Richland Client APU

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AGENDA

- “Richland” Key Features
- Overview of AMD Turbo CORE Technology
- "Richland" Enhancements to AMD Turbo CORE Technology
  - Temperature-smart AMD Turbo CORE
  - Configurable TDP (cTDP)
  - Intelligent Boost
  - Additional boost Pstate
- "Richland" Improvements to Battery Life
- Other Salient Features
  - AMD Wireless Display
  - Dock Port Technology
- Results: Performance and Battery Life
"RICHLAND" KEY FEATURES

<table>
<thead>
<tr>
<th>IMPROVED PERFORMANCE &amp; POWER EFFICIENCY</th>
<th>Higher performance:* Up to 29% higher CPU performance and up to 41% higher GPU performance</th>
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<tbody>
<tr>
<td></td>
<td>• Higher frequencies than 2nd Gen A-Series APU (both x86 and GPU) through process node improvements</td>
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<td></td>
<td>• New AMD Turbo CORE features</td>
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<td></td>
<td>• Temperature-smart AMD Turbo CORE, Intelligent Boost, addl. boost P-state</td>
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<td></td>
<td>• Higher memory speeds: Up to DDR3-1866 on NB and up to DDR3-2133 on DT</td>
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<td>Better battery life:** 10 or more hours idle, 7 or more web, 4 or more video</td>
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<td></td>
<td>• Optimized voltage/frequency</td>
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<td></td>
<td>• Process-tuning</td>
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<td>AMD Start Now technology **</td>
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<tr>
<td></td>
<td>• Quick S3, S4 resume and WLAN quick connect</td>
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<td></td>
<td>Motherboard compatibility with FS1r2, FM2 packages and FCH</td>
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<tr>
<td></td>
<td>• Quick TTM, minimize development costs</td>
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<tr>
<td></td>
<td>Configurable TDP</td>
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<td></td>
<td>• Configure TDP of APU based on design needs</td>
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<td></td>
<td>CAN ENABLE OEM FLEXIBILITY FOR 2013 MAINSTREAM SOCKETED PLATFORMS</td>
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<td>PROVIDES TABLET-LIKE RESPONSIVENESS, TAKING ADVANTAGE OF WINDOWS® 8 IMPROVEMENTS</td>
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<td>ALLOWS OEM TO TAILOR THERMAL DESIGNS BASED ON PLATFORM GOALS</td>
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<td>DELIVERING BEST VIDEO PLAYBACK EXPERIENCE</td>
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<td>UNIQUELY SCALABLE GRAPHICS LEADERSHIP</td>
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<td>WATCH MORE MOVIES ON ONE CHARGE</td>
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<tr>
<td>FLEXIBLE DESIGN OPTIONS</td>
<td>ENHANCED GRAPHICS AND ENTERTAINMENT</td>
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<td>Next-generation AMD media features</td>
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<td></td>
<td>• Wi-Fi standards-based wireless display</td>
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<td></td>
<td>• Dock Port technology</td>
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<td>New discrete graphics support</td>
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<td>• AMD Radeon™ Dual graphics*** with the “Solar System” family</td>
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<td>Power-optimized for media consumption</td>
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<tr>
<td></td>
<td>• Up to 51% improvement in HD video playback*</td>
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</table>

*Refer to slides 22-23 for performance results; **Refer to slide 24 for power results.

**AMD Start Now technology is a BIOS optimized solution designed to deliver a highly responsive system by minimizing the time to wake up the system from sleep mode, boot the system to desktop and connect to a wireless local area network. Actual times will vary based on operating system, APU, driver, disk drive and memory speed. AMD Start Now technology is available with select AMD APUs when running Windows® 7 or Windows® 8. Check with your component or system manufacturer or retailer for specific model capabilities.

