QuickLogic's Visual Enhancement Engine (VEE™) Brings iridix® to Mobile Devices

QuickLogic® White Paper

Introduction

The iridix core was developed by Apical Limited to drastically enhance image quality by employing dynamic range compression. This innovative and patented technology is the result of more than a decade of research by Apical scientists based on how the human eye perceives image contrast under various lighting conditions. This program research led to the development of the iridix core which first found success in the Digital Still Camera (DSC) market (shipping more than 50 million DSCs with iridix), and wide screen LCD televisions. The DSC applications used software-based solutions, and the television hardware solutions were based on large FPGAs – neither option suits the mobile market due to high power consumption.

Mobile Video Challenge

The iridix core dynamically calculates and applies a different tone curve to each pixel depending on content and position in the image. This pixel-by-pixel dynamic range and color correction enables far better control of contrast than traditional techniques. However, it also requires high CPU computing resources and, therefore, higher power consumption. Also, the iridix software must be optimized for different CPUs and DSPs. For example, in an ARM Cortex-A8 CPU the iridix software library processes 60 fps WVGA (800x480) while consuming about 41% of the resources. The processor load scales linearly with pixel count, pixel clock rate and frames per second.

With such a high CPU utilization requirement, it is very challenging to support a smooth and responsive user experience in a multi-tasking operating system. Users may experience slow transition from one application to another or see jerkiness in the video when another application with higher priority interrupts and slows the process down. Other features such as sharpening, dithering and color correction in addition to the iridix core further exacerbate the situation by putting more load on the power-hungry CPU. Even for processors that have a dedicated accelerator (such as the TI OMAP), it is estimated that the iridix core would consume most of the dedicated resources.

The development effort required to optimize the software code for a specific processor is not a trivial task. Apical required more than a year to optimize the iridix core for a TI application processor (ARM-based) used for a DSC application, primary still images only. Much of the time was spent optimizing resource sharing with other applications, which usually involves a lot of benchmarking on the actual device within the software application and testing. Normally, it takes three to six months of intensive development process for applications such as a DSC, and much longer for complex smartphone applications.

Visual Enhancement Engine (VEE)

The software implementation of iridix requires high CPU load and consumes a lot of power. Any power saving in the backlight by using iridix is almost completely offset by the increased CPU power consumption.

The only feasible implementation for the mobile market is a hardware-based solution. QuickLogic and Apical Limited have partnered to architect and develop the optimal blend of cores with QuickLogic's patented ViaLink programmable fabric for mobile and portable multimedia products. The VEE technology is based on the proven iridix cores and is supplemented by additional image and video enhancement blocks such as dithering, hue rotation, color correction, and non-linear sharpness filtering, among others.

As shown in **Figure 1**, the VEE solution substantially enhances image and video quality by optimizing the dynamic range, contrast, and color saturation pixel-by-pixel to provide a natural and usable viewing experience under low backlight or bright ambient light conditions. Seamlessly integrated into the display path, VEE enhances the user's mobile multimedia visual experience while drastically reducing backlight power to extend battery life.

Figure 1: VEE Solution Block Diagram

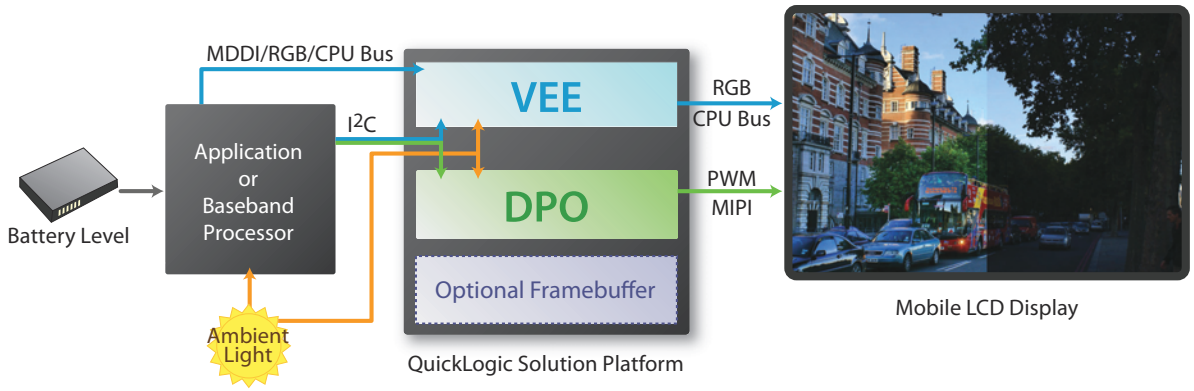


Table 1 shows a comparison between software implementation and VEE.

