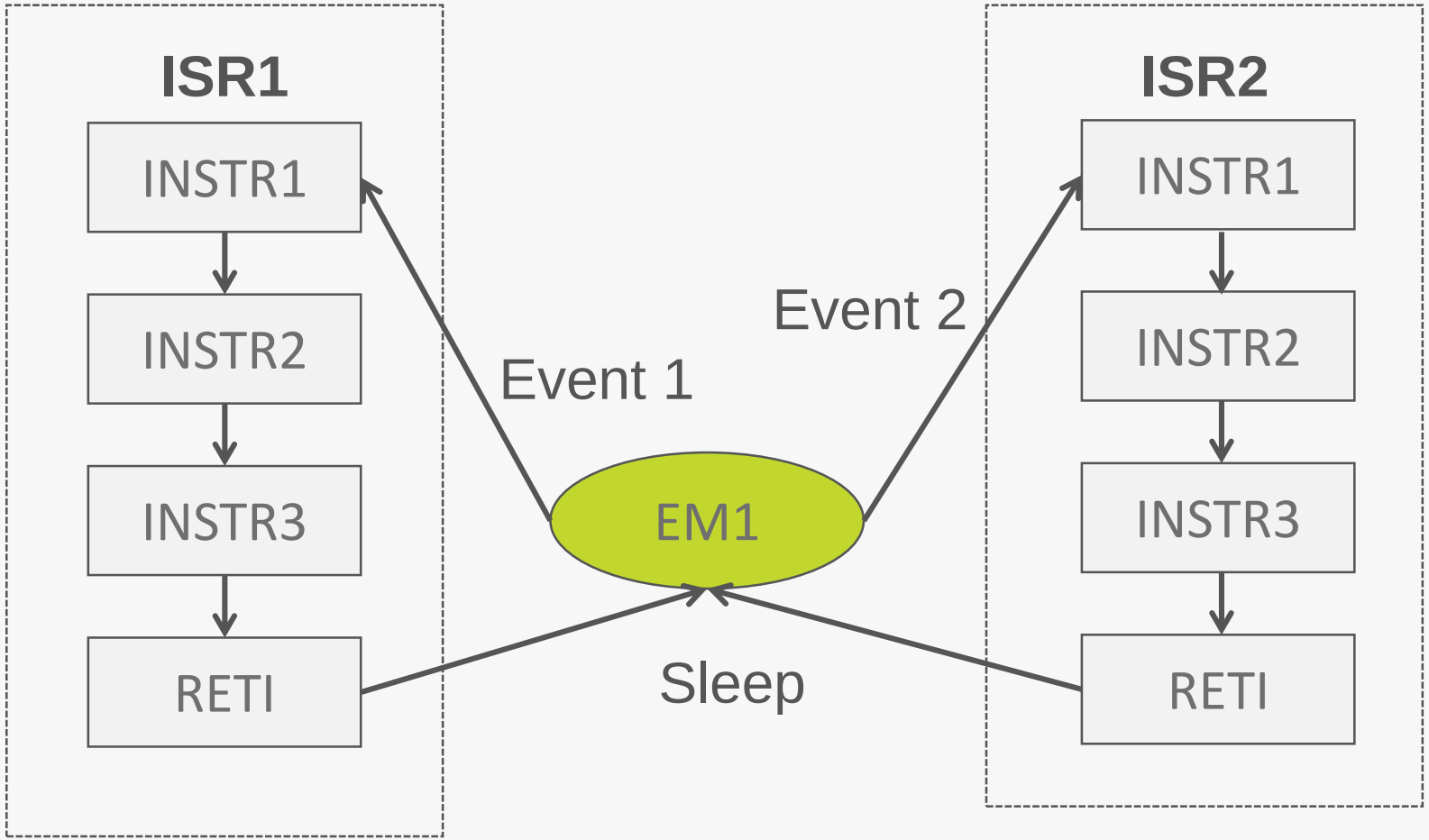
Running from RAM

- The RAM in itself has 0 wait-states at all clock speeds
  - BUT, the System Bus always uses 1 wait-state (standard CM3)
  - The system space is also not cached, so this solution is generally slower and consumes more power than running from flash.
- RAM can be accessed through IDCODE bus, by using addresses 0x10000000 and upwards
  - BUT, bus matrix sets default RAM access to System Bus, so every IDCODE bus access to RAM takes on extra cycle in arbitration to gain access to the RAM.
  - Can still save power/time vs using flash in conditions with 1 wait-state or more.

