8-bit Low Pin Count MCU Hands On Seminar

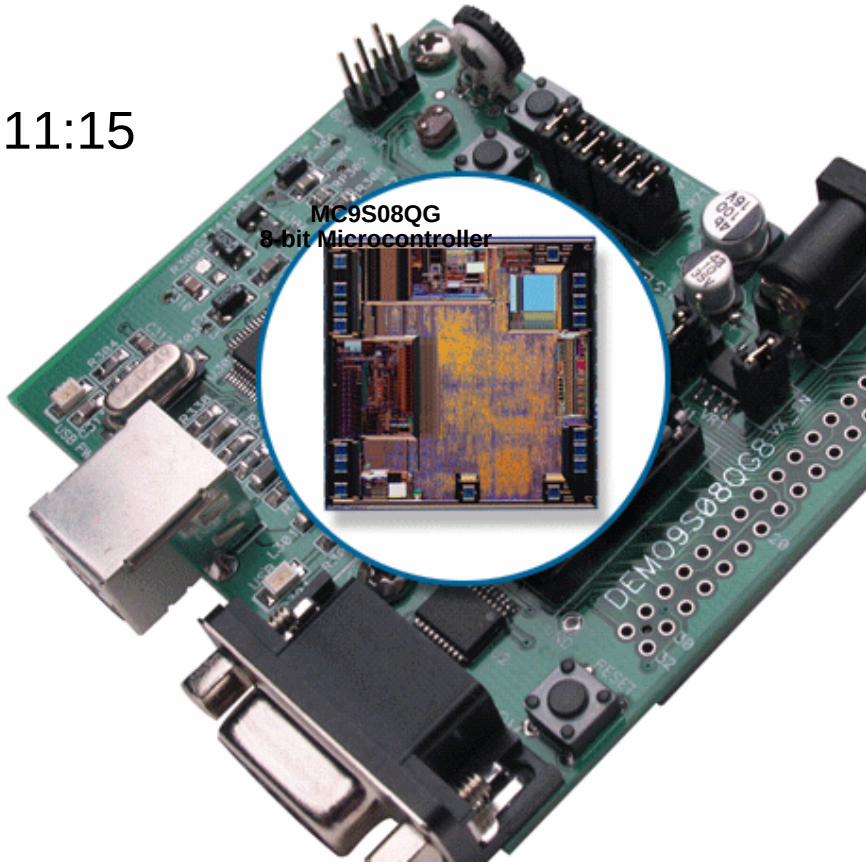
Technical Sales Presentation

October 25, 2005

freescale™ semiconductor

Agenda

- Introduction 9:00 – 9:15
- Technical Overview 9:15 – 9:45
- Peripherals Overview and Labs 10:00 – 11:15
  - MC9S08QG8 Demo Kit
  - CodeWarrior Installation
  - Lab 1 CodeWarrior Project
  - Lab 2 Application Software
  - Lab 3 ICS Lab
  - Lab 4 MTIM Lab
  - Lab 5 Analog Comparator Lab
  - Lab 6 ADC Lab
- RC Robot Demo 11:15 – 11:30
- Questions and Summary 11:30 – 12:00



Announcing Freescale's New MC9S08QG Family

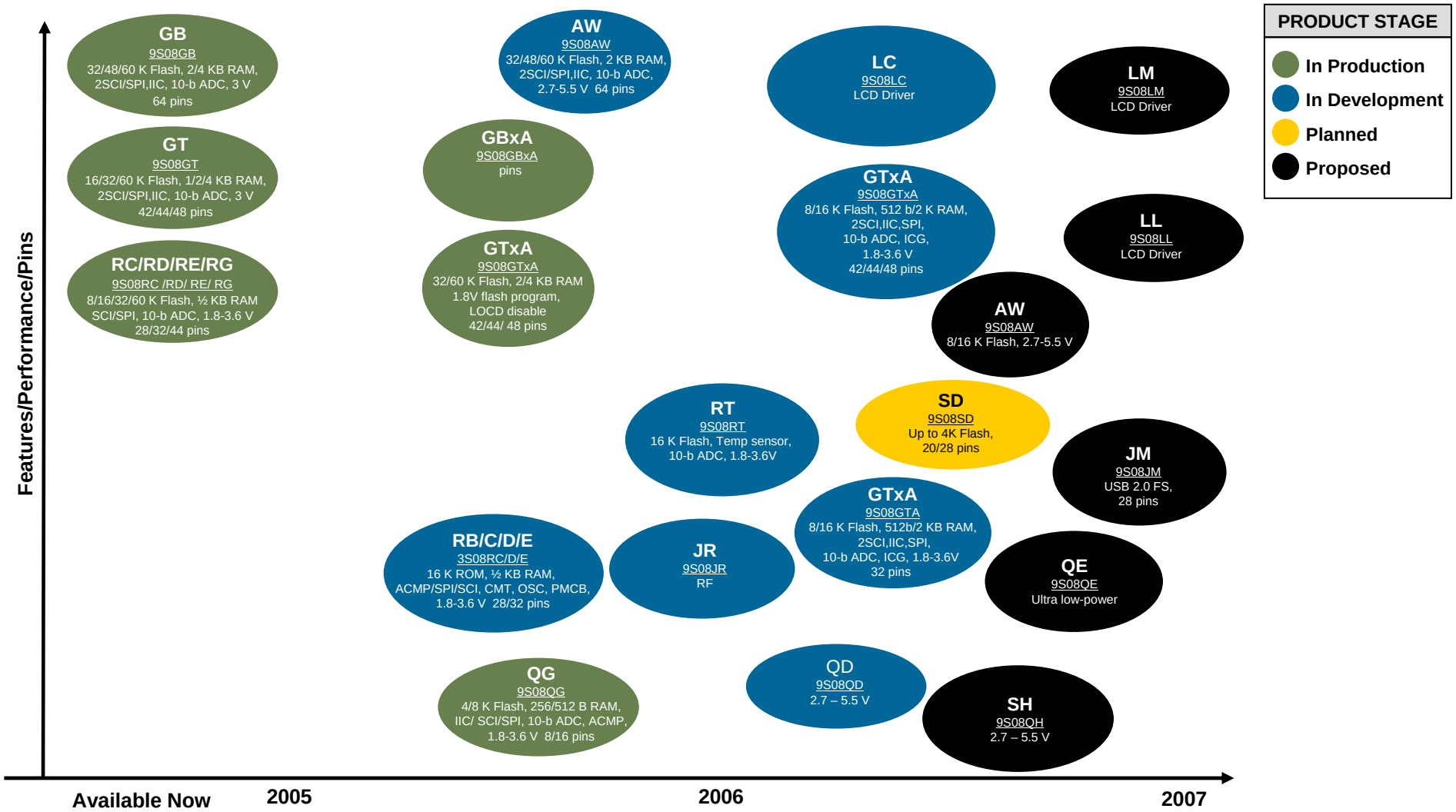
Highest Level of 8-bit On-Chip Integration for the Price

