The Evolution of Mobile Technology

Part 1:
Designing for High-Performance and All-Day Battery Life

January 28, 2009

Moderated by Jim McGregor
Chief Technology Strategist
In-Stat

Introduction

- **Welcome to the Evolution of Mobile Technology webinar series featuring:**
  - Designing of High-Performance and All-Day Battery life – 1/28/08
  - Increasing Performance and Design Reuse with Advanced Processing Architectures
  - Creating Flexible Designs for Future Features and Applications
  - Designing Challenges of Coexistent Wireless Technologies
  - The Impact of the Cloud on Mobile Devices
  - The Future of Wireless Technologies
- **Today's host:**
  - Jim McGregor, Chief Technology Strategist, In-Stat
- **Agenda**
  - 5-minute overview
  - 30-minute discussion by panelists
  - 25-minute live Q&A
- **Archive of webinar available at:**
  - www.ti.com/wirelesspresentations
  - www.instat.com

Panelists

- **Doug Phillips – System Challenges**
  - Product Line Manager, TI's Portable Consumer Analog business
  - More than 10 years of design and marketing experience in battery management and power management semiconductors
  - Possess deep understanding of power design requirements and battery considerations in a smart phone environment
- **Steve Jahnke – Processor Challenges**
  - Chief architect, OMAP platform
  - Member of TI's Group Technical Staff
  - More than 10 years focusing on System-on-a-Chip (SoC) and software design at TI for the automotive, communication and consumer electronic markets
  - Oversees the entire production, from architecture and design to testing and release for OMAP processor Linux support

Performance is Inherent

Improvements

- Communication speeds
- Display resolution
- Graphics
- Storage capacity
- Processor performance
  - Applications

Enhancements

- Touch screens
- Wi-Fi connectivity
- Key boards
- Motion control
- Other enhanced features
  - **Pico projectors**

Higher Performance/More Features = More Power

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Battery Life is Constrained

Battery Capacity! = materials, size, thermal limits

Estimated Battery Life =

(Battery Capacity [mAh]/ Device Current Consumption [mA]) * 0.7

Improving Battery Life

- Increase battery ~~capacity~~ or size
- Reduce power consumption
  - Design using the most efficient components
  - Complete tasks as efficiently as possible
  - Turn off system components (HW/SW controls)

All-Day Battery Life

Those that can

- MP3 Player
- Cell Phone
- Smart Phone
- Digital Cameras
- e-Books

Those that can't

- Notebook PCs
- Mini-notes/Netbooks
- MIDs
- Digital Camcorders
- GPS/Navigation

