

# NEC



*The first scalable, high performance 3D system  
with advanced realism for arcade machines,  
personal computers and games consoles*



*PowerVR Comdex 95 demo by*



# namco®

## Power VR - A revolution in 3D graphics technology

Developed jointly by VideoLogic and NEC, PowerVR is the future of high quality 3D graphics for the next generation of interactive entertainment. Its revolutionary techniques bring you the ultimate in realistic, real-time 3D rendering at the best price/performance, whether you are developing 3D systems for console, PC or arcade systems.

The PowerVR design team have drawn on years of experience in flight simulators, ray tracing and other advanced 3D fields to produce a system that breaks conventional price/performance barriers by eliminating expensive memory and bandwidth bottlenecks. PowerVR delivers unprecedented realism with great detail, smooth shading and high frame rates.

VideoLogic and NEC's patented PowerVR system is fully scalable, so it can be used in a wide range of 3D applications and entertainment markets from games consoles, through PCs, right up to high-end arcade machines. This also allows content producers to target a range of different platforms without redesigning their titles. And, because PowerVR's architecture is inherently scalable, its performance will go on getting better as silicon technology improves—leaving other 3D rendering technologies caught in the memory bandwidth trap.

PowerVR's core 3D rendering algorithm is infinite plane (surface) based. This approach allows the system to efficiently cater for polygons, polygon meshes, infinite planes, and convex objects. Its polygon object rendering allows the use of conventional, industry-standard APIs such as Microsoft's™ Direct3D™, and the ability to directly process infinite planes and convex objects allows PowerVR to provide advanced features such as full shadows and searchlights in real-time. In addition to support for industry-standard APIs, PowerVR has its own high-level object oriented API, called PowerVR SGL, that provides full access to all the capabilities of the PowerVR hardware.

- ▶▶ Real shadows can be cast from any object over any surface, and updated every frame
- ▶▶ PowerVR's equivalent 32-bit Z buffer makes solid outdoor objects a reality
- ▶▶ Pixel perfect hidden surface removal
- ▶▶ Anti-aliased textures using PowerVR's mip mapping stops shimmering
- ▶▶ Perspective-correct textures do not bend because PowerVR performs a division per pixel
- ▶▶ Smooth shading does not change when rotated
- ▶▶ Translucency can be applied to whole objects, polygons, or individual pixels for effects like dirty glass, fire, water, and even simulated lens flare and radiosity
- ▶▶ True logarithmic colored fog calculated per pixel
- ▶▶ Real color, real time, real resolution (24-bit RGB, 30 to 60Hz, 640 x 480) with mip mapping, fogging and shadows over the whole scene.

### What can PowerVR do for you?

**System Designers:** PowerVR's scalable architecture means you can design to match your price/performance requirements.

**Title Producers:** PowerVR provides the performance and advanced features that enable you to concentrate on producing an engaging 3D world using the development environment that suits you.

**Modellers:** Use full 24-bit color, texture and shading.

**Game Players:** Solid, detailed and flawless images let you enter a realistic new world, not just corridors.

## PowerVR Architecture - High Performance 3D system

### PowerVR 100ISP - Image Synthesis Processor

The PowerVR 100ISP performs image synthesis which includes hidden surface removal, shadow generation and depth cueing. Hidden surface removal (Z buffering) is carried out on-chip, so no Z buffer memory is needed, eliminating cost as well as the associated bandwidth bottleneck. The ISP operates directly on 3D data (polygons or infinite planes/convex objects). Processing is performed on-chip in each PE (Processing Element). The ISP has 32 PEs operating in parallel, producing 32 pixels at a time. This is the key to PowerVR's scalability—each additional ISP can be connected without glue logic, and produces a linear increase in performance.

Each PE calculates the object closest to the eye for each pixel, producing pixel accurate intersection of objects. Shadows can be cast onto meshes and convex objects. The ISP automatically calculates which visible pixels are in or out of shadow and, as a result, any object or shape has a pixel accurate shadow. Using PowerVR's depth calculation, visible pixels can be depth cued with a true color fog.

ISP's processing is done in programmable tiles, reducing the amount of work needed at every pixel. Tile sizes can be adjusted to match scene complexity. Usual sizes are 32 x 32, 64 x 32, or 64 x 64 pixels. The device uses an on-chip parameter cache and a pre-calculation unit to keep the processing active almost 100% of the time. The cache has an expansion bus that is used when there are two or more ISPs, allowing linear expansion of the cache to handle the increased complexity of the scene.

