



MOTOROLA

Imaging Systems Division

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REV 3

MPC823

Product Brief

MPC823

PowerPC Mobile Computing Microprocessor

MPC823 Overview

The MPC823 microprocessor is a versatile, one-chip integrated microprocessor and peripheral combination that can be used in a variety of portable electronic products. It is described as a low-cost version of the MPC821 microprocessor that provides an effective price/performance along with system enhancements for communication and displays. Specifically, it has a universal serial bus (USB) interface and video display controller, as well as the existing LCD controller of the MPC821 device. The MPC823 microprocessor particularly excels in low-power, portable, image capture, and personal communication products. The MPC823 microprocessor integrates a high-performance embedded PowerPC™ core with a communication processor module that uses a specialized RISC processor for imaging and communication. The communication processor module can perform embedded signal processing functions for image compression and decompression. It also supports six serial channels—one serial communication controller, two serial management controllers, one I²C® port, one universal serial bus channel, and one serial peripheral interface. This two-processor architecture consumes power more efficiently than traditional architectures because the communication processor module frees the core from peripheral tasks like imaging and communication.

FEATURES

The following list summarizes the main features of the MPC823:

- Embedded PowerPC Core Provides 107 MIPS (Using Dhrystone 2.1) or 186K Dhrystones 2.1 at 81 MHz
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SEMICONDUCTOR PRODUCT INFORMATION

MPC823 Overview, continued

FEATURES (continued)

- Single-Issue, 32-Bit Version of the PowerPC Core (Fully Compatible with the PowerPC Architecture Definition) with 32 x 32-Bit Fixed-Point Registers
- Low Power Consumption, 2.2V Internal, 3.3V I/O Boundary with Microprocessor Core, Caches, Memory Management, and I/O in Operation
- Performs Branch Folding, Branch Prediction with Conditional Prefetch, without Conditional Execution
- 1K Data Cache and 2K Instruction Cache
- Instruction and Data Caches are Two-Way, Set-Associative, Physical Address, 4-Word Line Burst, LRU Replacement Algorithm, Lockable Online Granularity
- Memory Management Units with 8-Entry Translation Lookaside Buffers (TLBs) and Fully Associative Instruction and Data TLBs
- Memory Management Units Support Multiple Page Sizes of 4K, 16K, 512K and 8M (1K Protection Granularity at the 4K Page Size); 16 Virtual Address Spaces and 16 Protection Groups
- Advanced On-Chip Emulation Debug Mode
- Data Bus Dynamic Bus Sizing for 8-, 16-, and 32-Bit Buses
 - Supports Traditional 68K Big-Endian, Traditional x86 Little-Endian, and PowerPC Little-Endian Memory Systems
 - Twenty-Six External Address Lines
- Completely Static Design (0–81 MHz Operation)
- Communication Processor Module
 - Interfaces to PowerPC Core Through On-Chip Dual-Access RAM and Virtual (Serial) DMA Channels on a Dedicated DMA Accelerator
 - Programmable Memory-to-Memory and Memory-to-I/O (Including Flyby) DMA Provided by Virtual DMA Support
 - 80+MIPS @ 81 MHz
 - Protocols Supported by ROM or Download Microcode and the Single Hardware Serial Communication Controller Include, But Are Not Limited To, the Digital Portions of:
 - Ethernet/IEEE 802.3 (CS/CDMA)
 - HDLC/SDLC and HDLC Bus
 - Appletalk
 - Universal Asynchronous Receiver Transmitter (UART)

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MPC823 Overview, *continued*

FEATURES (*continued*)