The Real Difference

100s of million units/yr vs. Billions of units/yr

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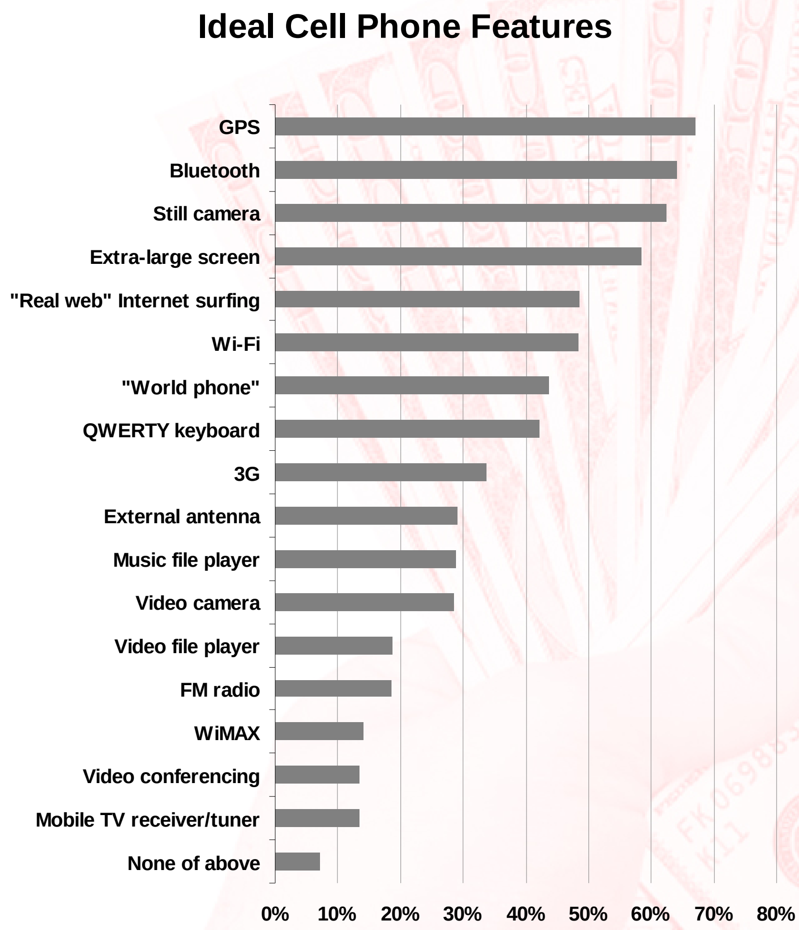
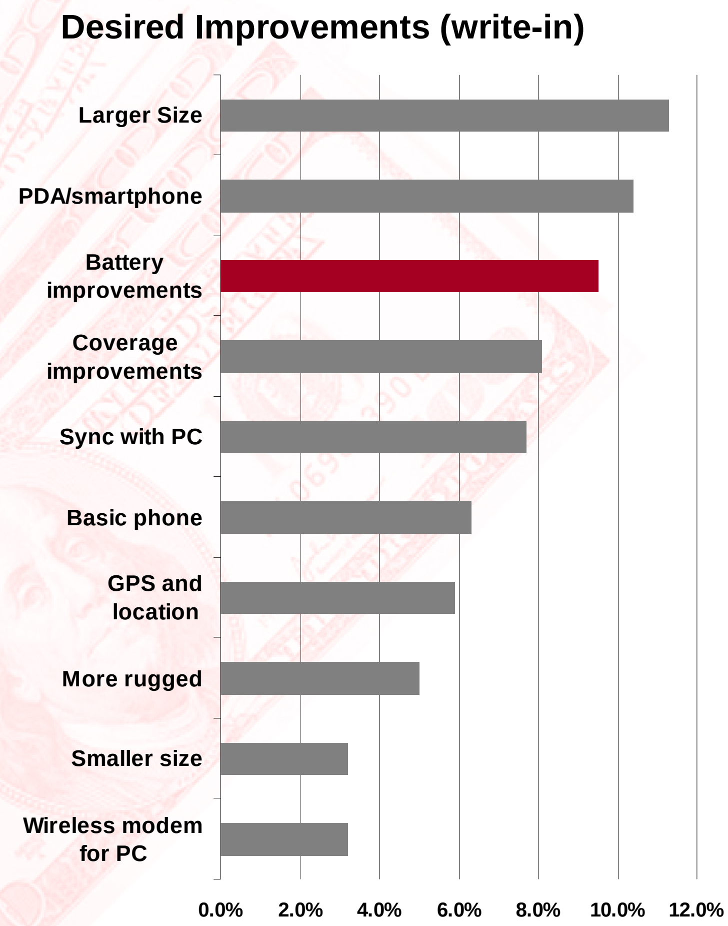
Consumer Value





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System Challenges

Doug Phillips
Product Line Manager, Portable Consumer Analog business
Texas Instruments

Customers demand better power and battery management

Longer Battery Life

Safer + Faster Charging

- Number of mobile users increasing
- Functionality increasing
- More power applications
- Power demand increasing faster than battery improvements
- Efficiency increasing
- Cost
- Portable consumers demand more out of their battery