***AMD Radeon™ Dual Graphics requires an AMD “A” Series APU plus an AMD Radeon™ discrete graphics configuration and is available on Windows® 7 and/or Windows® 8 OS. Linux OS supports manual switching which requires restart of X-Server to engage and/or disengage the discrete graphics processor for dual graphics capabilities. With AMD Radeon™ Dual Graphics, full enablement of all discrete graphics video and display features may not be supported on all systems and may depend on the master device to which the display is connected. AMD Radeon™ “G” series and AMD Radeon™ “G2” Dual Graphics series do not support AMD Eyefinity technology. Check with your component or system manufacturer for specific mode capabilities and supported technologies.
Without AMD Turbo CORE technology, power and temperature headroom may be left untapped in many workload scenarios.
## Evolution of AMD Turbo Core Technology

<table>
<thead>
<tr>
<th>Year</th>
<th>Processor</th>
<th>Boosting decision based on</th>
<th>Notes</th>
</tr>
</thead>
</table>
| 2010 | AMD Phenom™ II | ▪ Number of cores active | ▪ **Single boost Pstate** used if half or more cores are inactive  
▪ Coarse-grain power margin exploited |
| 2011 | 1st-Generation AMD A-Series APU | ▪ Calculated power | ▪ **Unidirectional power transfer** between thermal entities  
▪ GPU→CPU  
▪ Exploit fine-grain power margin |
| 2012 | 2nd-Generation AMD A-Series APU | ▪ Calculated power  
▪ Calculated temperature | ▪ **Bidirectional power transfer** between thermal entities  
▪ GPU→CPU  
▪ CPU→GPU  
▪ Exploit temperature margin |
| 2013 | 3rd-Generation AMD A-Series APU ("Richland") | ▪ Calculated power  
▪ Calculated temperature  
▪ Measured/Sensor temperature  
▪ **Efficiency of power usage** by individual entities (CPU, GPU, etc.) | ▪ Designed to more effectively exploit temperature margin by detecting favorable thermal conditions in real time |
BUILDING BLOCKS OF AMD TURBO CORE TECHNOLOGY

THERMAL ENTITIES

"Richland" incorporates:

- Two “Piledriver” high-performance x86 modules (core-pairs)
- 2-MB shared L2 cache per x86 module
- AMD Radeon™ HD 8000 series DirectX®11-capable GPU with six compute units
- Next-generation media acceleration technology
- Dual 64-bit memory channel supporting up to DDR3-2133
- Integrated DisplayPort 1.2 interfaces
- PCI Express® I/O Generation 2 interfaces

"Richland" is implemented in a 32-nm SOI node2+ high-K metal gate process technology

• 3 main thermal entities (TE)
  - TE1: 1st x86 module + L2
  - TE2: 2nd x86 module + L2
  - TE3: Graphics + Northbridge + Multimedia

• On each TE
  - Power and Temperature tracked
  - Frequency and Voltage controlled

  Also account for I/O power influence on each of the other TEs
BUILDING BLOCKS OF AMD TURBO CORE TECHNOLOGY

POWER CALCULATION

Activity from Cac Monitors

Power Calculation

\[ P_{\text{calculated}} = Cac \times V^2 \times F + \text{Static} \]

\[ Cac = \sum \text{weight}_i \times \text{Activity}_i \]

\[ \text{Static} = F_n(V,T) \]
BUILDING BLOCKS OF AMD TURBO CORE TECHNOLOGY

TEMPERATURE CALCULATION

RC MODEL represents:
- Cooling solution (APU heat sink, fan, etc.)
- Temperature influence of other TEs

Using calculated temperature in the AMD Turbo CORE algorithm is designed to enable AMD to deliver robust, dependable, and repeatable performance that is insensitive to part variations.
BUILDING BLOCKS OF AMD TURBO CORE TECHNOLOGY

**PSTATE SELECTION**

- If $T_{\text{calc}} < \text{Limit}$ → Step up a Pstate (i.e., raise F,V)
- If $T_{\text{calc}} > \text{Limit}$ → Step down a Pstate (i.e., lower F,V)

