

# Graphics Display Controllers

## Product and Technology Overview



### Introduction

The Fujitsu Graphics Display Controllers (GDCs) offer a unique blend of functionality that merges two popular graphics-based technologies into a single device, improving efficiency and performance.

Specifically, the Fujitsu GDCs combine powerful 2.5D/3D Graphics Processing Units (GPUs) with Fujitsu's advanced Display Controller Unit (DCU) capability. DCUs provide a highly efficient, cost-effective way to generate graphics to display and animate recurring content such as menus, messages, and icons. Offloading this function to the display controller frees up memory and the GPU for rendering-based tasks.

Fujitsu has been developing DCU technology for more than 20 years. Current implementations drive up to four high-resolution displays simultaneously, manage up to six video-capture ports, and blend up to eight layers of graphics and video data.

Although the roots of Fujitsu's DCU and GPU technologies are in consumer and desktop-gaming applications respectively, the current lineup of GDC products is designed for the harsh automotive environment. All devices meet a minimum temperature range of -40 to +85°C, and many are rated for -40 to +105°C. The devices meet AEC-Q100 and ISO/ TS-16949 requirements. Moreover, all devices must meet the auto industry's requirement that the products be available for 10 years. Of course non-automotive developers can take advantage of the long lifecycle.

At the core of the Fujitsu GDCs is a powerful graphics engine capable of rendering realistic 2.5D and 3D graphics to a broad variety of screen sizes ranging from 240 x 320 (QVGA) to

1920 x 768 (for the most powerful GDC, "Triton-C"). The engine consumes only two to three watts of power under normal conditions, and no more than four watts in the most extreme scenarios. Fujitsu employs these specific design targets to eliminate the need for secondary cooling aids. Not even heat sinks are required.

Add to the mix the many special features — such as direct and palletized color, video capture and scaling, multiple display layers, and a variety of alpha options — and it's clear the Fujitsu GDCs have no equal in the embedded market.

### Layers

Fujitsu GDCs feature a layered display structure providing six to eight separate frame buffer layers. Each layer is capable of managing unique content that can be rendered, captured from one or more video sources, blitted from a bitmap library, or a combination of these options. These functions are carried out in the display controller block where the processing has little or no impact on the GPU, which might be simultaneously processing the rendering.

At least four of the layers have separate color palettes, which are set up to draw using 8-bit pallet registers. Each layer is independent, so some layers can be configured for palletized color while others can be set for 16-bit-per-pixel, direct-color mode. Layers can have a uniform transparency setting with a range of 256 levels. At least one layer will provide pixel-level transparency settings to produce special effects such as a roving spotlight on a navigation map.

In addition to the layer-alpha settings, an alpha-mask option can be applied to bitmaps and fonts alike. When the mask is applied to a font or bitmap, both are blt'd to a layer in one simple step. The effect is one of edge smoothing or anti-aliasing as the edges of the source bitmap or font are blended to the layer or layers below. When the alpha mask is combined with RGB+alpha, and layer-level / pixel-level alpha, the possibilities for special effects increase significantly.

## Video Capture

The ITU-656 or RGB-format video-capture port displays the images from perimeter cameras as well as accepts and displays video content. Because the GDC is a graphics processor, the captured content can be handled as a texture and then mapped to polygons for special effects, such as with Fujitsu's 360° Wrap-Around Video Image Technology. That technology maps the images captured from four cameras onto a circular polygon mesh to display a virtual, full-surround image.

## Unique Features

As described earlier, Fujitsu GDC products are unique in that they incorporate a GPU and an equally powerful display controller that gives users a high degree of flexibility in how graphics are processed and displayed.

Fujitsu also incorporates many special features designed specifically for applications that require particularly high reliability. For example, the Fujitsu Signature Unit (SU) is a special hardware function designed to add a level of safety to certain applications. Occasionally, incorrect memory reads or writes can result in images being shifted or put in the wrong place. The SU will perform a checksum on specific critical content to ensure the images are displayed in the right place. This eliminates the possibility, for example, that a warning light would be hidden behind other graphics or placed completely out of view.