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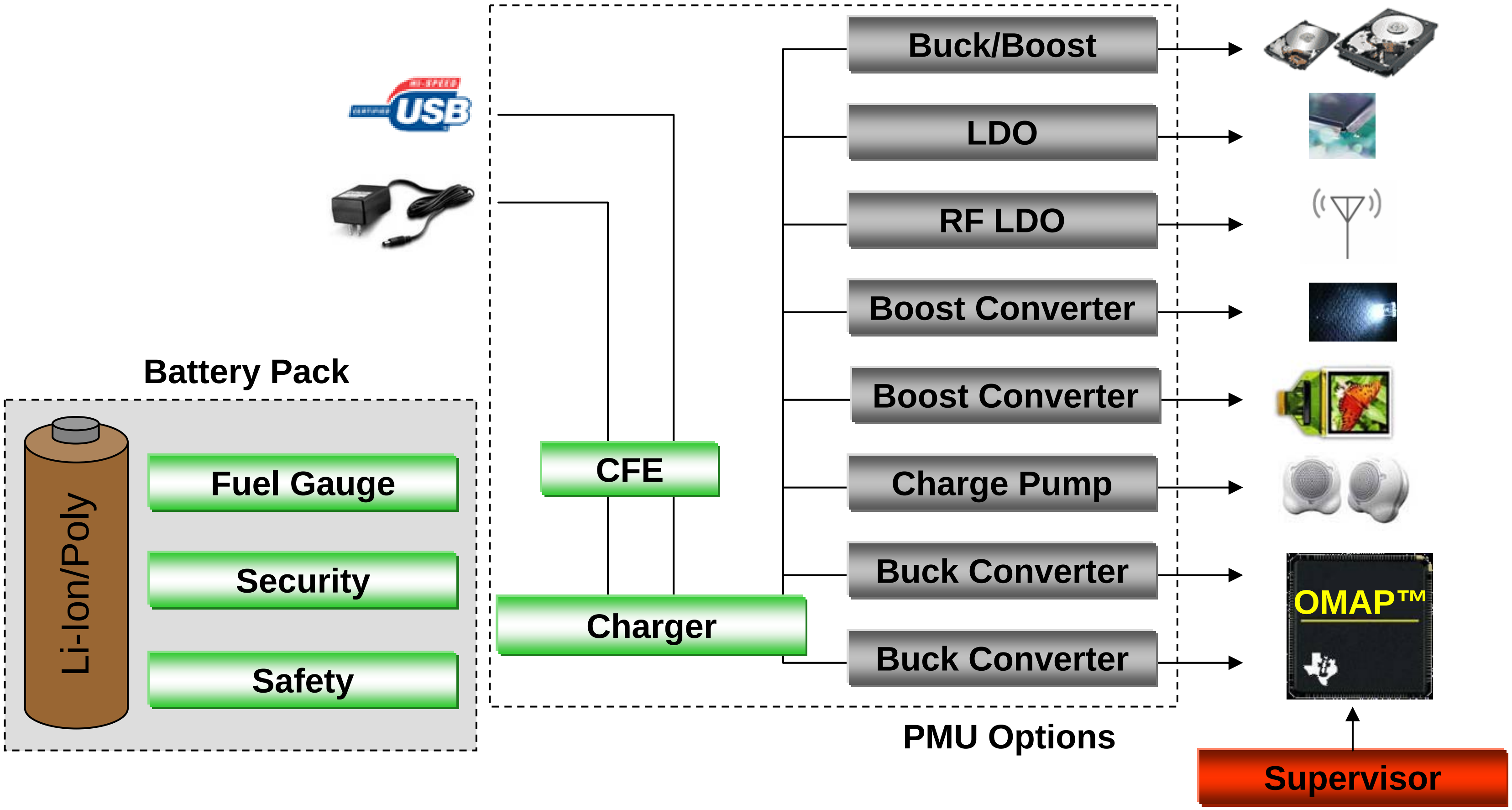
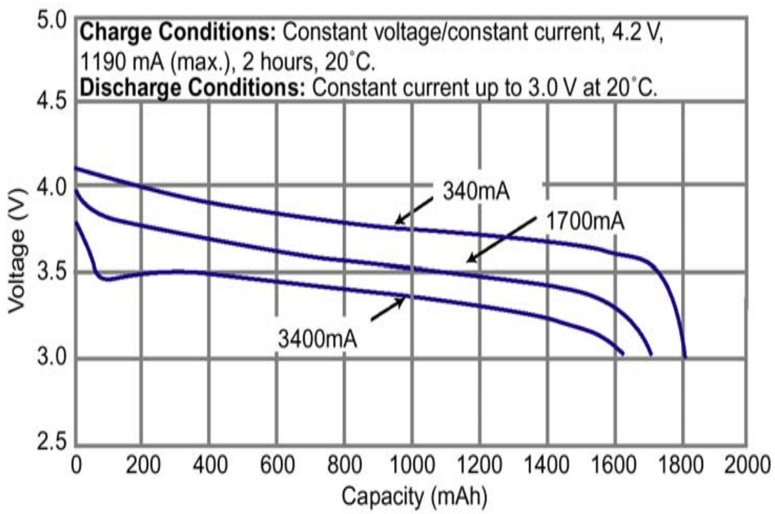
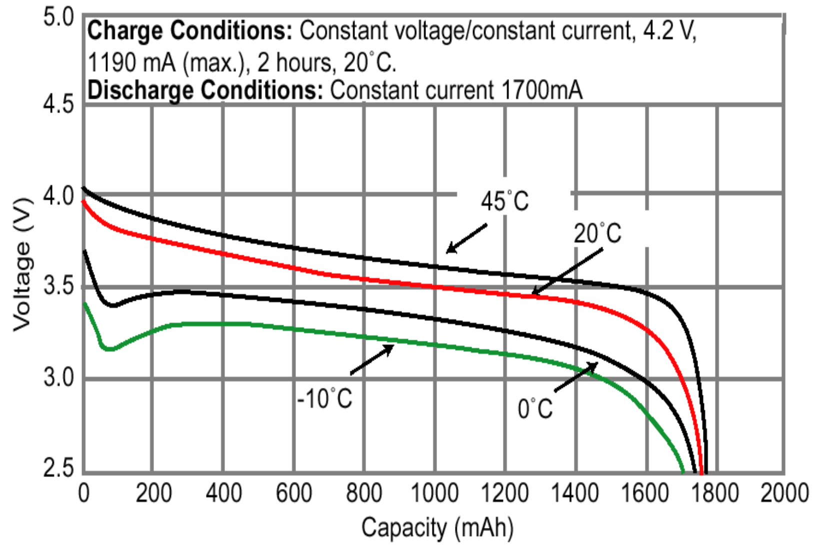
Portable power overview



