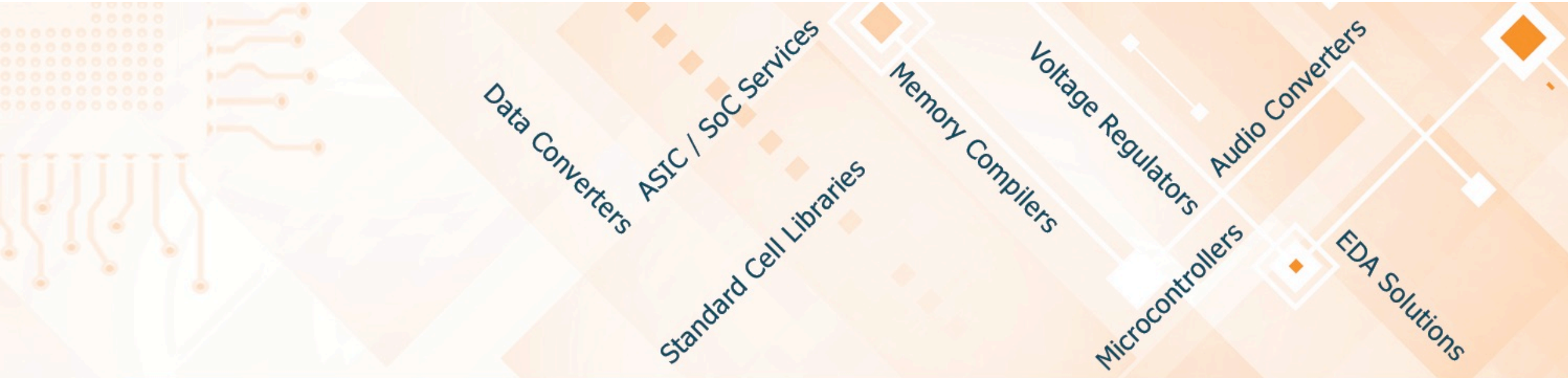
DOLPHIN INTEGRATION
The Enabler of Low-Power Systems-on-Chip