**Pstates**
- Discrete frequency and voltage operating points
AMD TURBO CORE CONTROL LOOPS
PUTTING THE PIECES TOGETHER

Power Calculation

Freq
V
T_{calc}

Temp. Calculation

P_{calc}

T_{calc}

Max Temp.? Limit

Max Temp.? Limit

P_{boost0}
P_{0}
P_{1}
P_{2}
P_{3}
P_{min}

Loop executed at a specific interval

T_{calc} <= Max Temp.? Limit

Check against current (EDC/TDC) And other limits

If limits encroached, throttle F and V

New Operating F, V

Control Loop (similar to above)

Control Loop (similar to above)
"RICHLAND" ENHANCEMENTS TO AMD TURBO CORE TECHNOLOGY

Temperature-smart AMD Turbo CORE
- Designed to enable achievement of repeatable higher performance for typical operating conditions
- Designed to supplement the previous AMD generation’s power-driven temperature calculations with on-die temperature sensors

CONFIGURABLE TDP (cTDP)
- Designed to provide system design flexibility to OEMs
- Designed to provide flexibility to processors to fit well in platforms that have thermal solutions designed for higher or lower TDP than nominal

ADDITIONAL BOOST STATE
- Designed to enable the core to improve the power manager’s ability to settle on the optimal operating point and deliver the right performance for each workload

Intelligent Boost (IB)
Designed to ensure that the power budgets allocated to CPU and GPU entities are based on whether the individual entities can efficiently translate the power (and corresponding frequency) to higher performance
TEMPERATURE-SMART AMD TURBO CORE

- The real-time, power-based temperature calculations ($T_{\text{calc}}$) include many conservative assumptions about the nature of the cooling solution and ambient conditions (e.g., 35°C external ambient).

- By supplementing our power-driven temperature calculations with on-die temperature sensors ($T_{\text{sense}}$), this feature is designed to deliver repeatable higher performance for typical operating conditions.

### Thermal Environment/Condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Die Temp (in steady state)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst-case (max of spec) (e.g., 35°C ext. ambient)</td>
<td>$T_{\text{calc}} = \text{Max Temp. Limit}$ $T_{\text{sense}} = \text{Max Temp. Limit}$</td>
</tr>
<tr>
<td>Typical (e.g. 25°C ext./room ambient)</td>
<td>$T_{\text{calc}} = \text{Max Temp. Limit}$ $T_{\text{sense}} &lt; \text{Max Temp. Limit}$</td>
</tr>
</tbody>
</table>

- Temperature-smart AMD Turbo CORE kicks in
- Delivers higher boost performance
**Using Temperature Sensors**

**Factoring in Under/Over-Reporting Errors**

IF

Ambient Temp.

THEN

Die Sensor Temp.

- After AMD Turbo CORE control loops reach **steady state**
- Die temp shown before application of temperature-smart AMD Turbo CORE

**MAX SPEC Ambient**

- 35°C
- 100°C

**TYPICAL Ambient**

- 25°C
- 90°C

- **X°C**
  - Sensor's potential **under-reporting error**

- **Y°C**
  - Sensor's potential **over-reporting error**

**Temp. margin that temperature-smart AMD Turbo CORE can leverage**

$$= 10 \degree C - X \degree C - Y \degree C$$

Under-reporting error needs to be accounted for to ensure max temp. reliability limit is not exceeded.

Over-reporting error needs to be accounted for to allow deterministic higher performance at typical thermal environments.

The temperature values above
- are for illustrative purposes only
- may not reflect actual product implementation
CONFIGURABLE TDP (cTDP)

- TDP of the APU can be configured to match the cooling capabilities of the system
- Provides system design flexibility to OEMs

The TDP & cTDP values above
- are for illustrative purposes only
- may not reflect actual product implementation
INTELLIGENT BOOST

MOTIVATION

- CPU and GPU share a cooling solution, which means that when one burns more power, the other must burn less.
- Without Intelligent Boost:
  - Each thermal entity uses the following approach:
    - CPU and GPU entities raise frequency (and power) as high as possible, within their thermal/other limits (or until the highest Pstate is reached).
    - Computational efficiency (whether freq translates well to perf) is not considered.
  - Power and frequency that CPU ends up with may be more than is needed for GPU-centric workloads.
  - Can affect power efficiency (performance/watt).