- Synchronous UART (USART)
- Totally Transparent Mode With/Without CRC
- Asynchronous HDLC
- IrDA Version 1.1 Serial Infrared
- Basic Rate ISDN (BRI) in Conjunction with Serial Management Controller Channels
- Primary Rate ISDN
- 16 x 16-Bit Multiply-Accumulate (MAC) Hardware
 - One Operation Per Clock
 - Two Clock Latency and One Clock Blockage
 - Operates Concurrently with Other Instructions
 - Uses DMA Controller to Burst Data Directly into Register File without Interacting with the PowerPC Core
- DSP Functions Are Supported by ROM or Download Microcode and the Communication Processor Module DSP Capabilities, Include, But Are Not Limited To:
 - V.32bis Datapump Filters
 - V.34bis Datapump Filters
 - JPEG Compression/Decompression
- 8K Dual-Port RAM; Revision 0 Contains 5K Dual-Port RAM
- Twelve Serial DMA (SDMA) Channels
- 32-Bit, Harvard Architecture, Scalar RISC Microcontroller
- Communication-Specific Commands
- Supports Continuous-Mode Transmission and Reception on All Serial Channels
 - Each Serial Channel has Externally Accessible Pins
- Four Baud Rate Generators. (If you are using the first Mask Revision, Base #F98S, there are only two baud rate generators)
 - Independent and Can Be Connected to A Serial Communication Controller or Serial Management Controller
 - Allows Changes During Operation
 - Autobaud Support Option
- One Serial Communication Controller
 - Ethernet/IEEE 802.3 Support (10Mbps and Full-Duplex Operation)
 - GeoPort Support
 - HDLC Bus Implements an HDLC-Based Local Area Network

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MPC823 Overview, *continued*

FEATURES (*continued*)

- Universal Asynchronous Receiver Transmitter
- Synchronous UART
- Serial Infrared (IrDA) Supporting a Maximum of 4Mbps
- Totally Transparent. Frame Based with Optional Cyclical Redundancy Check
- Maximum Serial Data Rate of 35Mbps
- One Dedicated High-Speed Serial Channel for the Universal Serial Bus (USB)
 - Supports USB Slave Mode At a Maximum of 12Mbps With Four USB Endpoints
- Two Serial Management Controllers with Externally Accessible Pins
 - UART
 - Transparent
 - General Circuit Interface (GCI) Controller
 - Can Be Connected to the Time-Division Multiplexed (TDM) Channel
- One Serial Peripheral Interface
 - Supports Master and Slave Modes
 - Supports Multimaster Operation on the Same Bus
- One I²C Port
 - Supports Master and Slave Modes
 - Supports Multimaster Environments
 - Supports High-Speed Operation
 - Supports 7-Bit Addressing
- Serial Interface with the Time-Slot Assigner
 - Allows Serial Communication Controller and Serial Management Controllers To Be Used in Multiplexed and/or Nonmultiplexed Operation
 - Supports T1, CEPT, PCM Highway, ISDN Basic Rate, ISDN Primary Rate, User-Defined
 - 1- or 8-Bit Resolution
 - Allows Independent Transmit and Receive Routing, Frame Syncs, and Clocking
 - Allows Dynamic Changes
 - Can Be Internally Connected to Three Serial Channels

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MPC823 Overview, *continued*

FEATURES (*continued*)

- General-Purpose Timers
 - Four 16-Bit Timers or Two 32-Bit Timers (if you are using the first Mask Revision, Base #F98S, there are only two timers)
 - Gate Mode Can Enable/Disable Counting
 - Interrupt Can Be Masked on Reference Match and Event Capture
- Interrupts
 - Seven External Interrupt Request (IRQ) Lines
 - One Nonmaskable Interrupt
 - Twelve Port Pins with Interrupt Capability
 - Ten Internal Interrupt Sources
 - Programmable Highest Priority Request
- Memory Controller (Eight Banks)
 - Can be Programmed to Support Almost any Memory Interface
 - Each Bank Can Be a Chip-Select or $\overline{\text{RAS}}$ to Support a DRAM Bank
 - A Maximum of 30 Wait States per Memory Bank Can Be Programmed
 - Glueless Interface to DRAM Single In-Line Memory Modules, Static RAM, Electrically Programmable Read-Only Memory, Flash EPROM, or Synchronous DRAM
 - Four $\overline{\text{CAS}}$ lines, Four $\overline{\text{WE}}$ lines, and One $\overline{\text{OE}}$ Line
 - Boot Chip-Select Available at Reset (Options for 8-, 16-, or 32-Bit Memory)
 - Variable Block Sizes—32K to 256M
 - Selectable Write Protection
 - On-Chip Bus Arbitration Supports External Bus Master
 - Special Features for Burst Mode Support
- System Integration Unit
 - Hardware Bus Monitor
 - Spurious Interrupt Monitor
 - Software Watchdog Timer
 - Periodic Interrupt Timer
 - Low-Power Stop Mode
 - Clock Synthesizer
 - PowerPC Decrementer
 - PowerPC Timebase