Table 1: Comparison Between QuickLogic VEE and Software Implementation

Characteristic	QuickLogic VEE	Software Implementation
Package	Single-chip CSSP component.	Object library and API.
Processing speed	Sufficient for any mobile display requirement up to WXGA at 60 frames per second.	Depends on processor, memory and hardware accelerator. WQVGA or VGA at 30 frames per second consumes significant resources and is only achievable on high-end processors.
CPU load	Zero.	Depends on processor architecture – how much processing can be handled by hardware accelerator, if any.
Memory management	Zero (all on-chip).	Size of cache and speed of memory access are critical in achieving real-time performance. Interaction of memory usage with that of other applications must be considered.
Power consumption	Very low. (See **Table 2**.)	High. (See **Table 2**.)
Interrupts	No real-time communication with baseband CPU required.	Interrupts and call-back functionality typically required.
Core	Iridix core plus additional functions such as sharpening, dithering, black levelling, color correction and gamma correction.	Iridix core and other functions require additional CPU resources.
Integration cost	Very low, seamless.	Significant depending on software development plan.
Testing cost	Very low.	QA testing required by customer as part of overall software application.
Support cost	Very low.	Significant if software platform is changed or updated frequently.

Power Comparison Data

To illustrate the power savings by adopting QuickLogic's VEE hardware implementation versus the software implementation, the power consumption increase was measured when running iridix at WVGA (800x480) resolution on an 800 MHz implementation of the ARM Cortex-A8 CPU. The data for other resolutions were obtained through linear scaling based on pixel clock frequency. **Table 2** shows the significant power consumption differences between the two implementations.

Table 2: Power Consumption Comparison Between QuickLogic VEE and Software Implementation

Display Resolution	Horizontal Pixels	Vertical Pixels	QuickLogic VEE 2.0 Power Consumption on ArcticLink® II Platform - Estimate (mW)	Software Implementation Power Estimate (mW)
WQVGA	480	234	15	60
HVGA	480	320	20	82
VGA	640	480	40	164
WVGA	800	480	50	203
FWVGA	854	480	52	216
SVGA	800	600	61	262
WSVGA	1024	600	75	334
XGA	1024	768	97	446
WXGA	1366	768	118	557

Figure 2 shows the significant power consumption differences between the two implementations in graph format.

Figure 2: Power Consumption Comparison Between QuickLogic VEE and Software Implementation