- **Solution to the increasing demand in the 8-bit market for more tightly integrated microcontrollers**
- **High integration on a single chip means:**
  - Fewer external system components
  - Lower overall system costs
  - Reduced design time
  - Lessened probability of overall board quality problems
- **Freescale's 8-bit portfolio performs well in providing**
  - High resolution analog
  - Multiple communications options
  - Motion control ready devices

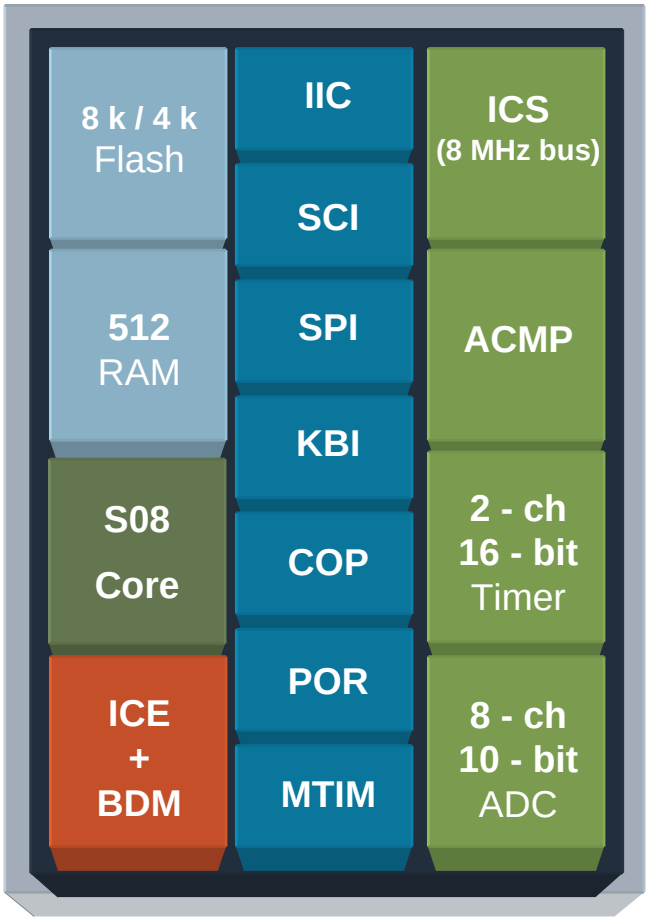
So Highly Integrated, It's a Shame to Call This One Low-End.

- **Brings all the advantages of the HCS08 Family to small package, low pin count devices.**
- **Combines advantages of 908Q with HCS08 core:**
  - **Small, general purpose + low power, feature rich = MC9S08QG8**
- **Further improves the already stellar low-power capabilities of HCS08 core!**
- **Full feature set for easy development:**
  - High resolution analog, multiple communications options, temp sensor, all the "extras"
- **Attractive price - General purpose use is only the beginning!**