FD-SOI Adaptive Body Bias solutions to accelerate energy-efficient SoC designs

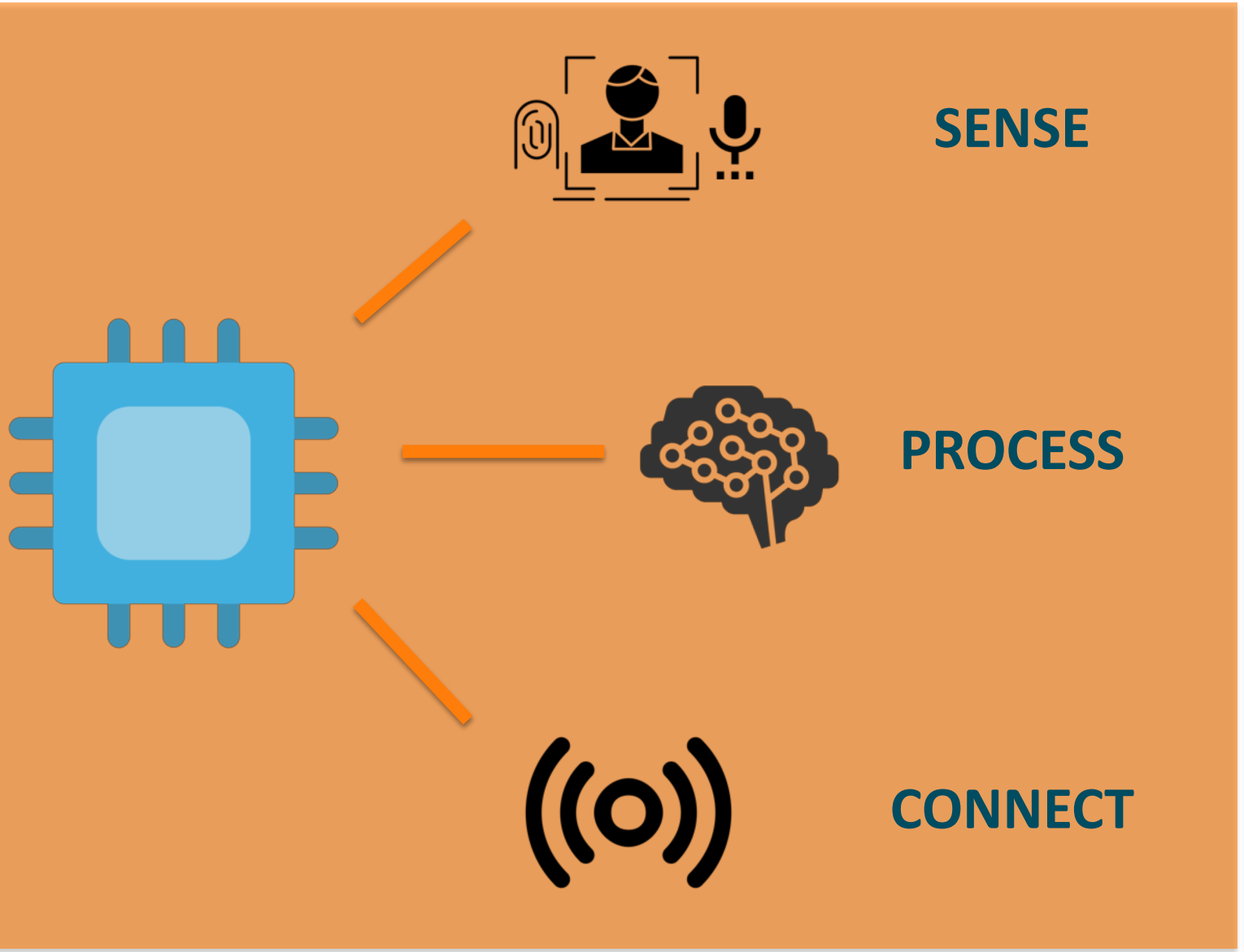
PIERRE GAZULL – BUSINESS DEVELOPMENT & PRODUCT MARKETING MANAGER

ChipEx2019 TEL AVIV - MAY 13TH



Not just a supplier of Technology, but provider of the Dolphin Integration **know-how**!

IoT SoC : Missions & Challenges



Increase
Battery Autonomy

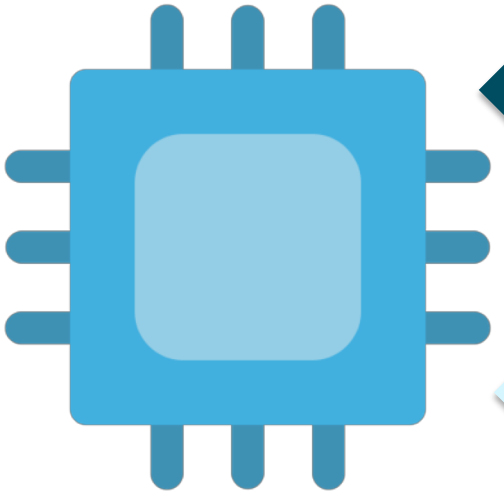
Boost
Performances

Reduce
Time-to-Market

ENERGY-EFFICIENCY CHALLENGES

Active	SoC running - All blocks ON	µA / MHz
Active-Low Power, Sleep	SoC running in low-power mode MCU OFF - RF OFF - Peripherals are active	µA / MHz
Deep Sleep, Trigger, …	Logic Domain & SRAM in retention mode IO and AON/RTC active	< 1 µA
Stop	Logic domain OFF - SRAM OFF IO disabled - AON/RTC active	< 500 nA
Shut Off	Only wake-up pin remain active AON/RTC is OFF	< 200 nA

Energy-Efficient IP
for Mostly-Off Domain



Low Leakage IP
for Sleep Mode & AON Domain

FD-SOI ENABLES SINGLE CHIP SoC

Power Management Unit

Clock Management Unit

Security Unit

Processing & Memory

Energy Harvesting

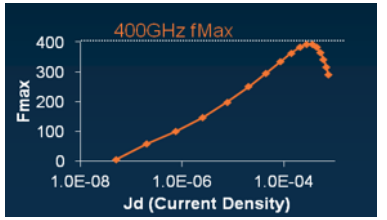
Always-On Domain

RF

Audio CODEC

IOs & Interfaces

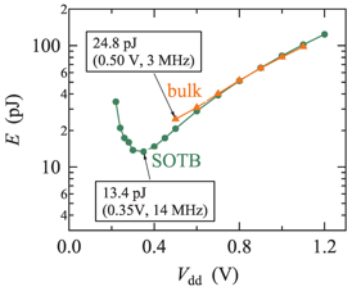
mmWave RF-CMOS



Source: GF, GTC2017

Best CMOS mmWave with similar performance to SiGe radios

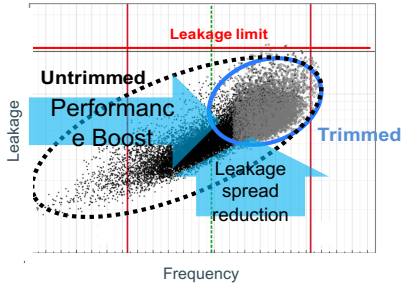
Ultra Low Voltage



Source: Sugii ,Low Power El. Appl. 2014

Operation at minimum energy point (<0.4V)

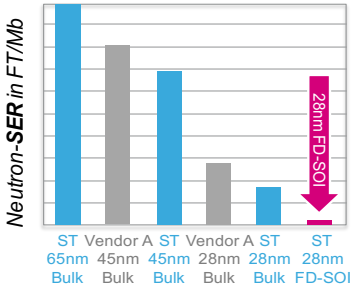
Body Bias



Source: ST, ICICDT17, P. Flatresse

5X energy efficiency gains at ULV

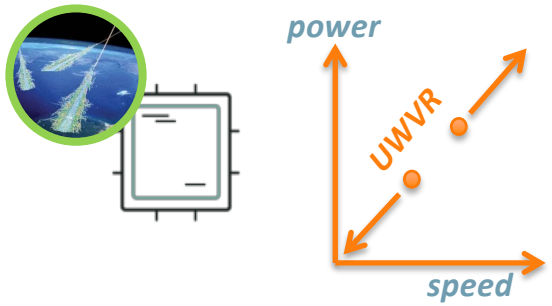
Reliability



Source: ST, Shanghai FDSOI forum, 2015

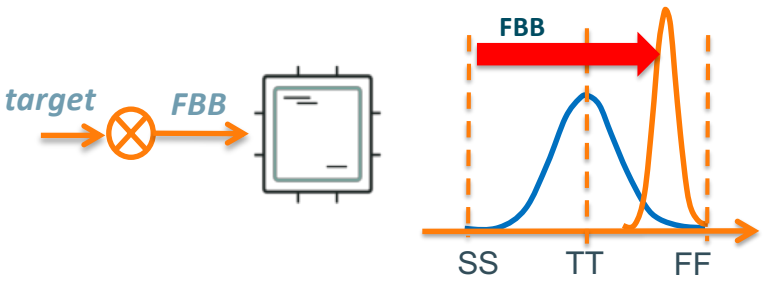
20x Soft Error Rate improvement vs. bulk