Without Intelligent Boost:

- Each control loop independently consumes power and raises frequency.
Intelligent Boost Design

- Monitor activity on GPU
- Detect cases when app code running on CPU is not sensitive to frequency and apply frequency limit on x86 CPU modules
  - GPU “reclaims” the saved CPU power through lower effective CPU temperature
  - System performance should be improved because the GPU is able to operate at a higher frequency
INTELLIGENT BOOST

EFFICIENT ALLOCATION OF POWER TO INCREASE GPU PERFORMANCE

Traditional Power Allocation

<table>
<thead>
<tr>
<th>Component</th>
<th>Power (W)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPU CU0</td>
<td>3</td>
<td>99°C-1.6GHz</td>
</tr>
<tr>
<td>GPU CU1</td>
<td>3</td>
<td>99°C-1.6GHz</td>
</tr>
<tr>
<td>DDR</td>
<td>2</td>
<td>96°C-0.3GHz</td>
</tr>
<tr>
<td>Northbridge</td>
<td>3W</td>
<td>99°C-1.6GHz</td>
</tr>
</tbody>
</table>

Efficient Power Allocation

<table>
<thead>
<tr>
<th>Component</th>
<th>Power (W)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPU CU0</td>
<td>1</td>
<td>96°C-0.8GHz</td>
</tr>
<tr>
<td>GPU CU1</td>
<td>1</td>
<td>96°C-0.8GHz</td>
</tr>
<tr>
<td>DDR</td>
<td>6</td>
<td>96°C-0.75GHz</td>
</tr>
<tr>
<td>Northbridge</td>
<td>1W</td>
<td>96°C-0.8GHz</td>
</tr>
</tbody>
</table>

- CPU power budget at minimum level to keep GPU fully utilized
- Reduced CPU temperature designed to allow GPU to sustain higher power level
- Total system performance increases

Overall Performance (CPU + GPU)

- Balanced
- CPU-limited, GPU starved
- GPU-limited, CPU using too much power

CPU Power Allocation

Increase CPU power

Reduce CPU power
We added additional operating points to enable more optimal power/frequency pairing and greater overall efficiency.

These new operating points are designed to enable the core to improve the power manager's ability to settle on the optimal operating point and deliver the right performance for each workload.
"RICHLAND" BATTERY LIFE IMPROVEMENTS

- Additional power-optimized energy-saving features
- Product voltage/frequency/margin optimization
- Fabrication process-tuning for power
- Additional system-level improvements

Up to 51% more efficient than previous generation in HD video playback*

(APU+FCH)

AMD INTERNAL TESTING. System Configurations: Data based on AMD proprietary “Pumori” Reference Design A10-5757M / AMD A10-4600M, AMD Radeon™ 8650G / AMD Radeon™ 7660G, (35W), 2x 2GB, DDR3L-1600, 1.35V, 14.0” eDP 1366x768/ LED Backlight set at 100 nits, HDD (SATA) - 250GB 5400rpm and Windows® 8 64bit. PC manufacturers may vary configuration yielding different results.

*Video Playback workload - average power when system is playback 720p video from HDD over 30 minutes, with screen set to 100 nits and Wi-Fi on. See slide 24 for backup.
2013 AMD ELITE PERFORMANCE APU PLATFORM

**AMD WIRELESS DISPLAY FOR WINDOWS® 8.1 – SUPPORTED ON 2013 CLIENT PRODUCTS**

**AMD WIRELESS DISPLAY**

- Up to 3.9X greater responsiveness than competition for best, low-latency user experience!*
  - As low as 41ms vs. competition’s 201ms
- Vivid HD playback with 1080p 60Hz (4:2:0)
- Rich audio playback