HCS08 Roadmap



MC9S08QG8/4 – Feature Set



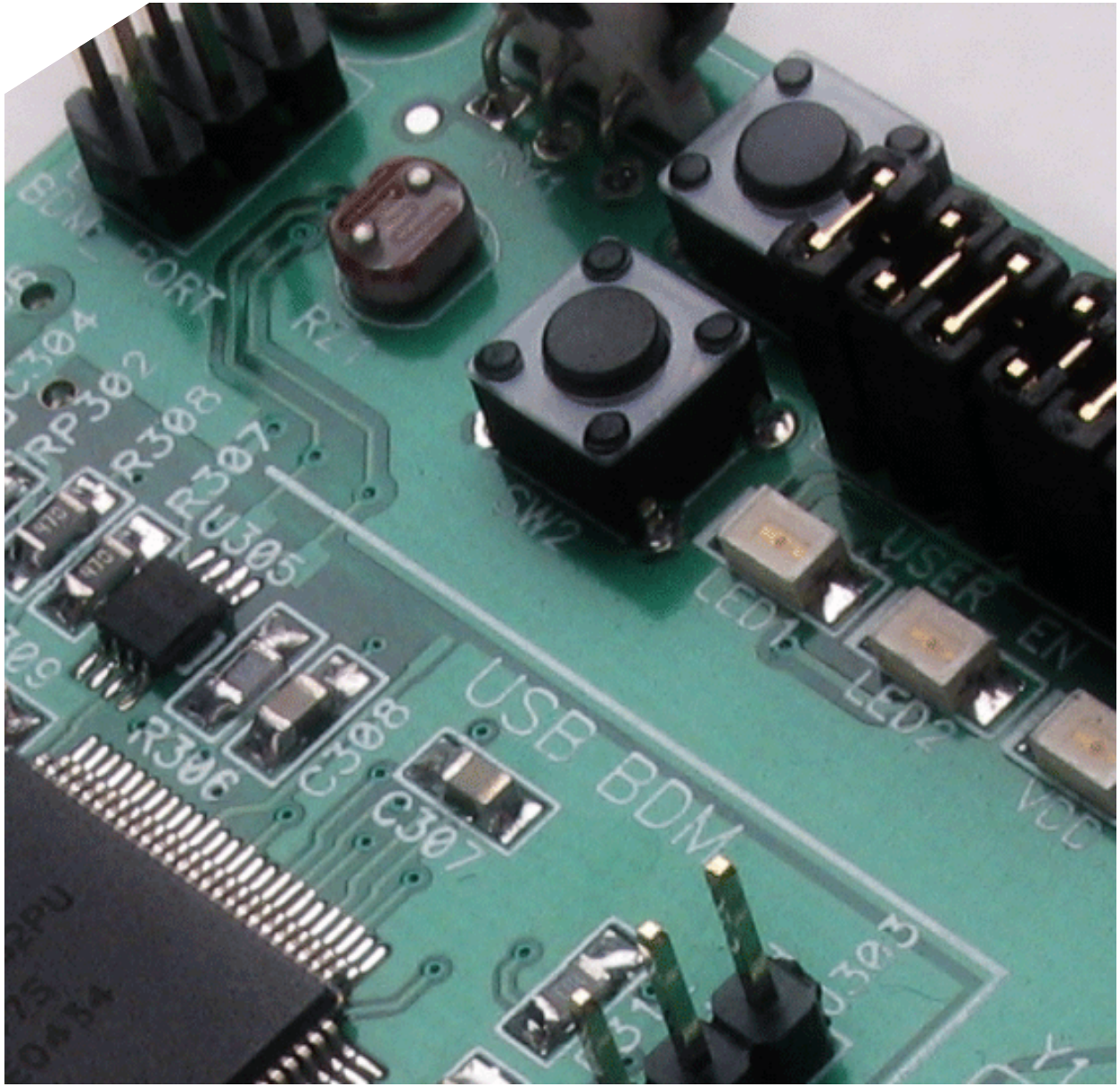
8 pin packages – PDIP, NB-SOIC, DFN
16 pin packages – PDIP, TSSOP, QFN

Features

- **Memory**
  - 4 - 8 k Flash, capable of EEPROM emulation
  - 512 bytes of RAM
- **Internal Clock Source (ICS)**
  - Up to 10 MHz bus
  - FLL
  - On-chip oscillator
  - External crystal support (16 - pin only) up to 10 MHz bus
  - 2% accuracy over full operating range
- **Serial Communication**
  - IIC (synchronous), SPI (synchronous), and SCI (asynchronous)
- **Timers**
  - 2 - channel Timer/PWM Module (TPM)
  - An 8 - bit modulo timer module (MTIM) with 8 - bit prescaler
- **Analog Modules**
  - 8 - ch, 10 - bit Analog-to-digital converter
  - Analog comparator
- **Development Tools**
  - On chip ICE and BDM

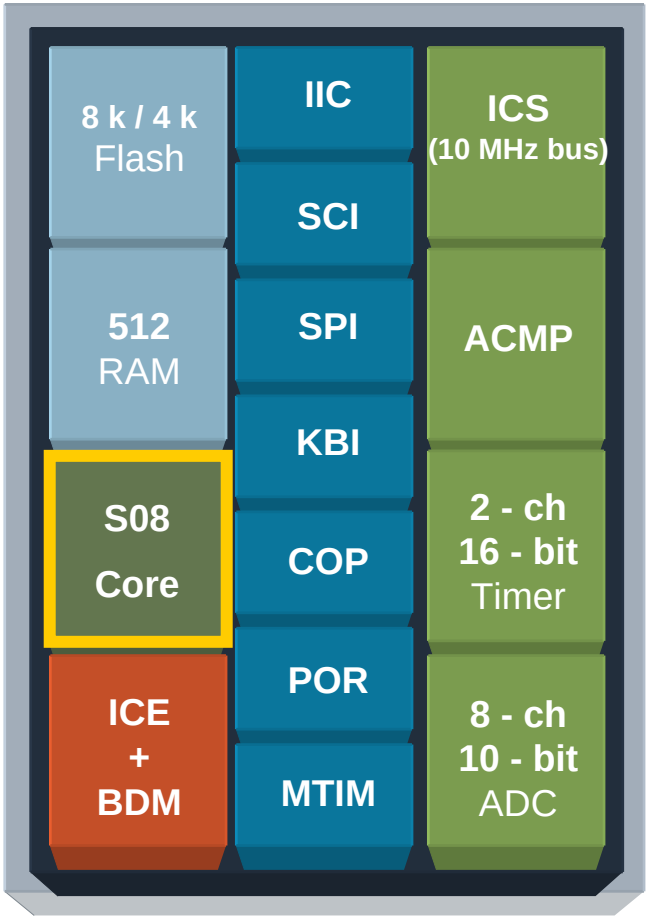
MC9S08QG8/4 Target Applications

- Wireless communications
- SMAC as part of Zigbee configuration
- Wireless sensor applications
- Watchdog co-processor
- Electronic power meters
- Handheld devices
- Home appliance
- Human input devices
- Secure boot co-processors
- Industrial control
- Security and alarm systems
- Sensing systems
- Small appliances
- Smart battery
- Smoke and CO detection
- Binary clocks
- Toys
- Lighting control
- PC peripherals
- Remote control
- Battery chargers