BODY-BIAS : A KNOB FOR ENERGY-EFFICIENCY



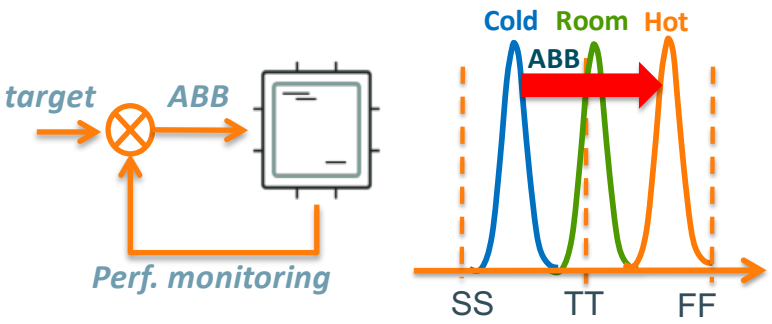
Past

- Low V_{dd} potential and UWVR capability
- Intrinsic radiation hardness
- Body-bias **boost** mode



Now

- **Static FBB** for process variations trimming

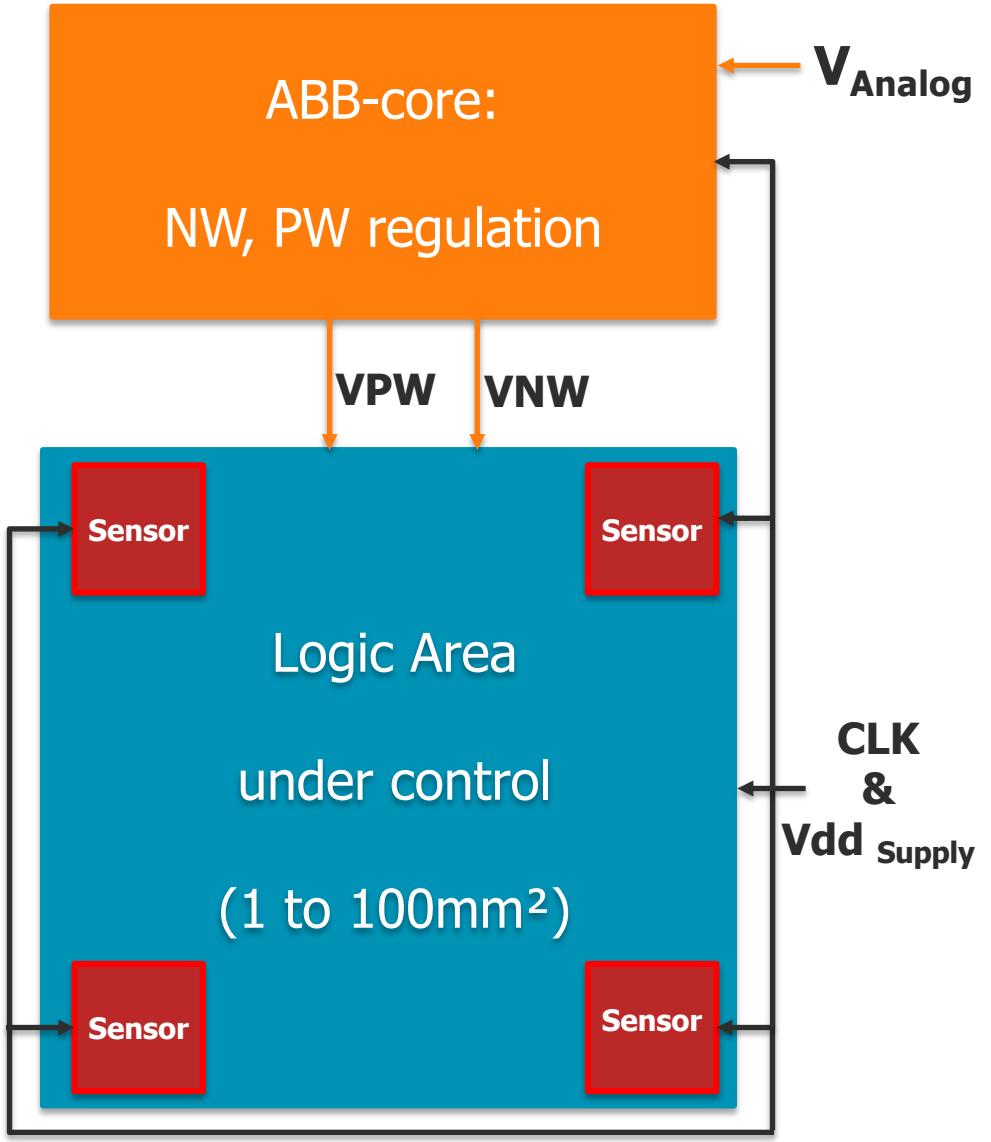


Future

- **Adaptive Body Bias** (**ABB**) for compensating
  - Temperature variations in Low V_{dd} range
  - Aging variations in Nom to High V_{dd} range