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MPC823 Overview, *continued*

FEATURES (*continued*)

- Real-Time Clock
- Reset Controller
- IEEE 1149.1 Test Access Port (JTAG)
- Video/LCD Controller
 - Video Controller
 - Supports Digital NTSC/PAL Video Encoders and Digital TFT
 - Sequential RGB, 4:4:4, and 4:2:2 YC_rC_b (CCIR 601) Digital Component Video Formats
 - CCIR-656 Compatible 8-Bit Interface Port
 - Horizontal Sync, Vertical Sync, Field and Blanking Timing Generation with Half-Clock Resolution and Programmable Polarity
 - Supports Interlace/Noninterlace Scanning Methods
 - Programmable Display Active Area
 - Programmable Background Color for Inactive Area
 - Glueless Interface for Most Digital Video Encoders
 - Hardware Horizontal Scrolling
 - Uses Burst Read DMA Cycles for Maximum Bus Performance
 - Panel Voltage Control Adjustments for Contrast Set with On-Chip Timers
 - End-of-Frame Interrupt Generation
 - LCD Controller
 - Supports Digital TFT and Passive LCD Panels
 - Horizontal Sync, Vertical Sync, Field and Blanking Timing Generation with Half-Clock Resolution and Programmable Polarity
 - 1-, 2-, or 4-Bit Per Pixel Grayscale Mode Using Advanced Frame Rate Control (FRC) Algorithm
 - Four or Eight Bits Per Pixel Color Mode
 - 4-, 8-, 9-, or 12-Bit Parallel Output to LCD Displays
 - Programmable Display Active Area
 - Non-Split or Vertically-Split Screen Support
 - Uses Burst Read DMA Cycles for Maximum Bus Performance
 - End of Frame Interrupt Generation
 - Data for Splits—2+2 or 4+4 Parallel Bits (x+x Refers to x Bits Each for Lower and Upper Screens in Parallel)
 - Built-In Color RAM with 256 12-Bit Entries

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MPC823 Overview, *continued*

FEATURES (*continued*)

- Programmable Wait Time Between Lines and Frames
- Panel Voltage Control Adjustments for Contrast Set with On-Chip Timers
- Programmable Polarity for All LCD Interface Signals
- Single-Socket PCMCIA-ATA Interface
 - Master Interface, Release 2.1 Compliant
 - Single PCMCIA Socket
 - Eight Memory or I/O Windows Available
 - Eight General-Purpose I/O Pins and Two General-Purpose Output-Only Pins are Available When the PCMCIA Controller Is Not in Operation
- Low-Power Support Modes
 - Normal High—All Units Are Fully Powered at High Clock Frequency
 - Normal Low—All Units Are Fully Powered at Low Clock Frequency
 - Doze—Core Functional Units Are Disabled, Except Timebase, Decrementer, PLL, Memory Controller, Real-Time Clock, LCD, and Communication Processor Module
 - Sleep—All Units Are Disabled, Except Real-Time Clock, Periodic Interrupt Timer, Timebase, and Decrementer. PLL Is Active for Fast Wake-up
 - Deep Sleep—All Units Are Disabled Including PLL, But Not the Real-Time Clock and Periodic Interrupt Timer, Timebase, and Decrementer
 - Power-Down—All Units Are Disabled Including PLL, but Not the Real-Time Clock and Periodic Interrupt Timer, Timebase, and Decrementer. Saves More Power Than Other Modes. The State of Certain Registers May Be Preserved
 - Separate Power Supply Input to Operate Internal Logic at 2.5V At or Below 40 MHz Operation
 - Can Be Dynamically Shifted Between High Frequency (3.3V Internal) and Low Frequency (2.5V Internal) Operation
- Development Capabilities and Interface
 - Program Flow Tracking
 - Instruction Show Cycle
 - Data Show Cycle
 - Branching

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MPC823 Overview, *continued*