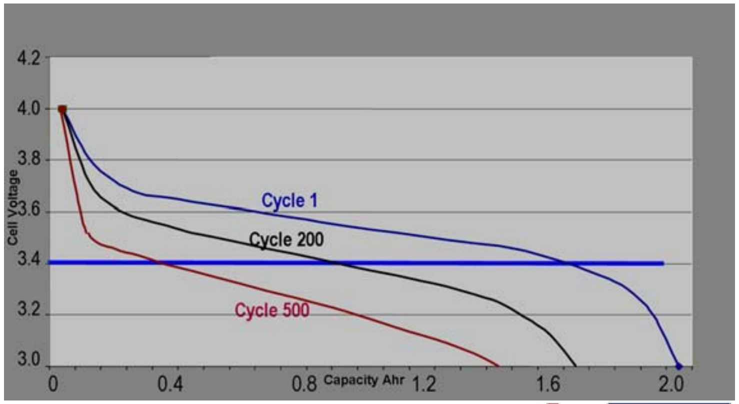
Know the battery source





Longer battery life can be achieved
With good battery management

- Accurate Charging for full capacity
- Nominal C rate profile (Charge / Discharge)
- Limiting temperature extremes



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What fuel gauging provides

- **<u>Predicts battery capacity</u> under all system active and inactive conditions**
- **<u>Battery capacity</u> can be reported in terms of accurate percentage, time to empty/full, milliamp-hours or watt-hours, talk time, idle time, # of pictures, etc.**
- **<u>Other data</u> can be obtained for battery health and safety diagnostics.**
  - # of charge/discharge cycles
  - Maximum operating temperature
  - Current I, V & T conditions
  - Fully charged, empty conditions
  - Near empty warnings
  - Over- / under-charge conditions

73%

Run Time 6:23

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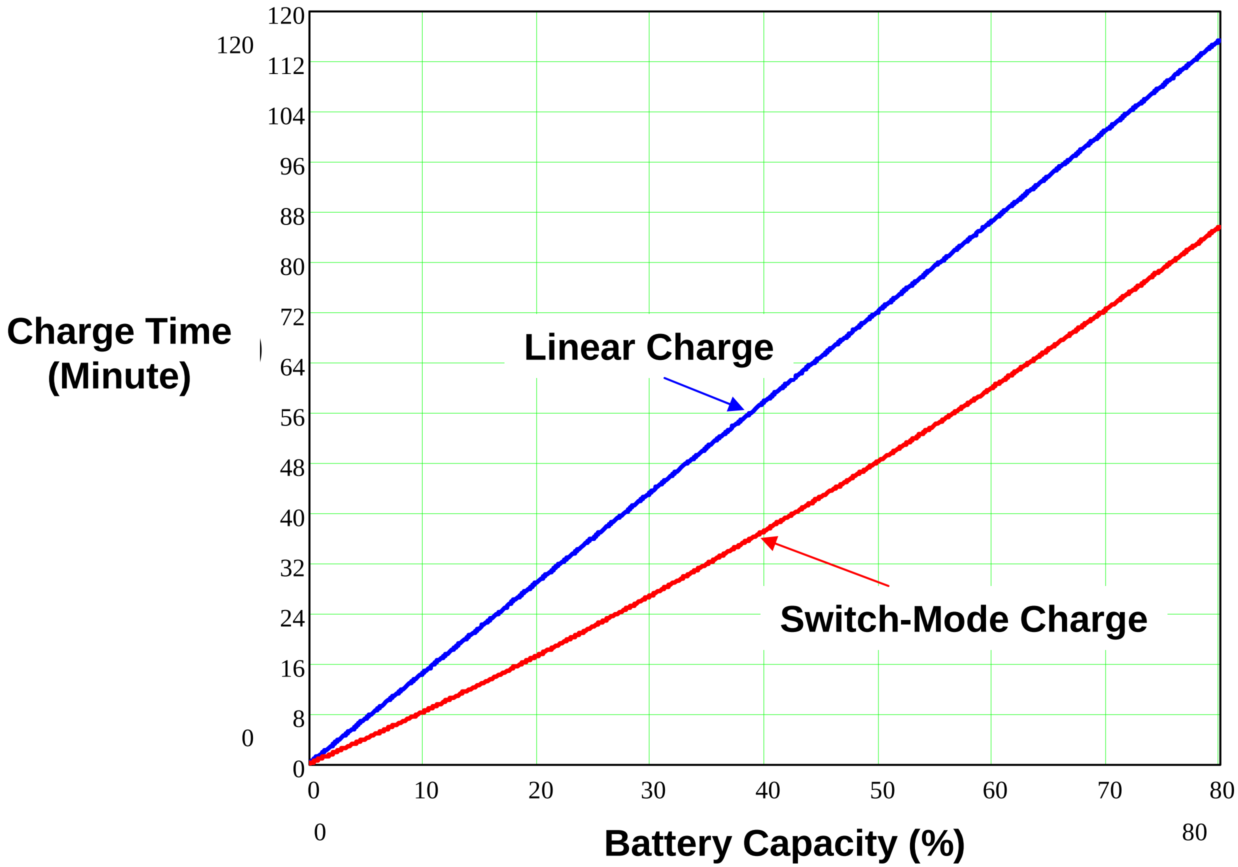
Charge Time Comparison Switch-Mode Charger vs Linear Charger