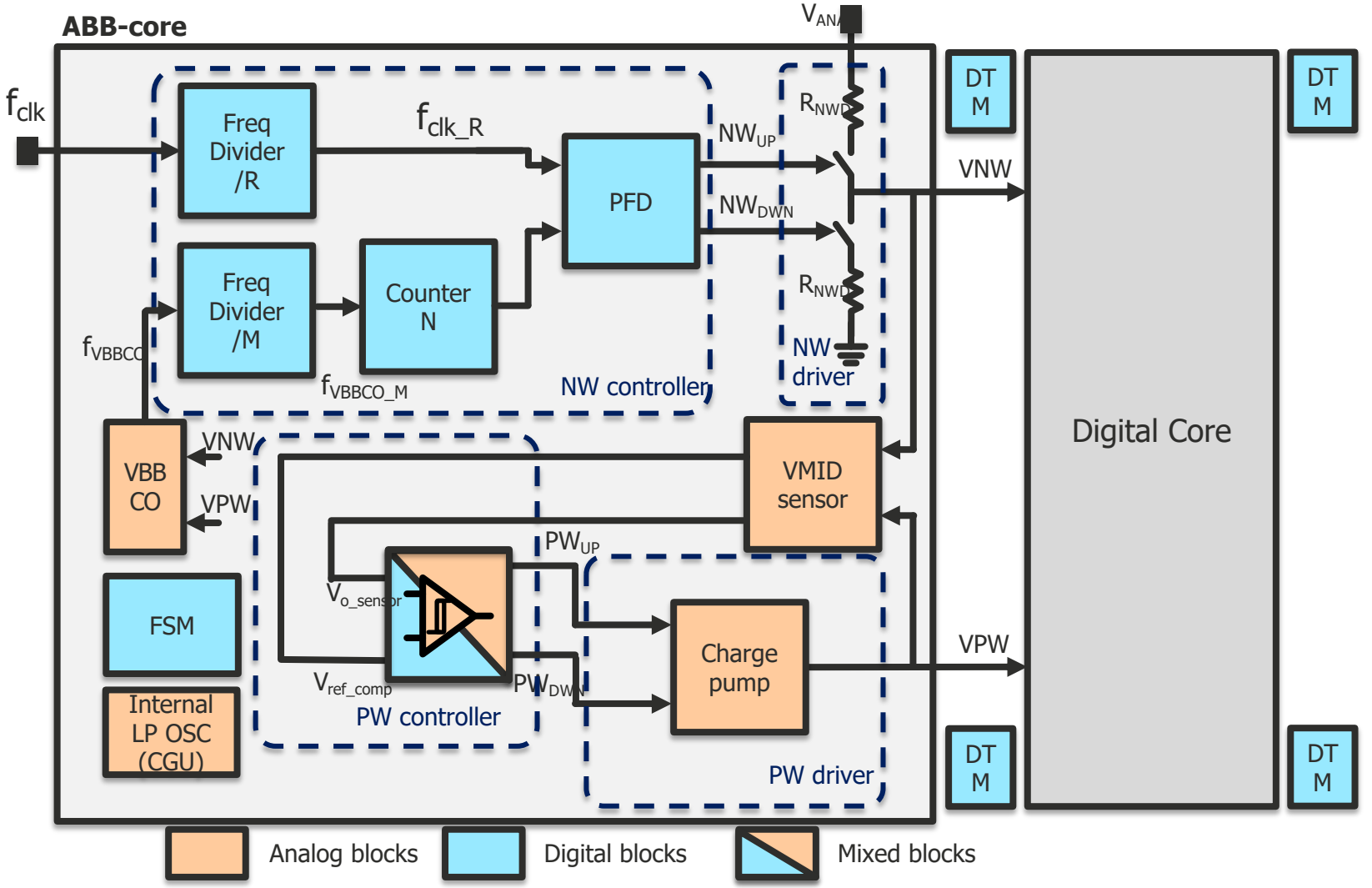
22FDX™ ABB IP KEY FEATURES

- **ABB IP** for Process, Voltage, Temperature & Aging compensation
- **All-in-one IP** including body-bias voltage regulator, low power sensors and control loop
- **Foundation IP independent**
- **Ultra wide voltage range:** 0.4V to 0.945V
- **< 1% area overhead** vs. logic area
- **< 10 µW power overhead**