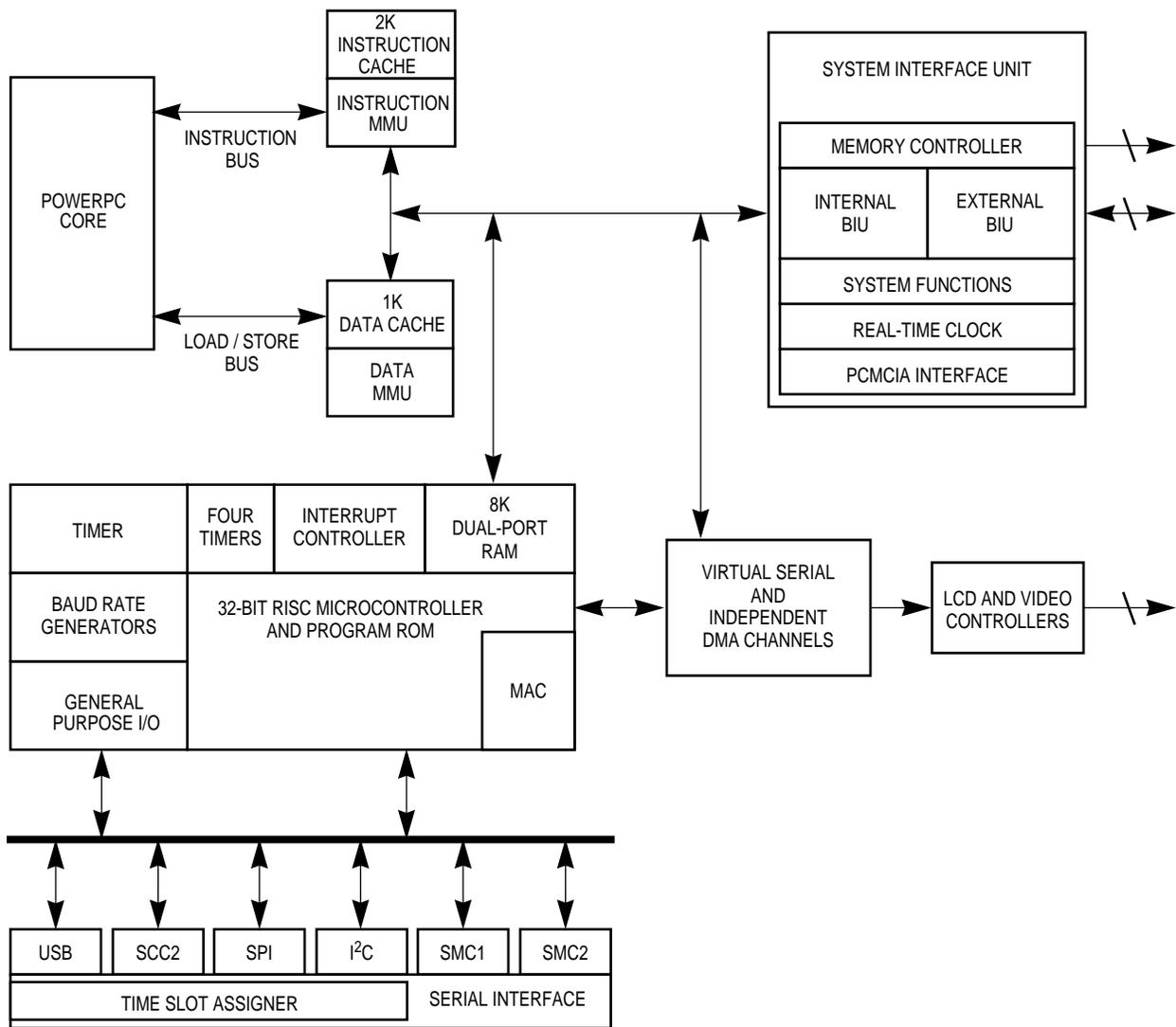
FEATURES (*continued*)

- Exception Traps
 - Watchpoints and Breakpoints
 - Four Hardware Breakpoints
 - Five Watchpoint Sources
 - Simple Hardware Interface
 - High-Speed Data Transfer
 - Internal Status Pins
 - Freeze Indication
 - Rich Control Register Set
 - 3.3V Operation with 5V TTL Compatibility for the General-Purpose I/O Port Pins and 3.3V for All Others. For Revision 0, All Pins are 5V TTL- Compatible
 - 256-Pin Plastic Ball Grid Array (BGA) Packaging
-