- Input current is 500mA
- V_{IN}=5V
- T_{AMB}=25˚C

- Assume Battery capacity is 1.2AH and 1AH is charged during constant current mode
- Battery is charged from 2.4V to maximum battery voltage (4.2V)
- For switch-mode charge, f_{SW}=3MHz, Lo=1.0µH, Co=10µF

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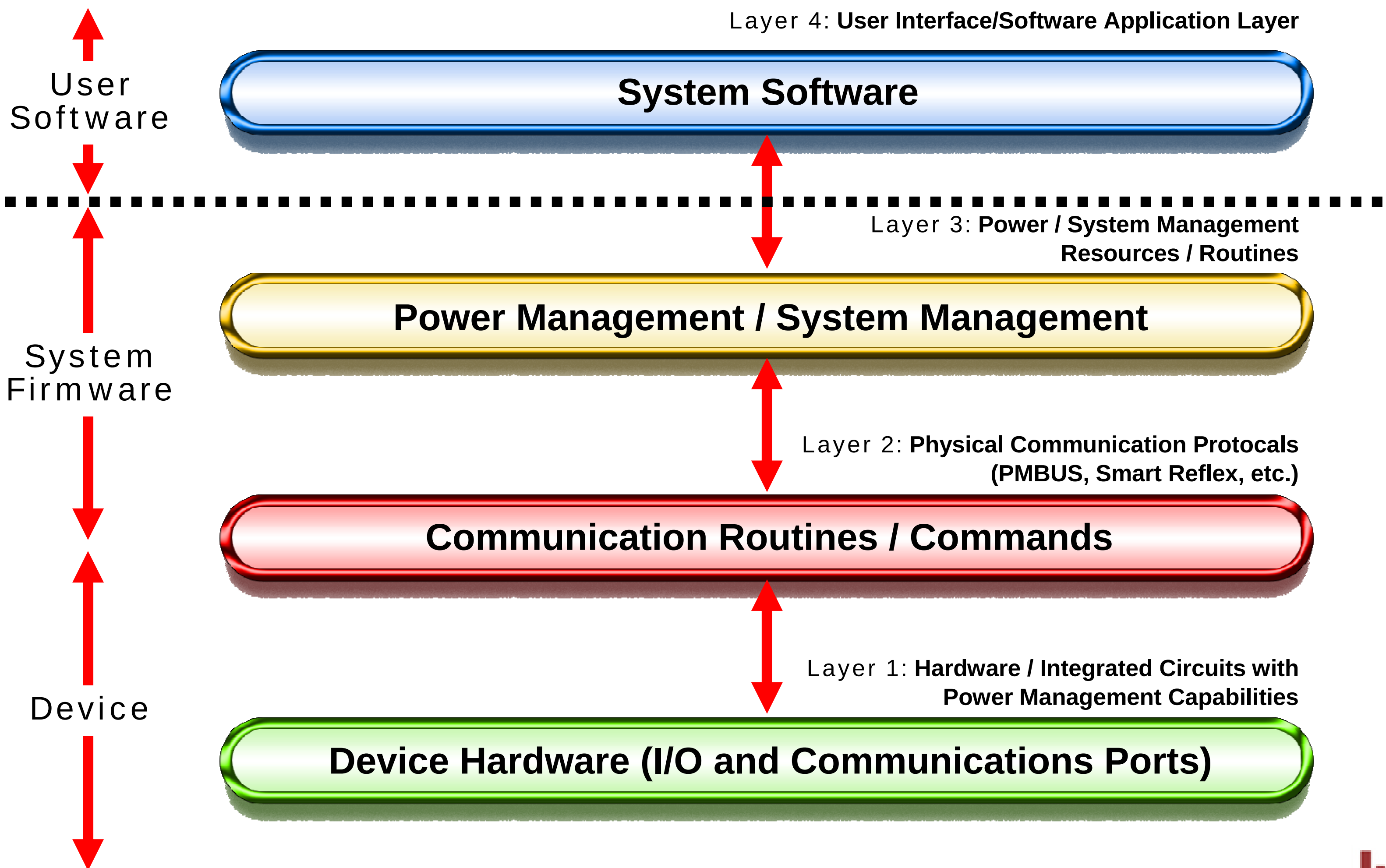
Power OS: Enabling the system



DC/DC considerations

Efficiency	Cost	Features
Solution Size	Switching Frequency (Switching Converter)	Power

Which set of attributes is the most important?