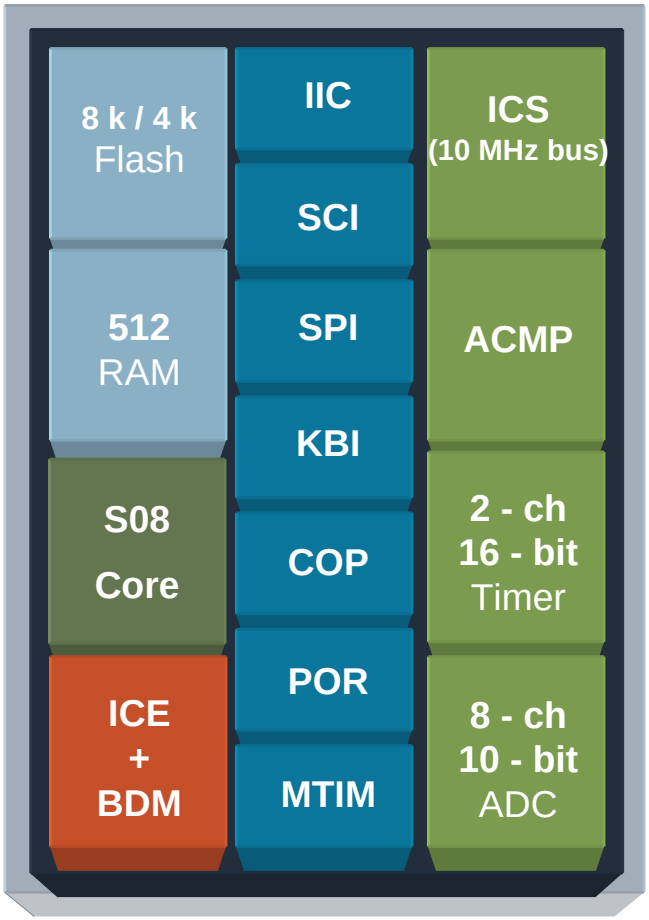
9S08QG8/4
Features and Benefits

MC9S08QG8/4 – S08 Central Processor Unit (CPU)



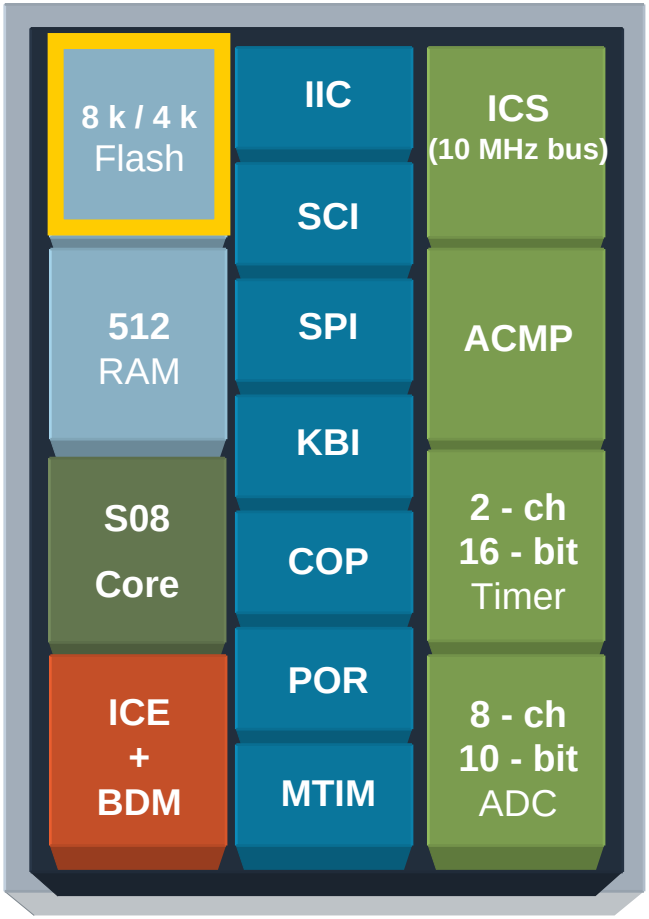
Features	Benefits
• Up to 20 MHz (10 MHz bus) at >2.1V operation for 100 ns minimum instruction time and 16 MHz (8 MHz bus) frequency at <2.1V	• Offering high performance, even at low voltage levels for battery-operated applications
• HC08 instruction set with added BGND instruction	• Easy to learn and use architecture • Backwards object code compatibility with 68HC08 and 68HC05, so existing libraries can still be used • Allows for efficient, compact module coding in assembly or C compiler • BGND allows user to enter the background debug mode that takes advantage of the on-chip In-circuit emulator (ICE)
• Support for up to 32 interrupt / reset sources	• Allows for greater software flexibility and optimization for real-time applications