## GDC Families

Fujitsu currently has four GDC families, each of which can feature up to three variations.

**MB88F33X "Indigo" Series:** This sprite-based, non-rendering GDC includes many peripheral-support functions such as backlight control, an advanced sound generator, and six stepper motor controls.

The MB88F332 features on-chip memory in the form of 160KB of NOR Flash and 128 KB of SRAM. The device supports up to 512 bitmaps, making it capable of acting as a stand-alone GDC in applications that require only animated bitmaps. The MB88F333 is a lower-cost addition to the series that supports two stepper motors and is packaged in a smaller 176 LQFP package.

The MB88F33x "Indigo" Series can also be configured to work with an advanced controller such as Fujitsu's MB86R02 "Jade-D." This pseudo master/slave configuration is possible owing to the inclusion of APIX®, the high-speed serial interface that supports bi-directional communications. The two-chip setup enables a broader variety of configurations that can reduce costs.

**MB86R0x "Jade" Series:** This product family is based on the 330MHz ARM® 926 core and the Fujitsu MB8629x "Coral" GDC core, which supports full 2.5D and 3D rendering.

The MB86R01 is designed for high-end, high-volume embedded automotive graphics applications such as on-board navigation systems, graphical dashboard systems, head-up display (HUD) units and rear-seat entertainment systems.

The three "Jade" variants – MB86R01 "Jade," MB86R02 "Jade-D," and MB86R03 "Jade-L" – support different peripheral sets. All "Jade" devices provide dual-display support, video-capture and DDR2 interfaces.

**MB86R1x "Emerald" Series:** The "Emerald-L" features an ARM Cortex™-A9 processor operating at 400 MHz (1000 DMIPs) plus a Fujitsu proprietary graphics core that supports OpenGL® ES 2.0. A DDR3 memory controller ensures high throughput and optimal graphics performance.

The MB86R11 "Emerald-L" features a variety of popular peripherals such as USB and Flash controllers. The SoC supports four video-capture ports and three display controllers. A dithering unit and ARM Neon DSP core help enhance images and manage certain audio-video processing. To enable



Example of a 2.5D/3D Instrument Cluster



Example of a Medical Device Application

advanced graphical content, the MB86R11 “Emerald-L” DDR 2/3 controller can access up to 1GB of memory.

The MB86R12 “Emerald-P” is a higher-performance device, featuring an ARM Cortex-A9 processor operating at 533 MHz (1333 DMIPs) and a 266MHz graphics core. The MB86R12 includes four high-speed APIX 2.0 ports – three output and one input. The device is rated for a -40 to +105°C operating range.

The MB86R1x “Emerald” Series integrates support for the new Fujitsu 360° Wrap-Around Video Imaging Technology. (See Software and Support below.)

**MB86R24 “Triton” Series:** The high-performance MB86R24 “Triton-C” combines the latest ARM Cortex-A9 dual CPU core with state-of-the-art, embedded 2.5D and 3D graphics cores. This third-generation application processor is the first device in Fujitsu’s new “BlueLine” family of high-performance GDCs.

The 3D core incorporates Imagination Technologies’ POWERVR™ SGX543-MP1, which supports open standard API formats such as OpenGL ES 2.0. The POWERVR core uses Tile-Based Deferred Rendering (TBDR) for render processing, which reduces performance loads on the CPU and GPU, and increases system capacity. The high-end SoC also combines six video-capture inputs and three, independent, parallel display outputs.