ARCHITECTURE

The MPC823 microprocessor uses a dual-processor architecture design approach to provide a high-performance, general-purpose RISC integer processor and a special-purpose 32-bit scalar RISC communication processor module. The peripherals are uniquely designed for communication requirements and can provide embedded signal processing functions for communication and user interface enhancements and the I/O support needed for high-speed digital communication. The MPC823 is comprised of four main modules that interface with the 32-bit internal bus:

- The embedded PowerPC core
 - The system interface unit
 - The communication processor module
 - LCD controller
-



MPC823 Block Diagram

THE EMBEDDED POWERPC CORE

The PowerPC core complies with standard PowerPC architecture. It has a fully static design that consists of three functional blocks—the integer block, hardware multiplier/divider, and load/store block. The core supports integer operations on a 32-bit internal data path and 32-bit arithmetic hardware. Its interface to the internal and external buses is 32 bits. The core uses a two-instruction load/store queue, four-instruction prefetch queue, and a six-instruction history buffer. It

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MPC823 Overview, *continued*

THE EMBEDDED POWERPC CORE *(continued)*

performs branch folding and branch prediction with conditional prefetch, but without conditional execution. With single bus cycles, the core can operate on 32-bit external operands and with critical-word-first in multiple bus cycles. The PowerPC integer block supports 32 x 32-bit fixed-point general-purpose registers and can execute one integer instruction per clock cycle.

The PowerPC core is integrated with the memory management units, an instruction cache, and a data cache. The memory management units (MMUs) provide 8-entry, fully associative instruction and data TLBs, with multiple page sizes of 4K (1K protection), 16K, 512K, and 8M. They support 16 virtual address spaces and 16 protection groups. Special registers are available to support software tablewalk and update.

The instruction cache is 2K, two-way, set-associative with physical addressing. It allows single-cycle accesses on hit with no added latency for miss. It is four words per line and supports burst line fill using an LRU replacement algorithm. The cache can be locked on a line basis for application critical routines. The data cache is 1K, two-way, set-associative with physical addressing. It allows single-cycle accesses on hit with one added clock latency for miss. It has four words per line and supports burst line fill using an LRU replacement algorithm. The cache can be locked on a line basis for application critical data and can be programmed to support copyback or writethrough mode via the memory management unit. The cache-inhibit mode can be programmed per MMU page. The PowerPC core, with its instruction and data caches, can deliver approximately 107 MIPS at 81 MHz (using Dhrystone 2.1) or 186K Dhrystones, based on the assumption that it is issuing one instruction per cycle with a cache hit rate of 94%.

THE COMMUNICATION PROCESSOR MODULE

The communication processor module (CPM) contains features that allow the MPC823 microprocessor to excel in imaging, personal communication, and low-power applications. These features are divided into three categories:

- DSP processing
- Communication processing
- Twelve serial DMA channels and two independent DMA channels

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MPC823 Overview, *continued*

THE COMMUNICATION PROCESSOR MODULE *(continued)*

The MPC823 embedded DSP function allows the communication processor module to execute imaging algorithms in parallel with the PowerPC core to achieve maximum performance with very little power. The DSP can execute one 16x16 MAC on every clock cycle. It has preprogrammed filtering functions like FIR, MOD, DEMOD, IIR, and downloadable imaging functions for JPEG image compression and decompression. These functions are also used by modem and speech recognition programs.

The robust communication features of the MPC823 are provided by the communication processor module. These features include a RISC microcontroller with multiply accumulate (MAC) hardware, one serial communication controller (SCC), two serial management controllers (SMCs), one dedicated serial channel for the universal serial bus (USB), one inter-integrated circuit (I²C) port, one serial peripheral interface (SPI), an 8K dual-port RAM, interrupt controller, time-slot assigner, and four independent baud rate generators.