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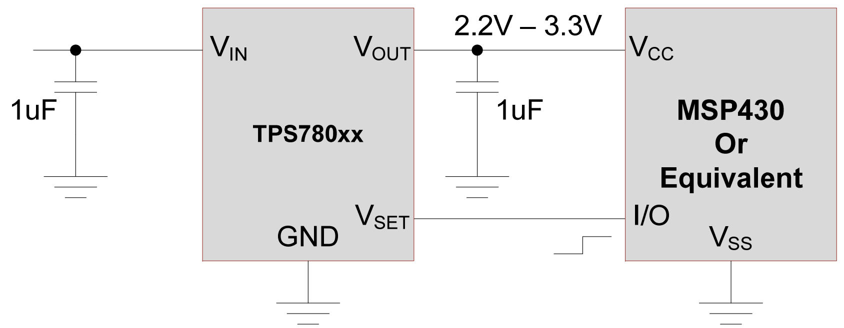
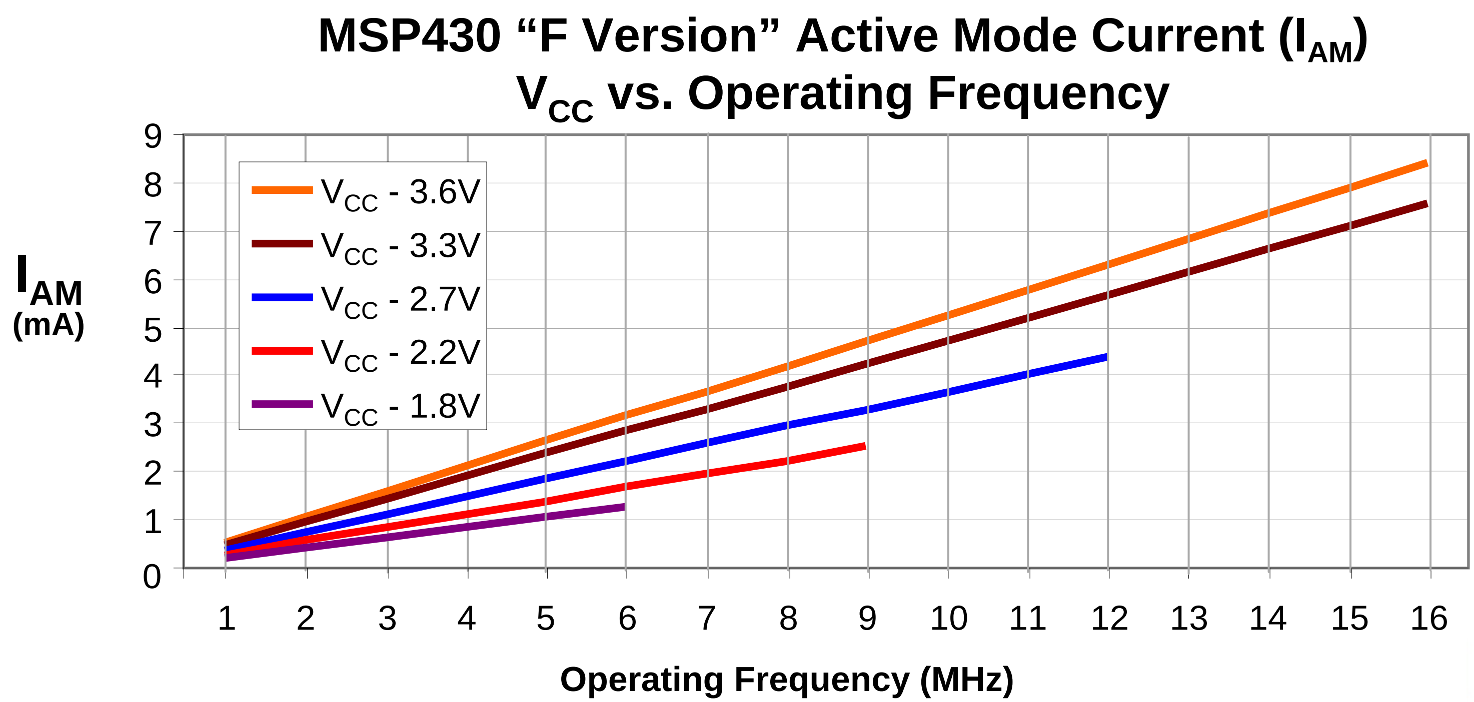
Dynamic Voltage Scaling (DVS)



Basic circuit diagram for the TPS780xx LDO and MSP430 MCU



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Dynamic Voltage Scaling (DVS)

Dynamic Voltage & Frequency Scaling (DVFS)

Consume less energy/power in low performance modes by lowering the voltage

	IVA MHz	ARM MHz	VDD_MPU_IVA
OMAP 3530 processor	430	600	1.35
	400	550	1.27
	360	500	1.20
	180	250	1.00
	90	125	0.95