*Testing conducted by AMD Performance Labs. PC manufacturers may vary configuration yielding different results. The 2013 AMD A10 “Richland” platform showed latency using AMD Wireless Display of 41 milliseconds (41ms) while the Intel WiDi system showed 201ms. Test used was a browser based stopwatch showing the time difference between the PC screen and display. Systems used were an ASUS N56DY with the AMD A8-5550M APU with AMD Radeon(tm) HD 8550G Graphics, 2x2048 MBytes of DDR3-800.0 MHz (PC3-12800) RAM, Microsoft® Windows® 8 Professional (x64) Build 9200; a LENOVO ThinkPad X230 with Intel(R) Core(TM) i7-3520M CPU @ 2.90GHz with Intel(R) HD Graphics 4000 graphics, 2x2048 MB DDR3-800.0 MHz (PC3-12800) RAM, Microsoft® Windows® 8 Professional (x64) Build 9200. Both platforms used the Netgear PTV3000 to connect to the HDTVs.

See backup for footnotes
CHANGING THE PARADIGM WITH DOCK PORT
BIG EXPERIENCE FROM AN ULTRATHIN
Dock your laptop and get virtually any other device or peripheral with USB 3.0* speed, up to four external monitors*, and charging power…

NOW YOU CAN:
- Get an experience that was once only possible on a desktop tower
- Get AMD Eyefinity Technology gaming**
- 3D stereoscopic gaming and 3D movie playback
- Dedicated back-up to external HDD
- Sync to smartphone

*Use of 4 1920x1200 external monitors does not support simultaneous USB 3.0 speed.
**AMD Eyefinity technology supports up to six DisplayPort™ monitors on an enabled graphics card. Supported display quantity, type and resolution vary by model and board design; confirm specifications with manufacturer before purchase. To enable more than two displays, or multiple displays from a single output, additional hardware such as DisplayPort-ready monitors or DisplayPort 1.2 MST-enabled hubs may be required. A maximum of two active adapters is recommended for consumer systems. See www.amd.com/eyefinityfaq for full details.

All at the same time…
All through a single connection**

LAPTOP WITH DOCK PORT | EXTERNAL MONITORS | OTHER DEVICES
---|---|---
1 | 2 | 3 | 4
Dock | DP / HDMI / VGA | DP / HDMI / VGA | DP / HDMI / VGA

Dock your laptop and get virtually any other device or peripheral with USB 3.0* speed, up to four external monitors*, and charging power…

1 | 2 | 3 | 4
DP / HDMI / VGA | DP / HDMI / VGA | DP / HDMI / VGA

Dock Port

DP 1.2 USB 3.0 powers notebook

DVD / Blu-ray | HDD | Smartphone | KBD & Mouse

HD

DVD / Blu-ray

KBD & Mouse

Sync to other USB devices – tablets, media players
Download and edit photos and video from cameras
Multi-monitor photo editing, productivity app, multi-tasking – ideal for SOHO/SMB
DVD and Blu-ray protected playback and streaming with virtually any media player
GENERATIONAL CPU PERFORMANCE UPLIFT
“RICHLAND” (AT LAUNCH) VS. AMD 2ND-GENERATION A-SERIES APU (AT LAUNCH)

Up to 29%+ CPU Uplift!

PCMARK® 7

- A10-5750M: 35W TDP, 19W "Richland" 13%
- A8-5545M: 19W "Richland" 19%
- A10-4600M: 35W TDP, 12%
- A8-4555M: 19W "Richland"