MC9S08QG8/4 – Operating Modes



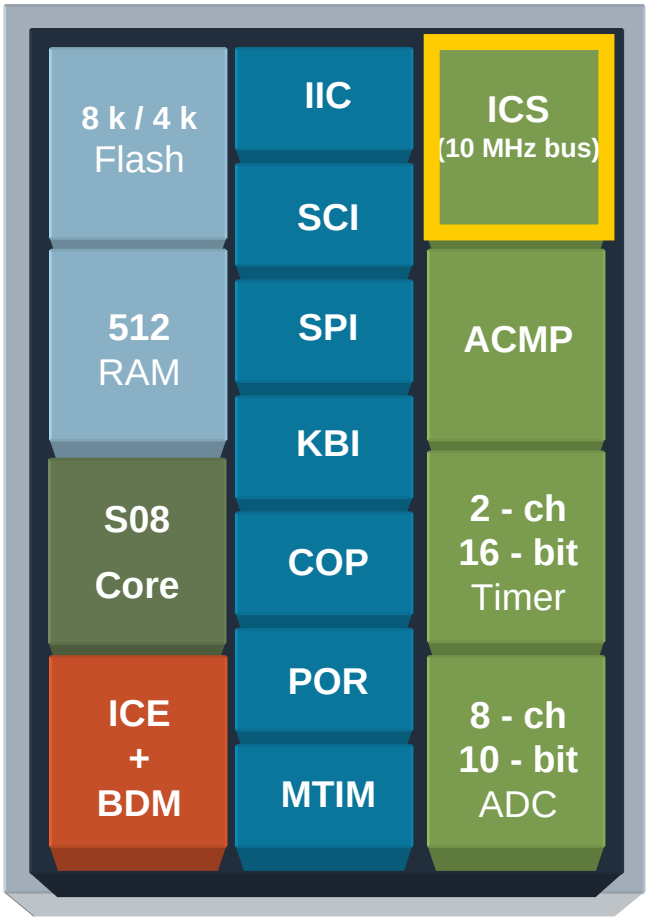
Features	Benefits
•Run currents typically 500uA per MHz of bus frequency.	• Longer battery life, when RUN mode is required often • Option to run at lower speeds for systems with sensitive power budget in active modes
Low-power STOP and WAIT modes •Wait •Stop3 •Stop2 •Stop1	• Flexiblity to choose best mode for performance vs power consumption. • Stop mode currents all less than 1uA
Ultra low power real-time interrupt with internal or external clock source	• Can be used in stop2, stop3, wait and run modes to generate periodic interrupt. • Wake MCU from stop2, stop3, and wait modes without any additional components • Operates on as little as 300nA of current

MC9S08QG8/4 – Flash Memory



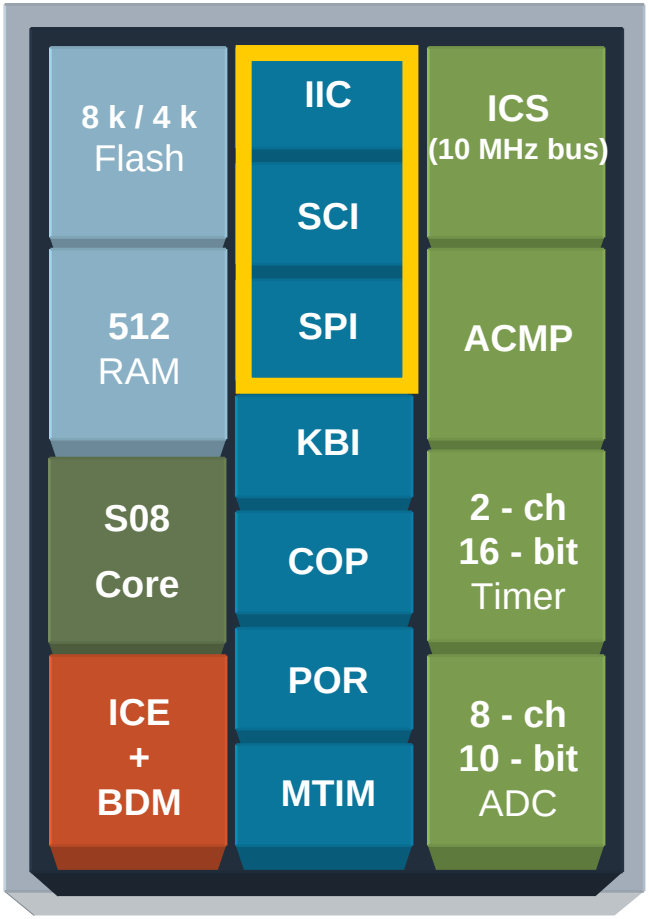
Features	Benefits
• In-application re-programmability	• Provides users a single silicon solution for multiple platforms • Allows field re-programmability and upgradeability to future-proof designs
• FLASH read/program/erase over full operating voltage (1.8V-3.6V) and temperature (-40°C to 85°C and eventually to 125°C)	• Allows user to take full advantage of in-application, re-programmability benefits in virtually any environment • EEPROM emulation for data storage across the full operating conditions of the device
• Single power supply program and erase	• Does not require additional pin or power supply for flash programming, simplifying the interface for in-line programming and allowing for more GPIO pins
• Extremely fast, byte-writeable programming – As fast as 20 µsec/byte	• Helps reduce production programming costs through ultra-fast programming • Helps reduce power and speeds application when writing nonvolatile data is required
• Up to 100,000 W/E cycles at typical voltage and temperature; 10 k minimum across voltage and temp	• Allows for EEPROM emulation, reducing system costs and board real estate, eliminating the need for external EEPROM
• Auto power-down for low-frequency read accesses	• Reduces system power consumption