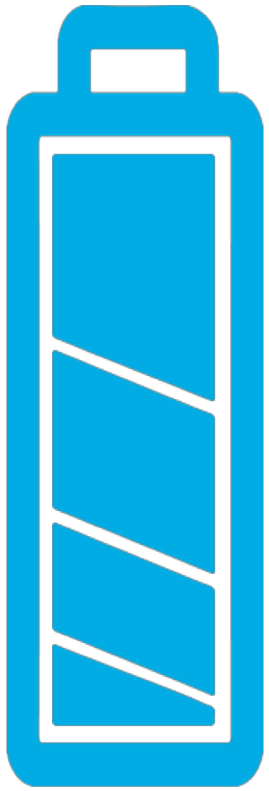


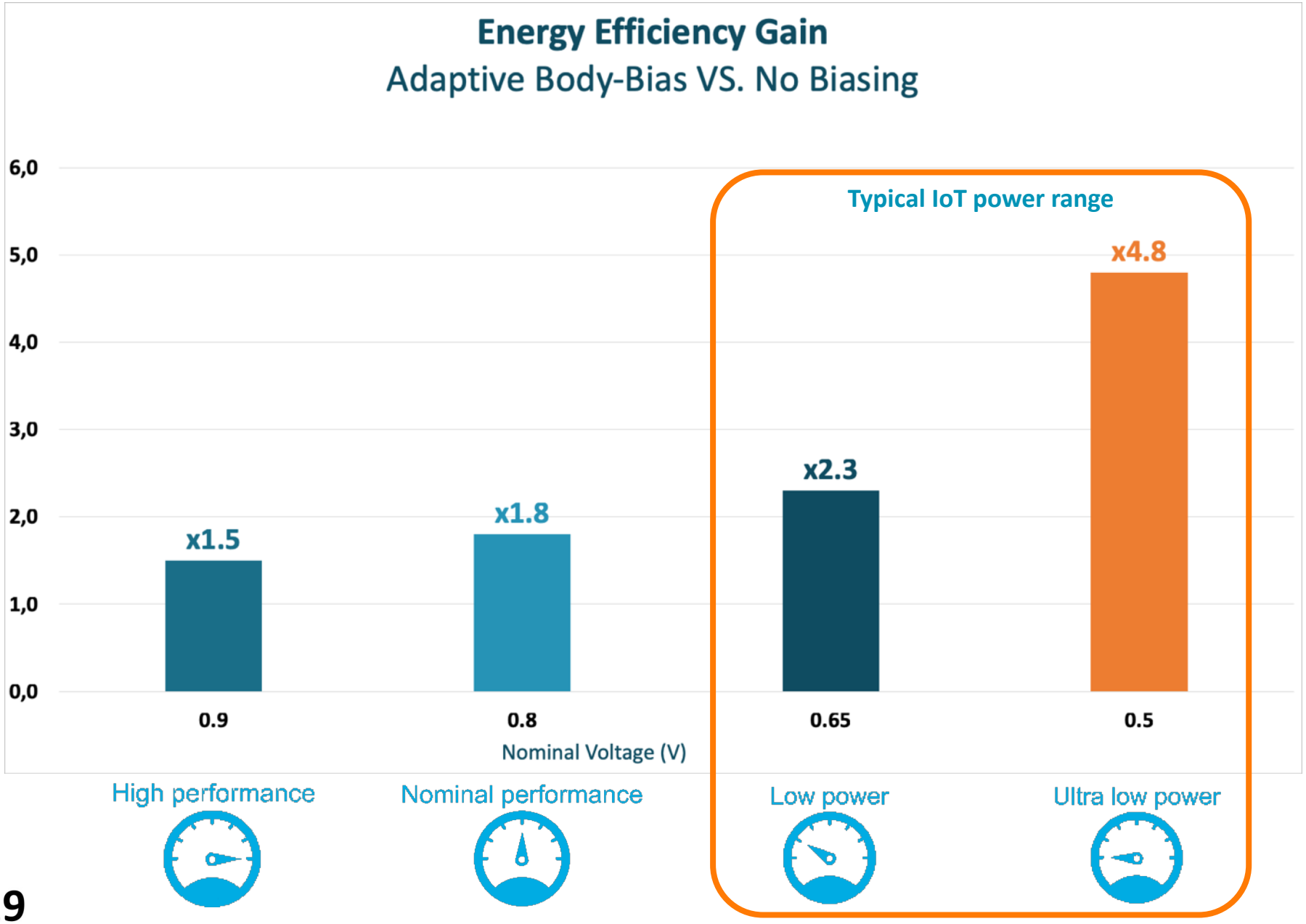
22FDX™ ABB IP KEY FEATURES

- **2 Sensors**
  - → VBBCO monitor for coarse-grain compensation
  - → Distributed Timing Monitors (DTM) for fine-grain compensation
- **2 independent N- & P-WELL regulation loops**
  - → VNW regulation refers to Fclk
  - → VPW regulation refers to VNW