### PowerVR 100TSP - Texture and Shaping Processor

The PowerVR 100TSP performs texturing, shading, and display management. A key advantage of this architecture is its use of deferred processing. Texturing and shading are only performed on visible pixels, making performance almost completely independent of scene complexity. Deferred processing also greatly reduces the bandwidth requirements of texture and frame-buffer memories. The TSP also handles display management, allowing overlays of 3D and 2D data which reduces the need for extra support chips.

The 32 pixel data from the ISP is processed under the control of parameters from an on-chip 4 KB cache. Pre-calculation and dual pipelines are used to maximize performance.

Textures are calculated using a division per pixel to allow for perspective-correct mapping, and are anti-aliased by interpolating between mip maps. Textures are stored as 8 or 16 bit RGB and can be used to texture every pixel. Shading is either flat or smooth and can be applied to textured surfaces. The shadow information supplied by the ISP is incorporated as an RGB color; highlights can be used to generate glinting on textures; and the programmable, exponential color fog value is included. All these color operations are performed at 24 bit or better.

Once the final pixels are generated, they can be held in a back-end on-chip buffer and accumulator which can be used for multi-pass operations such as translucency. This is only done for pixels that are covered by the translucent surface.

Display management supports 1-4 MB of 16 or 24-bit double buffered 3D data with a resolution of up to 1K by 1K pixels.

4 or 8-bit 2D overlay is provided and can be scrolled horizontally and vertically. The CRT controller is fully programmable, allowing the image to be clipped and offset.

### PowerVR 200PCX - PowerVR PC Processor

PowerVR 200PCX combines ISP and TSP functions and a high-performance master/slave PCI interface on a single chip, producing a powerful, cost-effective solution for the PC that incorporates a single SDRAM interface for accessing textures and local parameters. Because PowerVR uses tile-based rendering there is no need for a local frame buffer. Using DirectDraw, rendered images are transferred over the PCI bus to the VGA controller's memory for overlay and display. This approach is possible because PowerVR reduces memory bandwidth requirements to a minimum. It also means that PowerVR 200PCX is independent of the VGA controller, allowing it to be used with a wide range of PCs.

### Software Support

PowerVR is supported by several APIs, each targeting different requirements. These include Microsoft's Direct3D, Microsoft's RealityLab™ and the VideoLogic/NEC PowerVR SGL. Support for Microsoft's Direct3D will allow standard Windows 95 titles to exploit PowerVR's capabilities. PowerVR SGL takes full advantage of PowerVR's features such as shadows and searchlights, and also provides a unified programming environment for console, PC and arcade development.

PowerVR SGL is a high level API that gives application developers access to PowerVR's advanced features. With this development system you can use the same code to develop games for the arcade, PC and console markets. SGL's other features include display lists which allow for powerful instancing, automatic shadow generation, automatic collision detection, and level of detail management.

### Performance analysis

PowerVR's performance is directly related to clock speed, the size of the tiles, and the number of Processing Elements operating in parallel; there is no bottleneck caused by memory bandwidth. The performance figures shown below represent average values; peak performance may be up to 4 times higher. These figures also assume that the CPU(s) used in the system match the rendering power of PowerVR.

Performance figures shown for are for 640 x 480, 24-bit at 30 Hz, with every pixel mip map textured, fogged, lit and shaded.

Model	Speed	ISP	Tile size	Performance
PowerVR 100 family	66 Mhz	1	64 x 64**	257K triangles per second
PowerVR 100 family	66 Mhz	4	64 x 64**	1028K triangles per second
PowerVR 200PCX	66 Mhz	1*	64 x 64**	257K triangles per second