MC9S08QG8/4 –Clock Source Options



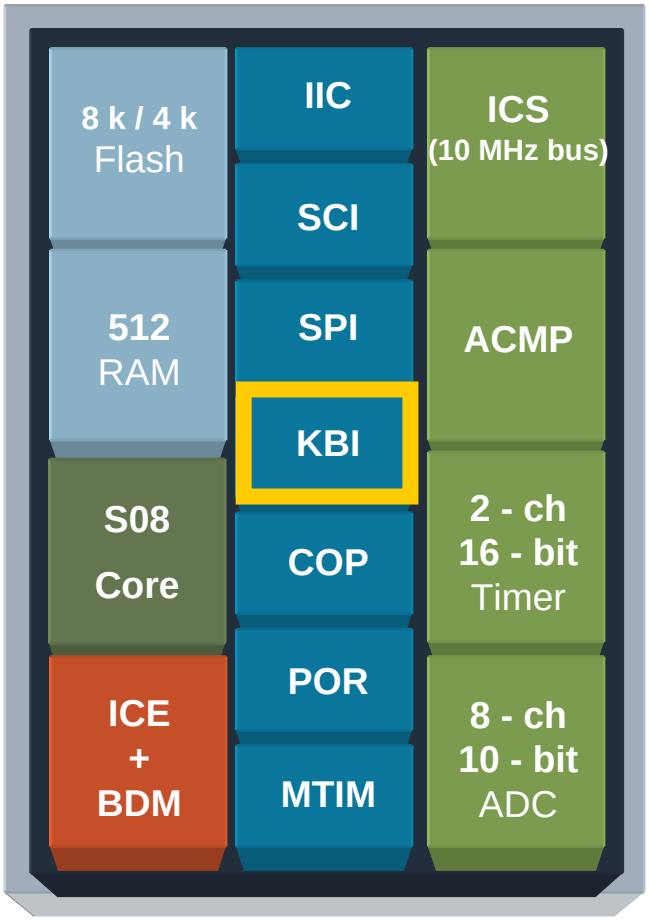
Features	Benefits
• Internal clock source (ICS) module containing a frequency-locked loop (FLL), controlled by internal or external reference	• Can eliminate the cost of all external clock components, reduce board space, and increase system reliability
• Precision trimming of internal reference allows typical 0.1% resolution and +0.5% to -1% deviation	• Provides one of the most accurate internal clock sources on the market • Ex: security sensor can check-in with control panel at accurate, regular intervals
• Internal reference can be trimmed from 31.25 kHz to 39.065 kHz, allowing for 8 MHz to 10 MHz FLL output	• Trim to adjust bus clocks for optimal serial communication baud rates and/or timer intervals • Ex: communicate to a host PC through the serial port at 115200 baud with reference trimmed to 36.0 kHz
• Post-FLL bus frequency divider, programmable for divide by 1 to divide by 8	• On-the-fly selectable bus frequencies provide fast code execution and power saving efficiency by allowing the device to ramp to higher speeds to execute code quickly, then drop back to a lower frequency, lower power state without having to reacquire FLL lock
• Low-power oscillator module (XOSC) with software selectable crystal or ceramic resonator range, 31.25 kHz to 38.4 kHz or 1 MHz to 16 MHz, and capable of supporting external clock source input up to 20 MHz	• 32 kHz oscillator provides low power option for systems requiring time-keeping functionality (i.e. time and date) while in low power modes