PPA Improvement with Adaptive Body-Bias

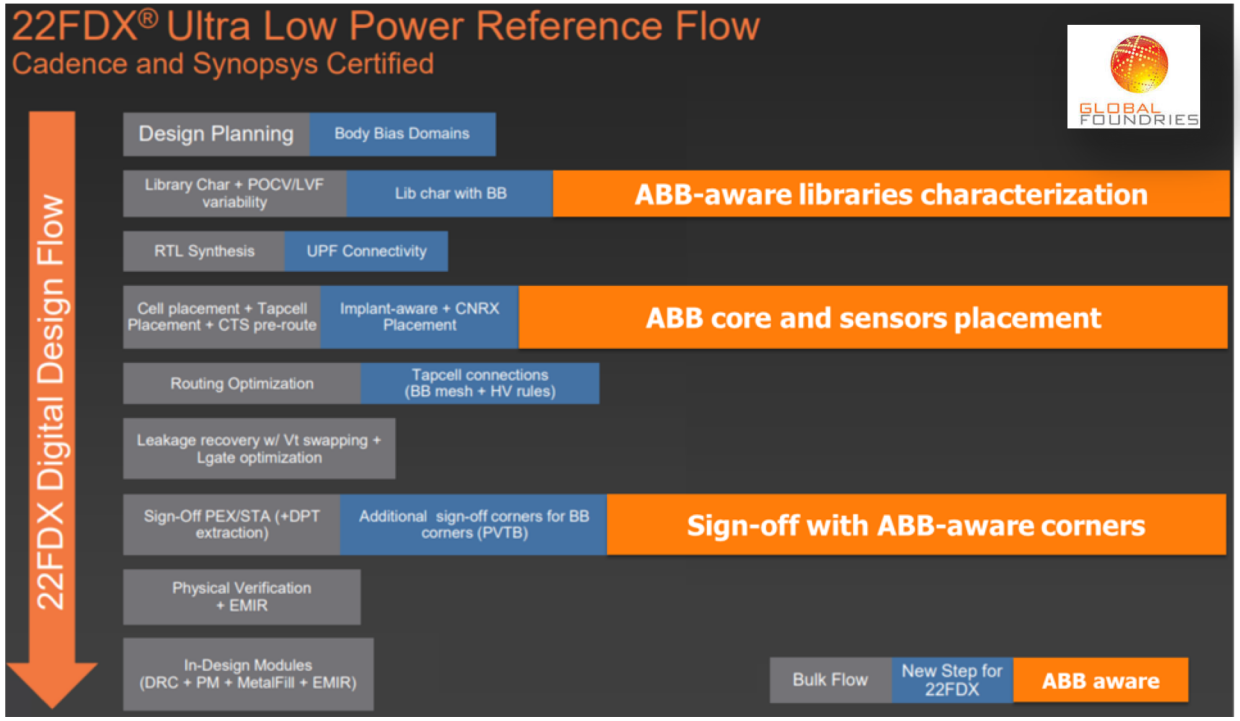


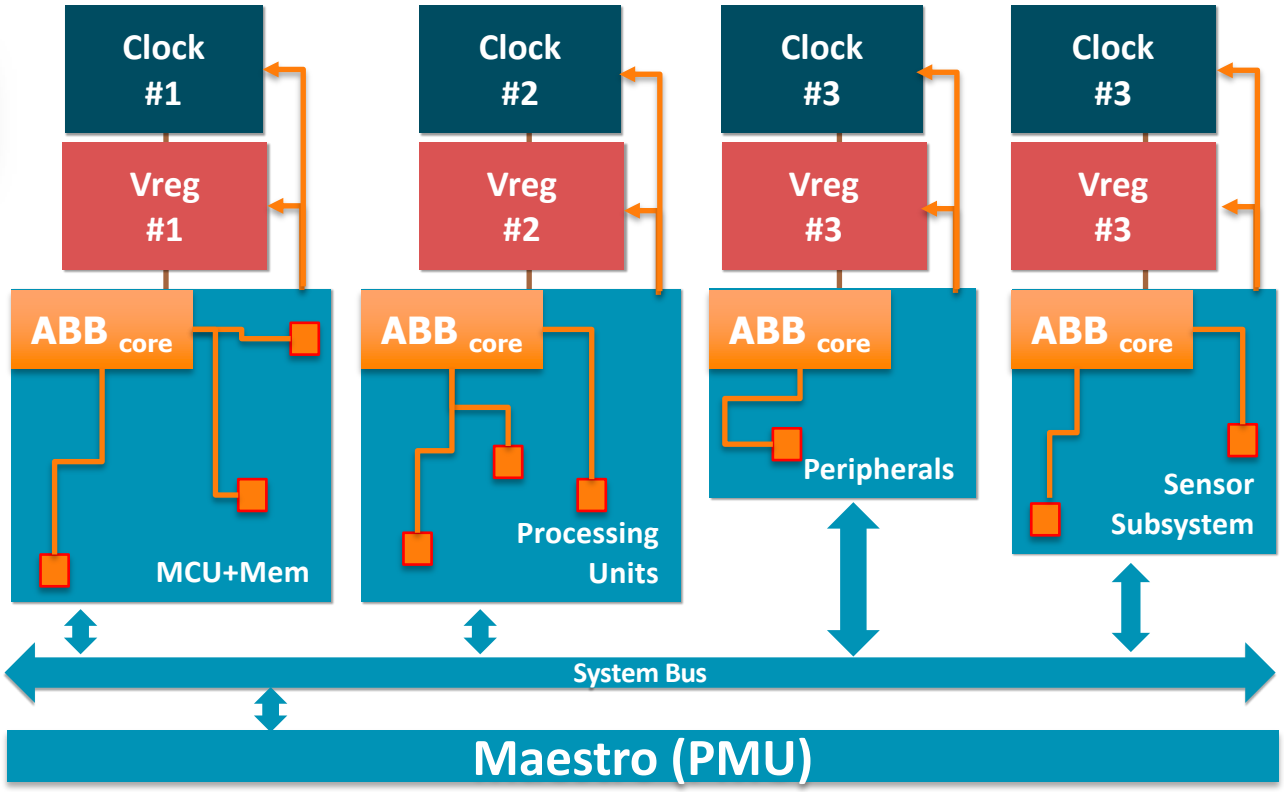


ARM® Cortex®-M4

GF 22FDX™

ADAPTIVE BODY-BIASING IN 22FDX™ SOC DESIGN FLOW



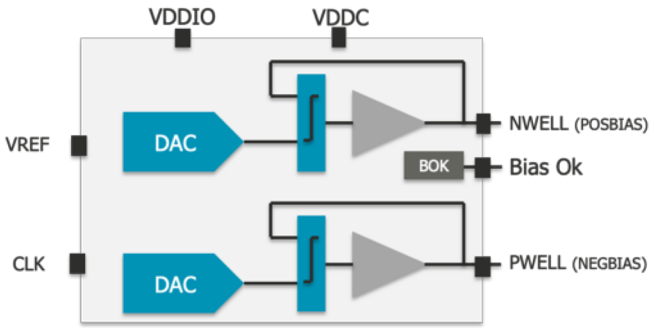


Seamless Integration in 22FDX™ Design Flow

Scalable to any SoC Architecture

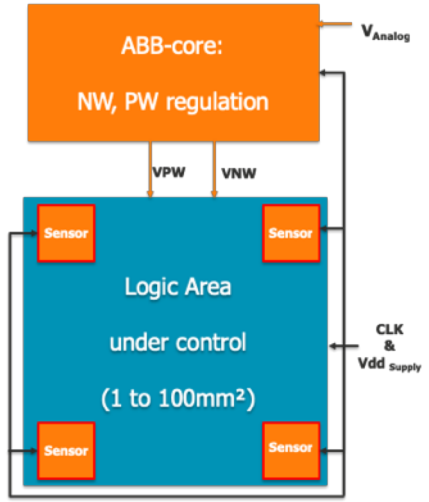
BODY-BIAS IP PORTFOLIO

Stand-Alone Body-Bias Generator



- **Several configurations** to support various loads size
- **Ultra low current consumption < 10µW** in active/shutdown mode

Adaptive Body-Bias for Mostly-Off Domain

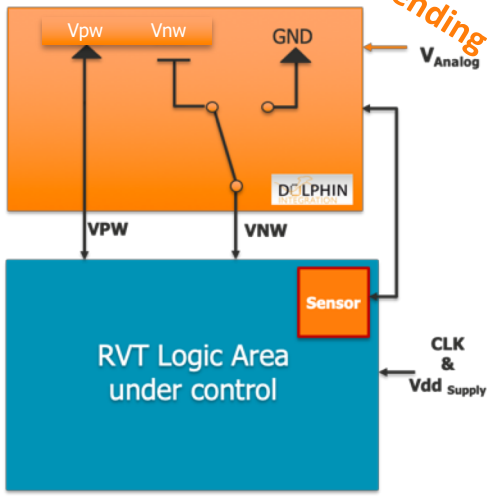


- **All-in one IP** for PVTA compensation
- **Ultra Wide voltage range**
- **< 1% area overhead** vs. logic area
- **< 10µW power overhead**

Zero Power BBGEN for Always-ON Domain

Patent Pending

- **AON** is dominated by leakage
- Hungry charge pump not an option
- **RBB** only as an attractive solution to reduce leakage



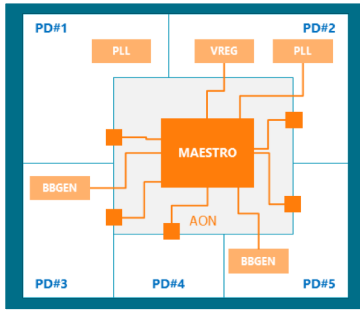
Energy-Efficiency is a function of PVT sensors accuracy

Accuracy

Energy-Efficiency

- **SlackGuard™** : Aging monitors
  - Timing margin detection of critical paths
- **DTM :** Delay Timing Monitor
  - Fine grain compensation
- **VBBCO :** Body Bias Controlled Oscillator
  - Coarse grain compensation