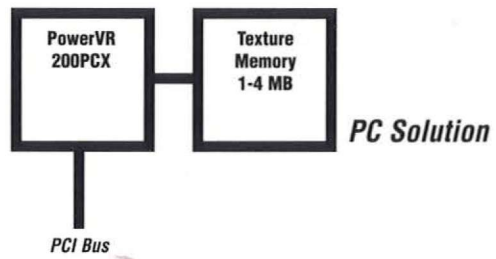
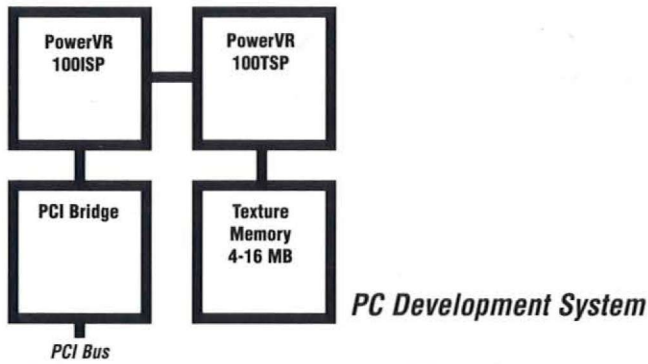
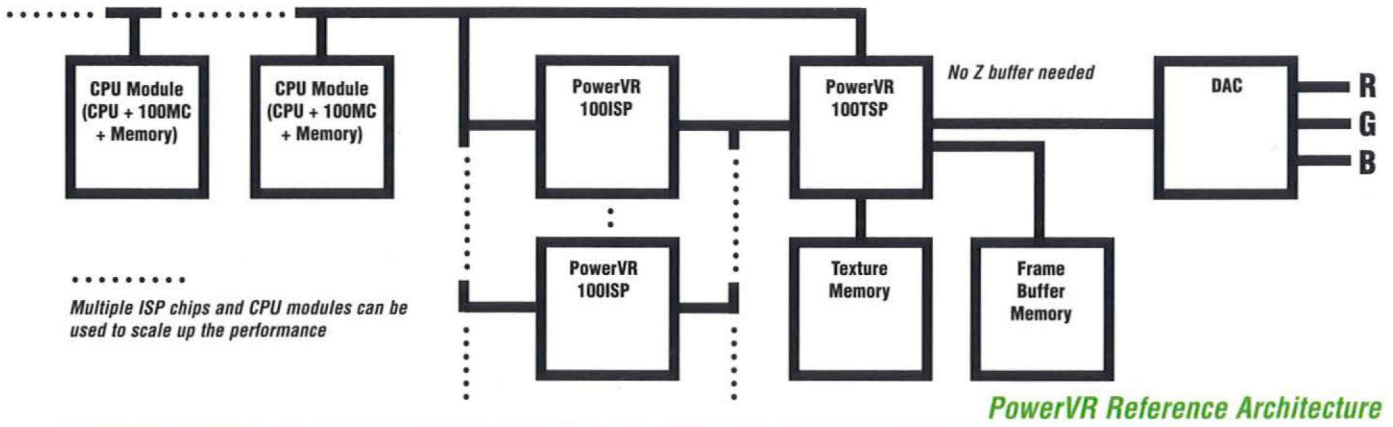
\* PCX is equivalent to one ISP and one TSP