MC9S08QG8/4 – Serial Communication Ports



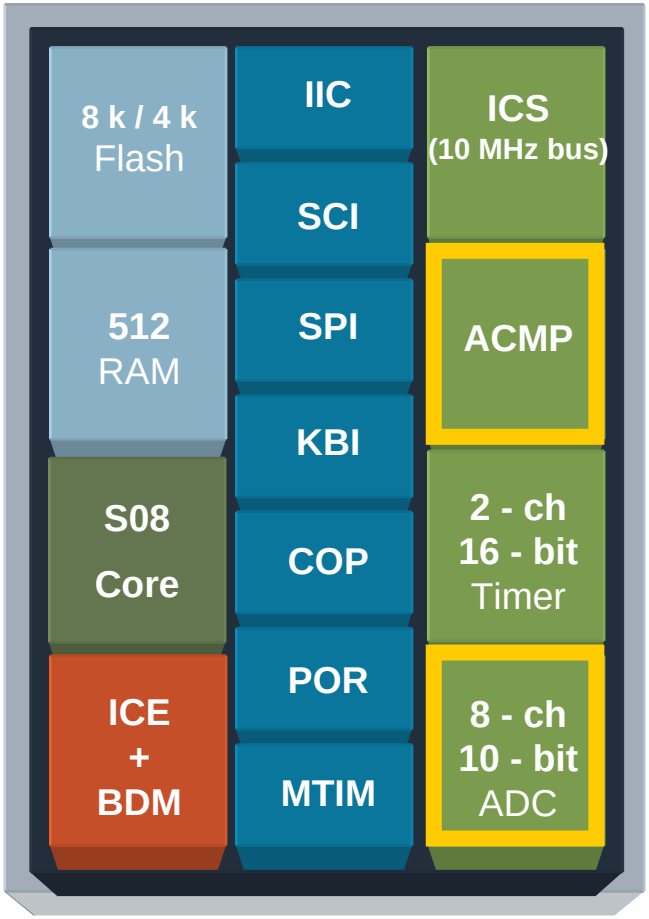
Features	Benefits
• All serial peripherals are available for use in parallel on 16 pin devices	• Maximizes customers' options for external components with which to interface
• Serial communications interface (SCI) module offering asynchronous communications ▪ 13 - bit break option ▪ Flexible baud rate generator ▪ Double buffered transmit and receive ▪ Optional H/W parity checking and generation	• Provides standard UART communications peripheral • Allows full-duplex, asynchronous, NRZ serial communication between MCU and remote devices
• Serial Peripheral Interface (SPI) module ▪ Full-duplex 3-wire synchronous transfer ▪ Maximum bit rate of 5 MHz for 10MHz bus frequency	• Cost effective serial peripheral expansion for applications, including EEPROM, high-precision analog-to-digital and digital-to-analog converters, real-time clocks and LCDs • High-speed synchronous communication between multiple MCUs or between MCU and serial peripherals
• Inter-integrated Circuit (IIC) bus module ▪ 2 - wire synchronous serial module to connect to standard IIC bus ▪ Designed to operate up to 100kbps with maximum bus loading and timing ▪ Capable of operating at *higher baud rates*, up to a maximum of clock/20, with reduced bus loading	• Fewer pins required for synchronous communications allows more pins to be reserved for I/O or other peripheral functions • Cost effective serial peripheral expansion for applications, including EEPROM, high-precision analog-to-digital and digital-to-analog converters, real-time clocks and LCDs

MC9S08QG8/4 –KBI and I/O



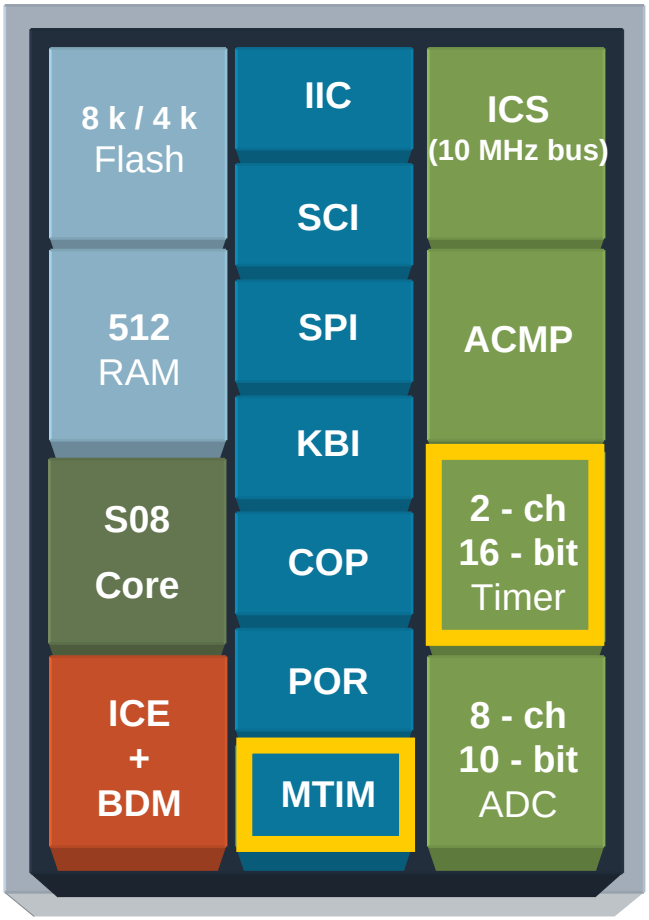
Features	Benefits
• 8 - pin keyboard interrupt (KBI) module with software selectable polarity on edge or edge/level modes	• Keyboard scan with programmable pull-ups/pull-downs virtually eliminates external glue logic when interfacing to simple keypads
• Pin-by-pin software selectable pull-ups on ports when used as input	• Reduces customer system cost by eliminating need for external resistors
• Pin-by-pin software selectable slew rate control on ports when used as output	• Can configure ports for slower slew rate to minimize EMI noise emissions from the MCU • The higher slew rate can be used on pins requiring fast transitions
• Pin-by-pin software selectable drive strength on ports when used as output • Outputs 10mA or 2mA each; 60mA total for MCU	• High-current I/O allows direct drive of LED without additional components • Reduced-current I/O minimizes power consumption