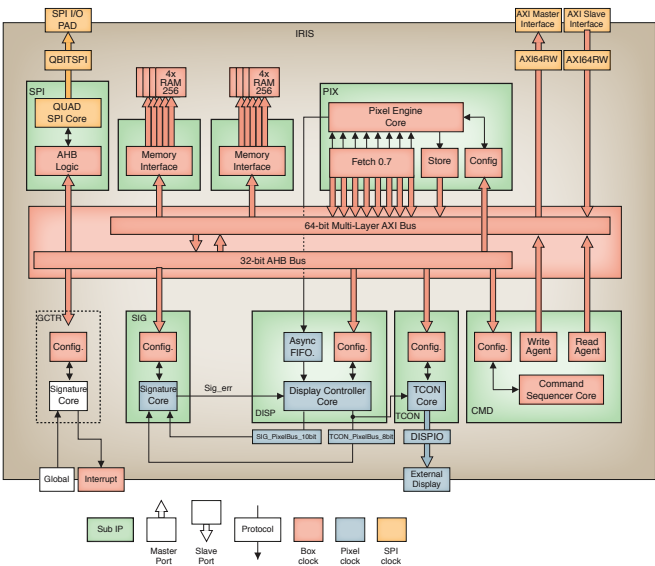
The chip’s architecture has been optimized for the simultaneous use of all functional blocks, virtually eliminating performance gaps. The device’s harmonized structure permits the simultaneous rendering of independent 2.5D and 3D graphics, the capturing of multiple video streams, and the display of content to multiple sources.

With its outstanding rendering performance and multiple standard and automotive-specific peripheral interfaces, this device is appropriate for a wide range of demanding automotive and industrial applications.

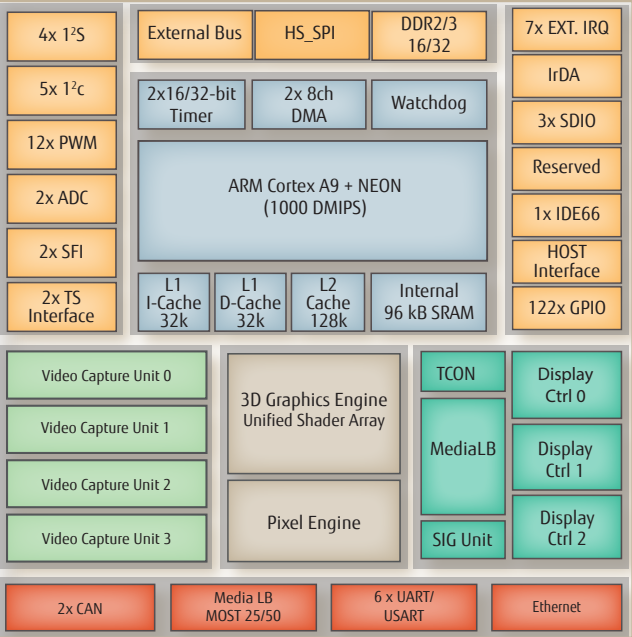
## 2.5D Graphics Engine Architecture

The Fujitsu fast 2.5D pixel engine can rotate and scale pre-rendered graphics data, and handle compressed bitmaps. (See block diagram.) All units in the pipeline work in synchronization with each other, courtesy of a signal that flows from the display to the start of the pipeline. Consequently, there is no need to flush the pipeline.

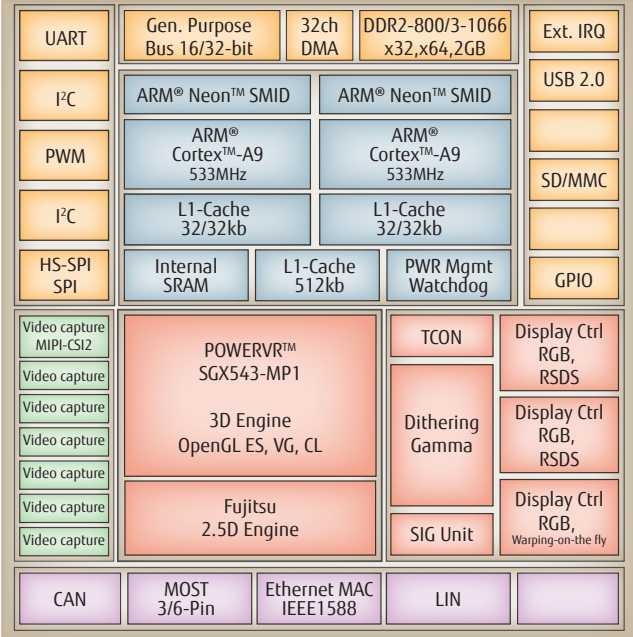
The Fujitsu 2.5D graphics engine is one of the key features of the Fujitsu FCR4 Cluster SoC family and the MB86R1x “Emerald” family of 2.5D/3D graphics SoCs. The engine’s modular system of building blocks can be combined to find the optimum scalable solution for customer requirements.