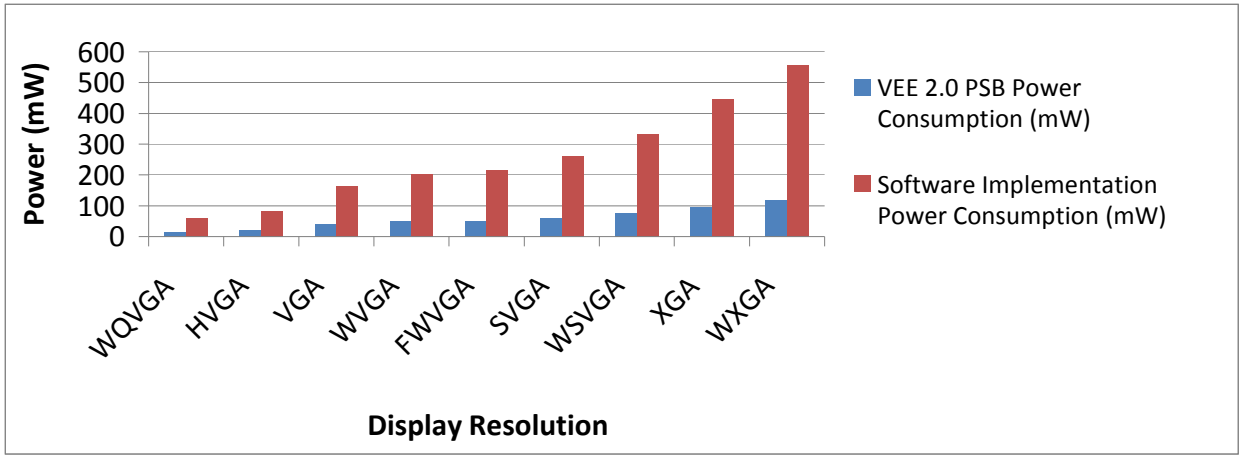


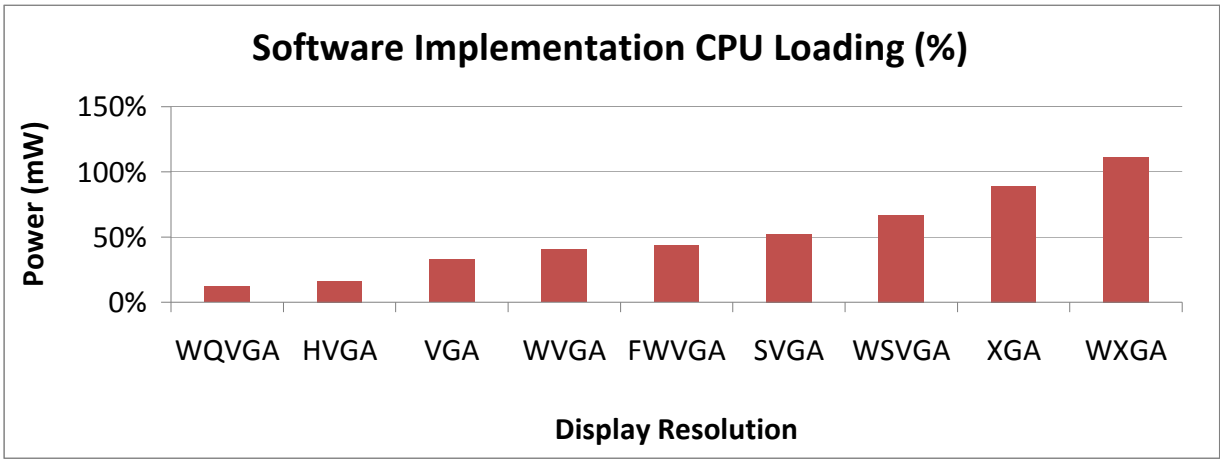
Table 3 illustrates the significant CPU utilization differences between the two implementations.

Table 3: iridix on ARM Cortex-A8

Resolution	Horizontal Pixels	Vertical Pixels	VEE 2.0 PSB Power Consumption (mW)	Software Implementation of Core	
				MIPS	% Loading
WQVGA	480	234	0	192	12%
HVGA	480	320	0	262	16%
VGA	640	480	0	524	33%
WVGA	800	480	0	650	41%
FWVGA	864	480	0	692	43%
SVGA	800	600	0	839	52%
WSVGA	1024	600	0	1069	67%
XGA	1024	768	0	1426	89%
WXGA	1366	768	0	1782	111%

Figure 3 illustrates the significant CPU utilization differences between the two implementations in graph format.

Figure 3: Software Implementation CPU Loading



Summary

By hard-wiring the core, the QuickLogic VEE technology brings the iridix core to the mobile market with optimized hardware implementation. Compared to a software implementation, VEE drastically reduces CPU overhead and power consumption to enable a much smoother user experience and longer battery life while playing back video content. VEE 1.0 with just the iridix core is currently available as a proven system block on the PolarPro solution platform. VEE 2.0 with additional functions such as sharpening, black leveling, color correction and gamma correction is available in the ArcticLink II VX solution platform family.

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Revision History

Revision	Date	Originator and Comments
A	March 2008	Howard Li, Andy Green and Kathleen Murchek
B	March 2008	Judd Heape and Kathleen Murchek
C	April 2008	Judd Heape and Kathleen Murchek
D	December 2008	Kathleen Murchek
E	September 2009	Brian Faith and Kathleen Murchek
F	February 2010	Brian Faith and Kathleen Murchek

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