Twelve serial DMA channels support the SCC, SMCs, USB channel, SPI, and I²C controllers. The independent DMAs give you two channels for general-purpose DMA usage. They offer high-speed transfers, 32-bit data movement, buffer chaining, and independent request and acknowledge logic. The RISC microcontroller is the only block that can access the IDMA registers directly. The CPU can only access them indirectly via a buffer descriptor.

THE SYSTEM INTERFACE UNIT

The system interface unit supports traditional 68K big-endian memory systems, traditional x86 little-endian memory systems, and PowerPC little-endian memory systems. It also provides power management functions, reset control, a PowerPC decremter, PowerPC timebase, and real-time clock. Although the PowerPC core is a 32-bit device internally, it can be configured to operate with an 8-, 16-, or 32-bit data bus. Regardless of the system bus size, dynamic bus sizing is supported, which allows 8-, 16-, and 32-bit peripherals and memory to coexist on a 32-bit system bus.

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MPC823 Overview, *continued*

THE SYSTEM INTERFACE UNIT (*continued*)

The memory controller supports as many as eight memory banks with glueless interfaces to DRAM, SRAM, EPROM, Flash EPROM, SDRAM, EDO and other peripherals with two-clock initial access to external SRAM and bursting support. It provides variable block sizes between 32K and 256M. The memory controller has 0 to 20 wait states for each bank of memory and can use address type matching to qualify each memory bank access. It provides four byte-enable signals for varying width devices, one output-enable signal, and one boot chip-select that is available at reset.

The DRAM interface supports 8-, 16-, and 32-bit ports and uses a programmable state machine to support almost any memory interface. Memory banks can be defined in depths of 256K, 512K, 1M, 2M, 4M, 8M, 16M, 32M, or 64M for all port sizes. In addition, the memory depth can be defined as 64K and 128K for 8-bit memory or 128M and 256M for 32-bit memory. The DRAM controller supports page mode access for successive transfers within bursts. The MPC823 supports a glueless interface to one bank of DRAM, while external buffers are required for additional memory banks. The refresh unit provides $\overline{\text{CAS}}$ before $\overline{\text{RAS}}$, a programmable refresh timer, refresh active during external reset, disable refresh modes, and stacking for a maximum of seven refresh cycles.

THE VIDEO/LCD CONTROLLER

The MPC823 has a dual-purpose video/LCD controller that shares common dual-port memory. However, only one of the controllers can be run at a time.

The video controller can be used to drive a digital NTSC/PAL encoder or a wide variety of digital LCD panels. The frame buffer is stored in system memory in the form of an orthogonal matrix—rows and columns. The 24-bit color data is organized as pixel components whether it is sequential RGB or YCrCb . Each pixel component is represented by a byte. The video controller uses a dedicated DMA channel to read the display data from the frame buffer and drive it to the video interface. It also generates the required timing signals, such as horizontal sync, vertical sync, field, and blanking.

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MPC823 Overview, *continued*

THE VIDEO/LCD CONTROLLER *(continued)*

The LCD controller provides extremely versatile LCD support for 8-bit color, monochrome or 4/16-level grayscale, color TFT (12 bits, 4x3 RGB), and passive color (xSTN) 4/8 bit data. The controller supports 4-bit single-scan, 8-bit dual-scan, 2+2 bit dual-scan, or 4+4 bit dual-scan. It is programmable for frame rate, number of pixels per line, and number of lines per frame. The panel voltage is programmable through the duty cycle for contrast adjustments implemented in the communication processor module program. Display data is stored in memory space and is transferred into the controller using the DMA channel.

THE PCMCIA-ATA CONTROLLER

The PCMCIA-ATA interface is a master controller that is compliant with Version 2.1 of the PCMCIA standard. The interface supports one independent PCMCIA socket with the required external transceivers or buffers. It provides eight memory or I/O windows that can be allocated to the socket. If the PCMCIA port is not being used as a card interface, it can provide eight general-purpose pins and two output-only pins with interrupt capability.

POWER MANAGEMENT

The MPC823 microprocessor supports a wide range of power management features, including normal high, normal low, doze, sleep, deep-sleep, and power-down modes. In normal high mode, the MPC823 microprocessor is fully powered with all internal units operating at the full speed of the processor. Normal low mode is the same as normal high, except it operates at a much lower frequency. There is a doze mode determined by a clock divider that allows the operating system to reduce the operational frequency of the processor.