POWER MANAGEMENT IP PLATFORM



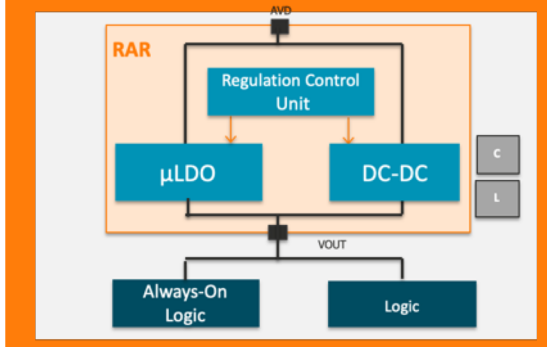
Embedded PMU/ACU

Scalable and configurable

Boot-up sequence management

Body-Bias, DVFS, AVS support

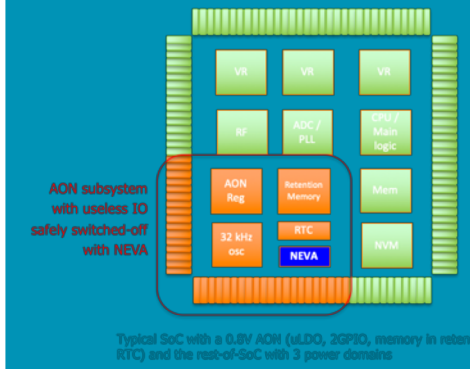
Voltage Regulators



High Efficiency DC/DC
Ultra-low quiescent LDO

95% Efficiency
Quiescent down to 150 nA

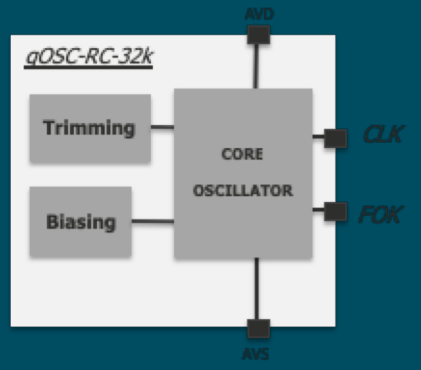
Power Gating Solutions



Ultra-low leakage IO & logic power gating

IO Leakage reduction up to x14

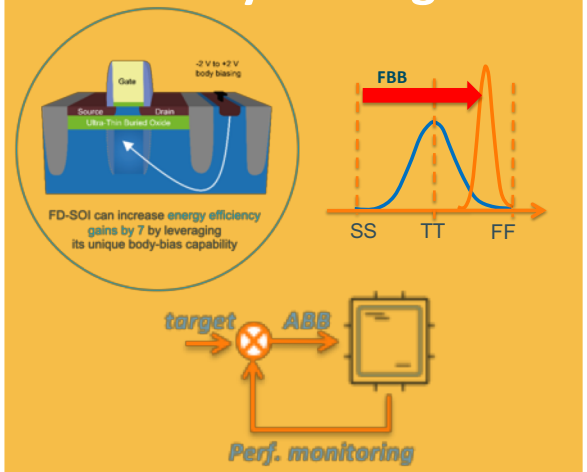
uLP Oscillators



32 kHz RC & XTAL

Ultra Low power < 80 nA

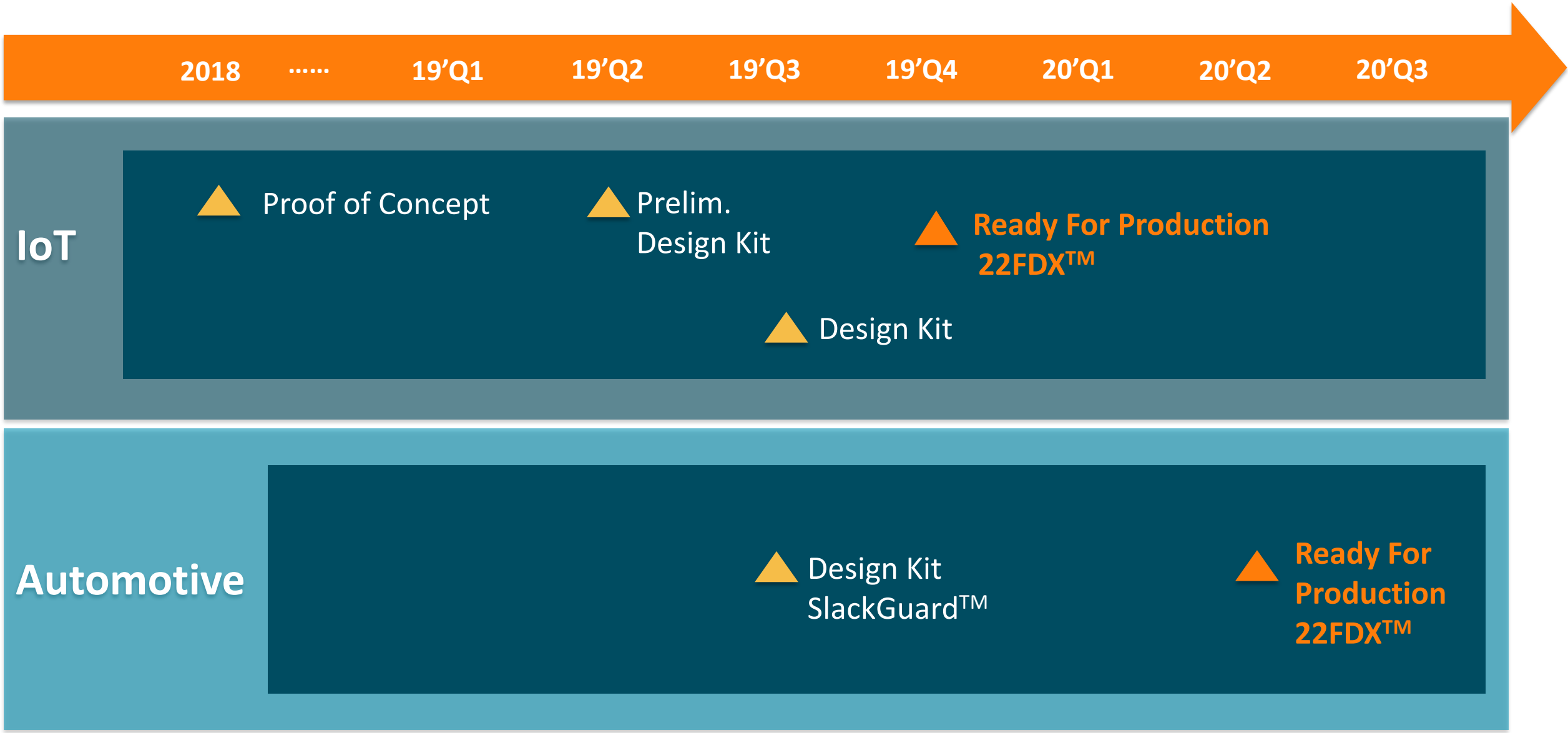
Body-Biasing



PVTA Compensation

5x Energy-Efficiency ABB
7x Energy-Efficiency ABB + AVS

ADAPTIVE BODY-BIAS ROADMAP



danke
謝謝
ngiyabonga
teşekkür ederim
спасибо
dank je
thank you
gracias
tapadh leat
bedankt
hvala
mauruuru
mochchakkeram
dziękuję
go raibh maith agat
obrigado
sagolun
sukriya
kop khun krap
arigatō
takk
dakujem
grazie
terima kasih
мерси
감사합니다
ευχαριστώ
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