### Emerald-M



### Triton-C





## Summary

Fujitsu has been active in the embedded graphics market for more than 10 years and in the graphics space for nearly 20. The company is committed to bringing the most advanced GDCs to market and to making those products available for an extended period of time (many times longer than is required for PC or desktop graphics chips).

Moreover, Fujitsu optimizes its products for embedded applications that require support for multiple, higher resolution display panels. The Fujitsu GDCs strike the right balance between performance and power, and between features and cost.

More information is available at:  
[www.fujitsu.com/us/semiconductors/gdc/index.html](http://www.fujitsu.com/us/semiconductors/gdc/index.html).

Product	Description	Embedded Processor
MB88F33x "Indigo" Series	Sprite-based GDC with an APIX interface designed to be used in conjunction with "Jade D" or MB86R1x "Emerald" Series	No
MB86R03 "Jade -L"	2.5D/3D, DDR2, dual display/single capture. Interfaces: SD (1), I <sup>2</sup> C (2), I <sup>2</sup> S (3), PWM (2), UART (6), GPIO (24)	ARM926E
MB86R01 "Jade"	"Jade L" features plus USB, Media LB, IDE66	ARM926E
MB86R02 "Jade-D"	"Jade" plus an APIX (USB, IDE removed) dithering unit added to the display controller	ARM926E
MB86R11 "Emerald-L"	3D GDC core supporting OpenGL ES 2.0 plus new PixBlt engine for enhanced 2.5D processing. Four video-capture ports, with the ability to drive five displays. Interfaces include: Ethernet (1), SD (3), USB (2), I <sup>2</sup> C (5), I <sup>2</sup> S (4), PWM (12), UART (6), GPIO (25), CAN (2), SPI (2), QSPI (1)	ARM Cortex-A9
MB86R12 "Emerald-P"	Faster CPU (533 MHz) and graphics core (266MHz). Four high-speed APIX 2.0 ports – three outputs and one input. Rated for a -40 to +105° C operating range	ARM Cortex-A9
MB86R24 "Triton-C"	Dual-core ARM Cortex-A9 processors with Imagination's IMG543 3D graphics core combined with Fujitsu's high-performance 2.5D engine. Six video-capture inputs and three independent display controllers. Interfaces: SPI (3), Ethernet, USB 2.0, SDIO/ MMC (1), UART (6), USART (5), I <sup>2</sup> S (2), I <sup>2</sup> C (4), and PWM (8)	ARM Cortex-A9

## GDC Software and Support



Fujitsu offers comprehensive software tools and support for its line of GDCs, including:

**CGI Studio** – CGI Studio is software development platform for the creation of 2.5D and 3D graphical interfaces (HMI/GUI) for automotive instrument clusters and infotainment systems. Made up of a suite of Windows-based software tools, the application allows customers who have little or no experience with Fujitsu graphics APIs to rapidly produce high-quality HMI/GUIs. For more information, visit:  
<http://www.fujitsu.com/us/semiconductors/gdc/products/cgistudio.html>.

**Fujitsu 360° Wrap-Around Video Imaging Technology** – Available as a toolset for use with Fujitsu GDCs, this revolutionary technology provides a real-time, omnidirectional view of a vehicle's perimeter. The new driver assistance technology adapts to different driving situations, enabling the driver to peripherally view the entire surroundings of a vehicle, from the most appropriate point of view and field of view. The technology improves safety by helping the driver in a variety of situations, such as parking, passing and turning. To learn more, visit: [www.fujitsu.com/us/semiconductors/gdc/products/omni.html](http://www.fujitsu.com/us/semiconductors/gdc/products/omni.html).

For a full list of technical papers and documentation related to Fujitsu GDCs, please visit:  
[www.fujitsu.com/us/semiconductors/gdc/doc](http://www.fujitsu.com/us/semiconductors/gdc/doc).

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