\*\* Tiles set to 64 x 64 pixels implies polygon sizes averaging over 100 pixels

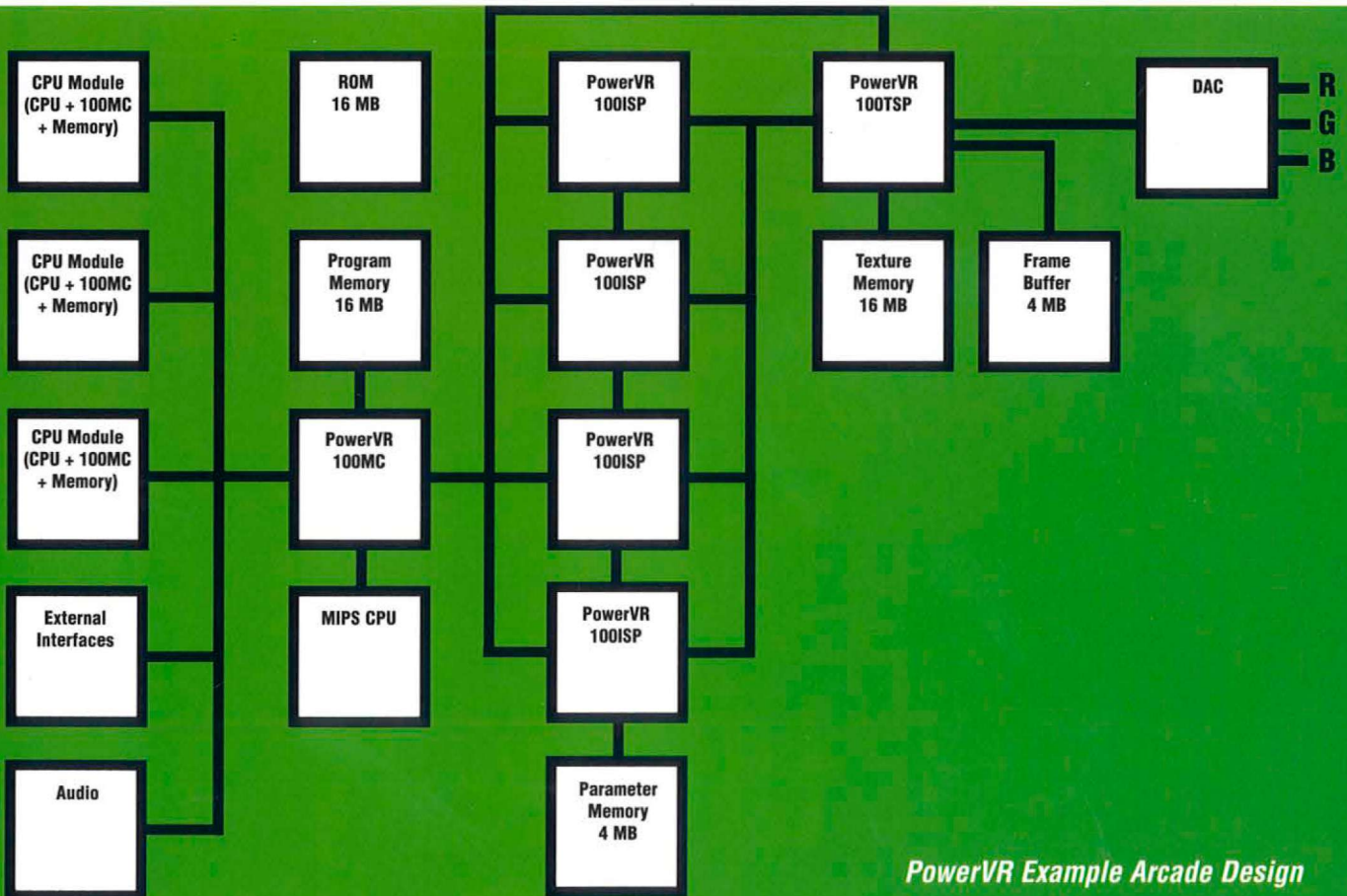
### PowerVR Developers Kit

Development reference boards; hardware reference designs; Microsoft Direct3D drivers and PowerVR SGL libraries; PowerVR SGL online documentation; sample applications including a model viewer; and model converters

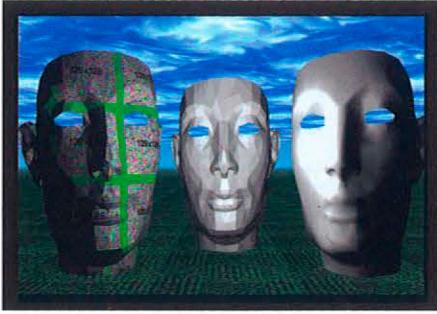
# PowerVR - Scalable Architecture



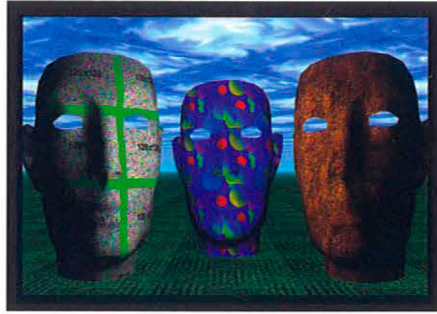
## PowerVR PC Design



## PowerVR - Advanced Realism



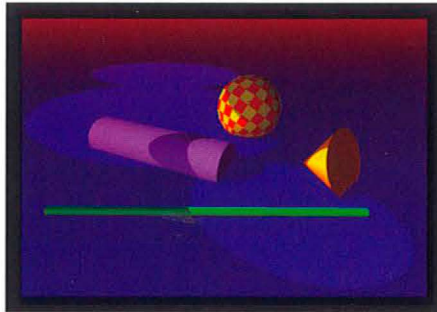
With a polygon mesh, surfaces can look angular and unrealistic. Texturing or shading improves the appearance of these objects. Note that lighting is from a point light source. PowerVR's smooth shading is 'Gouraud-like', and this smooth interpolation will be the same at all rotations.