Program Flow – Sleep and Interrupt

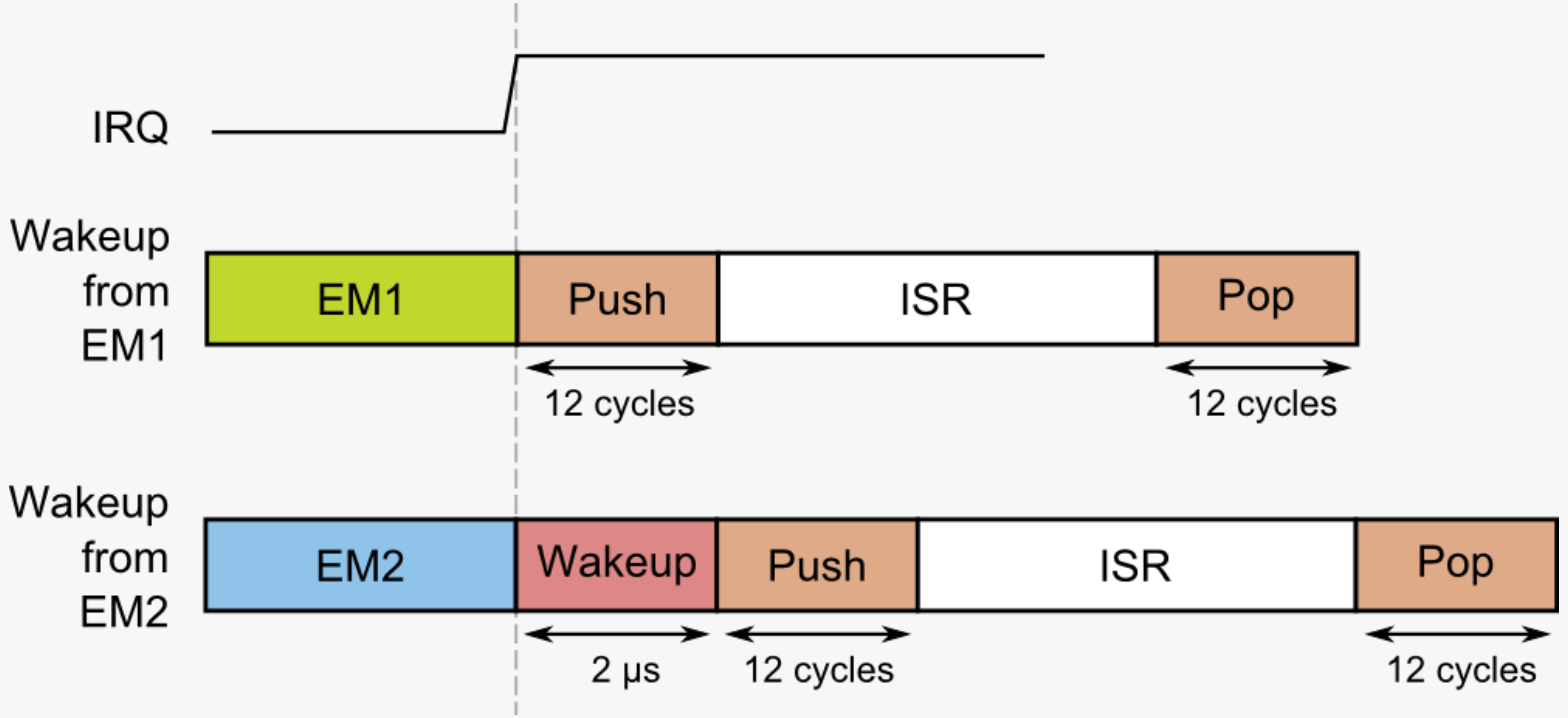


Program Flow Sleep-on-Exit



Note: SLEEPONEXIT bit in SCR must be set!

Reduce wake-up latency

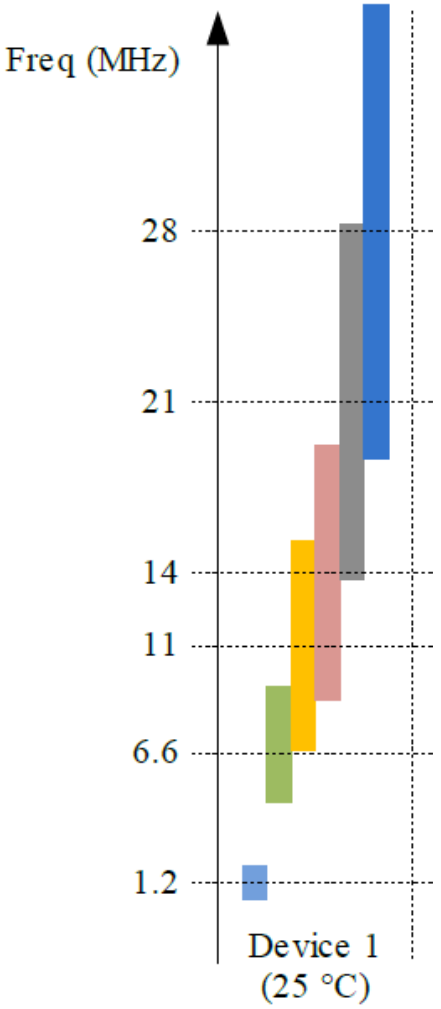


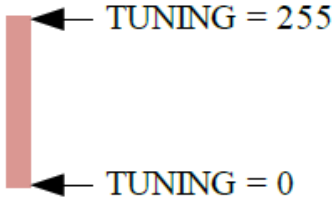
- Wait-for-interrupt (WFI) uses 12-cycles to push and pop state before when running ISR
- Wait-for-event (WFE) can be used to skip ISR (and push/pop) and continue in thread mode directly.
  - Fast wake-up, but interrupt source must be decoded and cleared.
  - SEVONPEND bit in SCR register must be set and interrupt vector disabled.

Other energy saving tips

- Analog bias settings
  - Reduce bias settings for analog peripherals like the ACMP, especially when in EM2 and EM3
- Supply voltage level
  - Supply voltage only affects current minimally as a linear regulator is powering most of the digital logic.
- Optimize emlib functions
  - Some overhead included to optimize for easy of use and different use-case handling
  - Leave originals unaltered by copying functions
- Use PRS and DMA to do more in sleep

HFRCO tuning





HFRCO tuning

- New version of «an0004 EFM32 Clocks and Oscillators»
  - Released once HFRCO characteristics is ready in datasheets (mid Feb)
- Tune HFRCO to any frequency between ~7 MHz to ~26 MHz
  - LFXO needed as reference for periodic calibration
  - Function library provided
  - Voltage and temperature variation still applies

These and more energy optimization tips in:
an0027 EFM32 Energy Optimization
an0039 EFM32 Interrupt Handling