Doze mode disables core functional units except the timebase, decremter, PLL, memory controller, real-time clock, LCD controller, and communication processor module. Sleep mode is a lower power mode that disables everything except the real-time clock, timebase, decremter, and periodic interrupt timer, thus leaving the PLL active for quick wake-up. The deep-sleep mode then disables the PLL for lower power, but slower wake-up. Power-down mode disables all logic in the processor, except the minimum logic required to restart the device. It saves the most power, but requires the longest wake-up time.

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MPC823 Overview, *continued*

POWER MANAGEMENT *(continued)*

The MPC823 microprocessor also provides a separate set of power pins for the internal logic in the device. These power pins can be used to give the device a 2.5V power source that can be used when the microprocessor is operating at 40 MHz or less. This capability reduces the power consumption of the device by an additional 30%.

SYSTEM DEBUG SUPPORT

The MPC823 microprocessor contains an advanced debug interface that provides superior debug capabilities without any loss of speed. It supports six watchpoint pins that can be combined with eight internal comparators, four of which operate on the effective address of the address bus. The other four comparators are split—two comparators operate on the effective address on the data bus and two comparators operate on the data on the data bus. The MPC823 microprocessor can compare using the =, ≠, <, and > conditions to generate watchpoints. Each watchpoint can then generate a breakpoint that can be programmed to trigger in a programmable number of events.

APPLICATIONS

The MPC823 microprocessor is specifically designed to be a general-purpose, low-cost entry point to the Motorola embedded PowerPC Family for systems in which advanced GUIs, communications, and high-level real-time operating systems are used. The device excels in applications that require the performance of single-issue PowerPC core with a moderate amount of data and instruction cache. It provides all the basic features of glueless memory connections along with highly functional serial connectivity, a graphical LCD, and a video display controller. The MPC823 excels in low-power and portable applications because of its extensive power-down modes and low normal operation current.

ORDER INFORMATION

The following table contains the package type and operating frequencies of the MPC823.

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MPC823 Overview, *continued*

ORDER INFORMATION (*continued*)

PACKAGE TYPE	FREQUENCY	TEMPERATURE	ORDER NUMBER
256 lead PBGA 23x23u 1.27mm pitch	25 MHz	0°C to 70°C	XPC823ZT25Z3
	50 MHz	0°C to 70°C	XPC823ZT50Z3
	25 MHz	-40°C to +85°C	XPC823CZT25Z3
	66 MHz	0°C to 70°C	XPC823ZT66A
	75 MHz	0°C to 70°C	XPC823ZT75A
	81 MHz	0°C to 70°C	XPC823ZT81A
256 lead GTBGA 17x17mm 1.00mm pitch	66 MHz	0°C to 70°C	XPC823ZC66A
	75 MHz	0°C to 70°C	XPC823ZC75A
	81 MHz	0°C to 70°C	XPC823ZC81A

The documents listed in the table below contain detailed information on the MPC823. You can obtain these documents from the Motorola Literature Distribution Center closest to you or from our website at www.mot.com/mpc823.

DOCUMENT TITLE	ORDER NUMBER	CONTENTS
<i>MPC823 User's Manual</i>	MPC823UM/AD	Detailed Information for Design
<i>MPC823 User's Manual Errata</i>	MPC823UMAD/D	Corrections, clarifications to the Manual
<i>MPC823 CD</i>	CDMPC823/D	User's Manual in PDF
<i>MPC823 Pocket Reference Guide</i>	MPC823RG/D	Quick Reference to the MPC823 User's Manual
<i>MPC823 Electrical Specifications</i>	MPC823ELE/D	Electrical Specifications for the MPC823
MPC823 Literature Package	MPC823PAK/D	MPC823 User's Manual, Pocket Reference Guide, Electrical Specifications, and CD.
<i>PowerPC Microprocessor Family: The Programming Environments for 32-Bit Microprocessors</i>	MPCFPE32B/AD	PowerPC Instruction Set
<i>PowerPC Resource Guide</i>	BR1724/D	Independent Vendor Listing of Supporting Software and Development Tools

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