By combining smooth shading and texturing, a much more realistic effect can be produced. The left hand image shows tiled repetitions and cylindrical mapping. The multicolored face demonstrates the full range of RGB colors smooth shaded with the point light source.



An object casting true shadows. The shadow is cast not only on the ground plane, but on the smaller object where it penetrates the shadow. Note that the shadow gives important clues as to the size and position of the objects in the scene. Plane modeling allows such advanced features to be provided with minimal resource.



Advanced features such as searchlights can be created using light volumes. These will also cast shadows, and could be used to produce headlights in a driving game.



Transparent objects can be used by setting transparency on a whole object, a particular polygon, or on a pixel-by-pixel basis.



PowerVR's solid image and visual clues provide a consistent and absorbing 3D world.

# PowerVR - Technical Specifications

## General

### Architecture

Base element - Polygon (for polygon meshes)  
Base element - Planes (for convex objects)  
Scalable design

### Performance

Average polygon size: 100-1000 pixels  
Low cost design - 250K+ mip mapped textured, smooth shaded triangles/second  
Arcade design - 1000K+ mip mapped textured, smooth shaded triangles/second

## PowerVR 100 Family

### PowerVR 100ISP: Image Synthesis Processor

66 MHz processor  
32 processor elements  
32-bit depth precision  
On-chip hidden-surface removal (no need for Z buffer memory)  
12K parameter cache for tile caching  
Expansion bus for multiple ISPs  
0 to 2 MB external parameter cache  
True shadow generation  
Per pixel fogging

### PowerVR 100TSP: Texture & Shading Processor

66 MHz processor  
Perspective correct texturing (division per pixel)  
Anti-aliased texture mapping (MIP mapping)  
32 x 32 to 256 x 256 texture bitmap sizes  
4 to 16 MB texture memory  
Texture flipping (horizontal and vertical)  
Texture formats:  
8-bit (2,3,2) RGB  
16-bit (5,5,5) RGB  
16-bit (4,4,4,4) RGBT  
Optimized architecture for low page break overhead  
4 KB internal parameter cache  
264 MB/sec peak texture memory bandwidth  
Smooth shading  
Smooth full shadows  
Flat shading with offset highlight  
24-bit mixing of texture, lighting and shading  
Exponential fogging - with programmable fog color  
Accumulation buffer - to allow multiple layers of translucency  
Translucent textures - 16 levels per pixel  
'Global' translucency allows objects to 'fade' - 16 levels  
2D overlay: 4/8 bit packed double buffered  
2D scrolling  
3D data: 16/24 bit packed double buffered

1 to 4 MB frame buffer  
Programmable SPG with sync master/slave (allows overlay)  
1024 x 1024 maximum resolution  
24/16 bit RGB modes

### PowerVR 100MC: Memory Controller

Support for 4300, 4400 and the latest MIPS CPUs  
SDRAM interface at 66 MHz  
System Control (SC) Bus interface at 66 MHz  
Master or Slave device

## PowerVR 200 Family

### PowerVR 200PCX: PC Processor

66 MHz processor incorporating ISP and TSP function  
32 processing elements in ISP module  
On-chip 12K ISP and 4K TSP parameter caches  
Single SDRAM external interface for texture and parameter caching  
PCI 2.1 interface  
True shadow generation and fogging  
Perspective-correct texturing and anti-aliased textures  
32 x 32 to 256 x 256 texture bitmap sizes  
1 to 4 MB texture memory  
Texture formats:  
8-bit (2,3,2) RGB  
16-bit (5,5,5) RGB  
16-bit (4,4,4,4) RGBT  
264 MB/sec peak texture memory bandwidth  
Smooth shading  
Flat shading with offset highlights  
24-bit mixing of texture, lighting, and shading  
Exponential fogging - with programmable fog color  
Accumulation buffer - to allow multiple layers of translucency  
Translucent textures - 16 levels per pixel  
Global translucency allows objects to 'fade' - 16 levels

## Software

### Microsoft Support

Direct3D driver support  
Reality Lab Support

### PowerVR SGL 3D Graphics API and Library

Cross platform  
High-level API  
Display list hierarchy  
Object instancing  
Features include: collision detection; level-of-detail management; full shadows; lighting; etc

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