L3 MHz	VDD_CORE
166	1.15
100	1
41.5	0.95

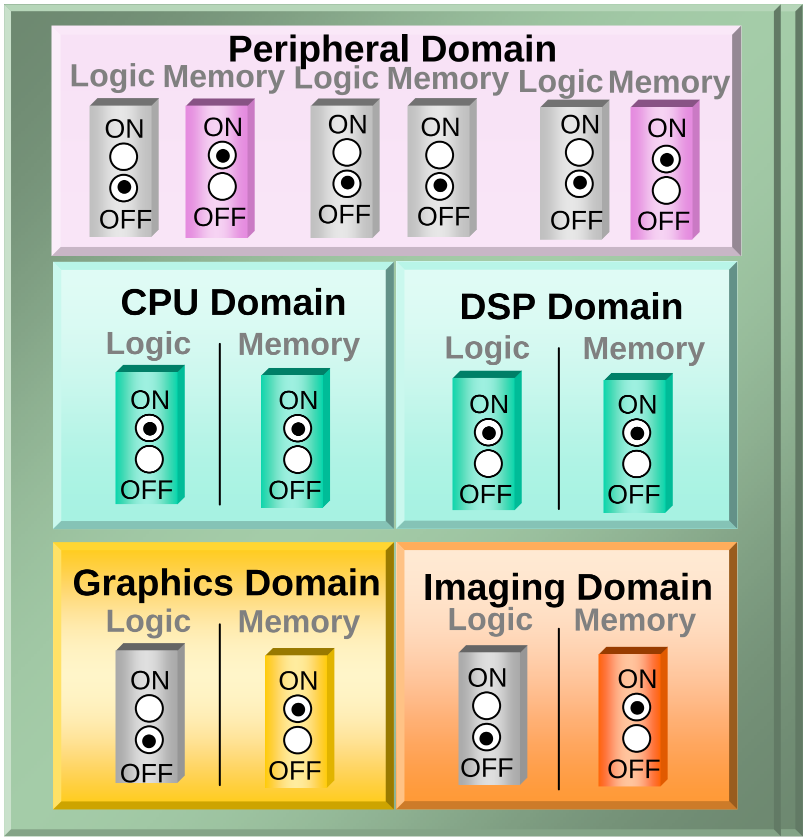
Summary

- Know the power source
- Design for all usage conditions
- Give users power management flexibility

Processor Challenges

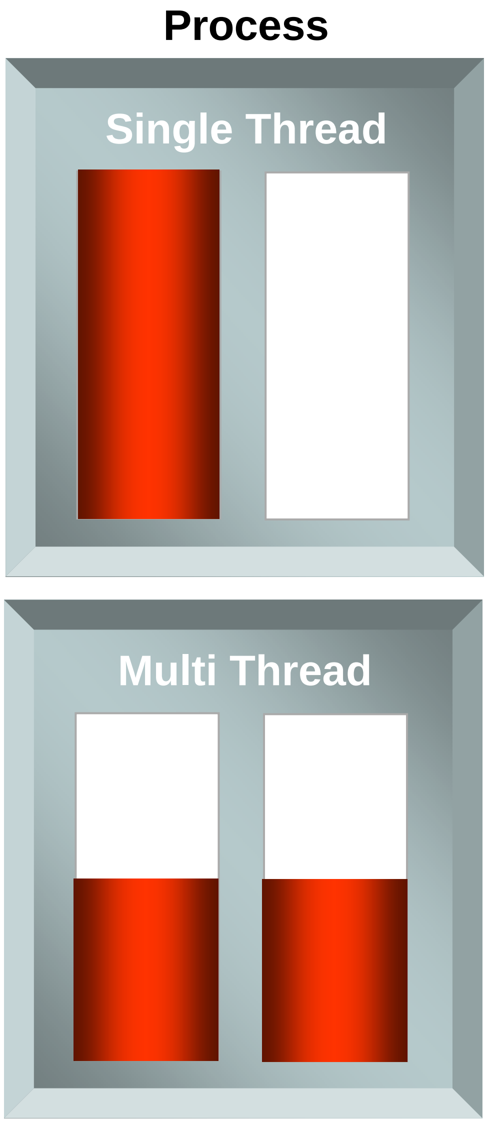
Steve Jahnke
Chief Architect, OMAP Platform
Texas Instruments

Integration and segmentation in silicon



- In a large SOC, not all the device logic will be used in all use cases
- It is not enough anymore to just turn clocks off to the unused logic, the entire power supply must be cut
  - Needed for leakage control
- Control to external power IC also is on its own power domain, and its logic is kept as small as possible
- Memories and logic are on separate power domains
  - Physical structures are different
    Voltage requirements differ