CINEBENCH R11.5 MULTI CPU

- A10-5750M: 35W TDP, 13%
- A8-4555M: 19W TDP, 29%
- A10-4600M: 35W TDP, 2.27
- A8-5545M: 19W TDP, 1.68

Testing conducted by AMD Performance Labs on AMD reference systems. PC manufacturers may vary configuration yielding different results. Specific product configurations used:
- AMD 2nd-Generation A-Series APU A10-4600M: AMD “Pumori” reference platform with an AMD A10-4600M Quad Core APU, AMD Radeon™ HD 7660G series graphics, 4GB DDR3-1600 memory, Microsoft® Windows® 7 64bit, Hitachi HTS545025B9A300
- AMD “Richland” A10-5750M: AMD “Pumori” reference platform with an AMD A10-5750M Quad Core APU, AMD Radeon™ HD 8650G series graphics, 4GB DDR3-1666 memory, Microsoft® Windows® 8 64bit, Hitachi HTS545025B9A300
- AMD 2nd-Generation A-Series APU A8-4555M: AMD “Manaslu” reference platform with an AMD A8-4555M Quad Core APU, AMD Radeon™ HD 7600G series graphics, 4GB DDR3-1333 memory, Microsoft® Windows® 7 64bit, Hitachi HTS545025B9A300
- AMD “Richland” A8-5545M: AMD “Manaslu” reference platform with an AMD A8-5545M Quad Core APU, AMD Radeon™ HD 8510G series graphics, 4GB DDR3-1333 memory, Microsoft® Windows® 8 64bit, Hitachi HTS545025B9A300
GENERATIONAL GPU PERFORMANCE UPLIFT

“RICHLAND” (AT LAUNCH) VS. AMD 2ND-GENERATION A-SERIES APU (AT LAUNCH)

Testing conducted by AMD Performance Labs on optimized AMD reference systems. PC manufacturers may vary configuration yielding different results. Specific product configurations used for 3DMark®11-P:

- AMD 2nd-Generation A-Series APU A10-4600M, AMD “Pumori” reference platform with an AMD A10-4600M Quad Core APU, AMD Radeon™ HD 7660G series graphics, 4GB DDR3-1600 memory, Microsoft® Windows® 7 64bit, Hitachi HTS545025B9A300 HDD, 8.94RC2 Graphics driver (launch configuration)
- AMD “Richland” A10-5750M: AMD “Pumori” reference platform with an AMD A10-5750M Quad Core APU, AMD Radeon™ HD 8650G series graphics, 4GB DDR3-1866 memory, Microsoft® Windows® 8 64bit, Hitachi HTS545025B9A300 HDD, 12.100.0.0 Graphics driver
- AMD 2nd-Generation A-Series APU A8-4555M: AMD “Manaslu” reference platform with an AMD A8-4555M Quad Core APU, AMD Radeon™ HD 7600G series graphics, 4GB DDR3-1333 memory, Microsoft® Windows® 7 64bit, Hitachi HTS545025B9A300 HDD, 8.94RC2 Graphics driver (launch configuration)
- AMD “Richland” A8-5545M: AMD “Manaslu” reference platform with an AMD A8-5545M Quad Core APU, AMD Radeon™ HD 8510G series graphics, 4GB DDR3-1333 memory, Microsoft® Windows® 8 64bit, Hitachi HTS545025B9A300 HDD, 12.100.0.0 Graphics driver
NEXT-GENERATION APU "RICHLAND" POWER DATA

"Richland" draws lower power for typical use cases (compared to AMD 2nd-Generation A-Series APU)

Up to a 51% more efficient in HD video playback (APU+FCH)

Improved battery life

AMD INTERNAL TESTING. System Configurations: Data based on "Pumori" Reference Design A10-5757M / AMD A10-4600M, AMD Radeon™ 8650G / AMD Radeon™ 7660G, (35W), 2x 2GB, DDR3L-1600, 1.35V, 14.0" eDP 1366x768/ LED Backlight set at 100 nits, HDD (SATA) - 250GB 5400rpm and Windows® 8 64bit. PC manufacturers may vary configuration yielding different results.

Video Playback workload - average power when system is playback 720p video from HDD over 30 minutes, with screen set to 100 nits and Wi-Fi on.

Web Browsing workload – average power when system is web browsing 20 popular web sites over a 40 minutes (2 minutes per page, 20 web pages) with screen set to 100 nits.

AMD "RICHLAND" APU | HOT CHIPS 25 | PRAVEEN DONGARA | AUGUST 2013
SUMMARY

- Greater performance and power efficiency via new AMD Turbo CORE technology features
- Improved battery life via product definition optimizations
  - Significant improvement in video playback power
- Configurable TDP feature introduced to provide system design flexibility to OEMs
- Dock Port technology introduced
- Support added for Wi-Fi standards-based wireless display
ACKNOWLEDGEMENTS

Acknowledging the entire "Richland" team at AMD for successful product development and launch!
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