Active cores in embedded systems



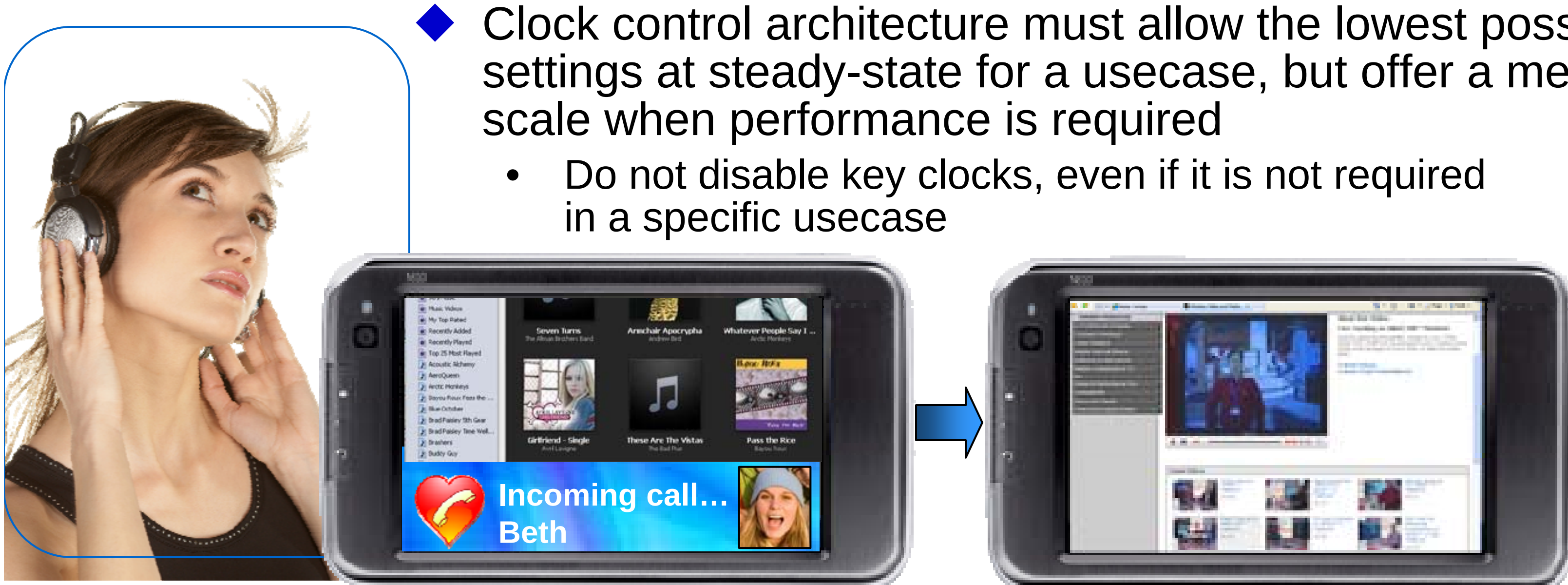
- Existing technology and software algorithms for dual-core processors is to always keep both cores active, and scale frequency only
- In order to reach ultra-low power consumption, it is necessary to be able to shut a core off
  - Only a single core is active at a low clock rate
- However, there will be some low power apps that thread well. In this case, we will want to keep all cores on at an even lower clock rate
- SW algorithms need to be employed that can understand the system behavior and make a decision on what basic approach to take:
  - Single core at a lower clock rate
  - Multiple cores at an even lower clock rate

Hardware vs. software control

- Hardware control offers speed and no-burden to the programmer, but at the expense of silicon area
  - Automatic clock gating when there is no bus activity.
  - AVS (Automatic Voltage Scaling) based on silicon process strength and ambient temperature
- Software control is used for complex decisions, but at the expense of CPU overhead and programming complexity
  - Policy management for use cases (application level control)
  - Silicon resource management based on device driver needs (driver level control)
- In general, power management done at the fundamental transistor level upto clock gating is done in hardware. Decisions made on what to power domains to cut, what operating frequency is used, up to application needs is done in software

Clock rate on power and user experience

- Clock rate is obviously an important contributor to power consumption
  - Whenever possible, want to run the CPUs at the lowest clock rate for the desired usecase, and shut off unnecessary clocks.
- However, battery life is only one component of the consumer care-about in a mobile product
  - Boot up, how fast to switch between apps, how fast is the web browser, etc.
- If clock control is too aggressive for a specific use-case (such as MP3 playback), it will affect the user experience on other, key functions.
  - Time it takes to turn on and re-sync any disabled clocks
- Clock control architecture must allow the lowest possible clock settings at steady-state for a usecase, but offer a means to quickly scale when performance is required
  - Do not disable key clocks, even if it is not required in a specific usecase



Summary

- Physics will continue to challenge enhancements in battery technology
- Consumers usage patterns combined with increased features and performance are driving a need for battery efficient devices
- Power management must be a critical decision driving all aspects of the mobile system design
- Power management must be done at all levels from silicon to system to software
  - External power management tools address system level usage
  - Integrated power management tools deliver additional power efficiencies

Q & A

- To participate, click on the Ask a Question link on the left side of the interface; enter your question in the box on the screen; hit “Submit.” We’ll answer them during the Q&A session or after the webcast.

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