MC9S08QG8/4 – Analog Integration



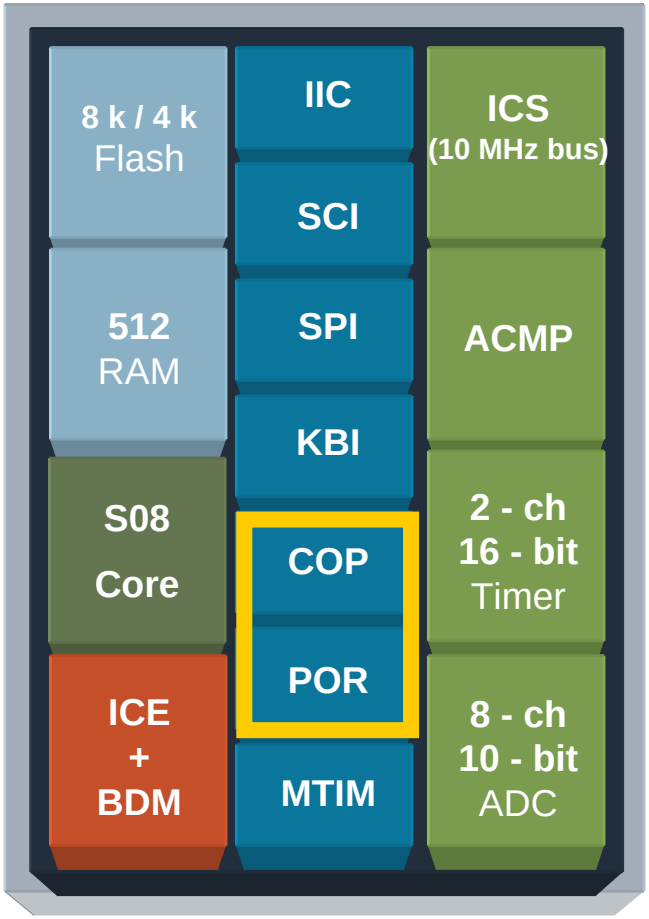
Features	Benefits
8 - channel, 10 - bit analog-to-digital converter (ADC)	• Easily interface to analog inputs, such as sensors
• 2.5 usec 10-bit conversion time	• 400k sample/second conversion rate allows for sampling high speed signals
• Automatic compare function, S/W programmable for greater than/equal to or less than conditions	• Used to set conversion complete and generate interrupt only when result matches condition, freeing up system resources
• Asynchronous clock source	• Can be used to run ADC when MCU clocks are off, such as in STOP3 low-power mode • Provides highest accuracy results by eliminating on-chip noise from other peripherals
• Temperature sensor	• Calculates temperature without any external components and saves an ADC input channel for other use
• Internal bandgap reference channel	• Constant voltage source for calibrating ADC results requires no external components
• Trigger conversion using the RTI counter	• Takes periodic measurements without CPU involvement • Can be used in STOP3 with compare function to take measurements and wake MCU only when compare value is reached
Analog comparator module (ACMP) • Option to compare to internal reference • Option to route comparator output directly to pin • Output can be optionally routed to TPM module as input capture trigger	• Requires only single pin for input signal, freeing up other pin for other use • Allows other components in system to see result of comparator with minimal delay • Can be used for single slope ADC and RC time constant measurements

MC9S08QG8/4 – Timers



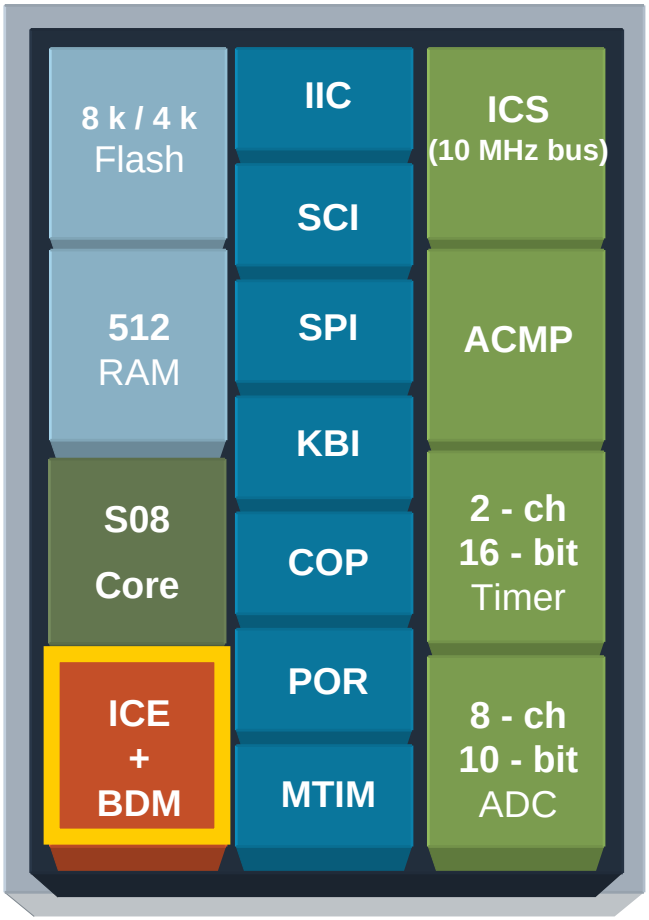
Features	Benefits
Programmable 16 - bit Timer/PWM module (TPM) ▪ Each channel can be independently programmed for: > input capture > output compare > buffered edge-aligned pulse width modulation (PWM) > buffered center-aligned PWM ▪ Three TPM counter clock sources: > bus clock > reference clock (XCLK) > external clock (TCLK)	• One of the most flexible timer modules for the money • PWM functionality ideal for motor control applications, as well as low-cost DAC (with some external components) • Center-aligned PWMs keeps both PWM channels from transitioning on the same clock edge when both are enabled, reducing EMI noise emissions • TCLK input can be used as an event counter
8 - bit modulo timer (MTIM) module with 8 bit prescaler ▪ Several software selectable clock sources and a programmable interrupt ▪ Four MTIM counter clock sources: > bus clock > reference clock (XCLK) > external clock (TCLK) – rising edge > external clock (TCLK) – falling edge	• Timer overflow interrupt can be enabled to generate periodic interrupts for time-based software loops • Can be used for software input captures, output compares or PWMs • TCLK input can be used as an event counter

MC9S08QG8/4 – System Security Features



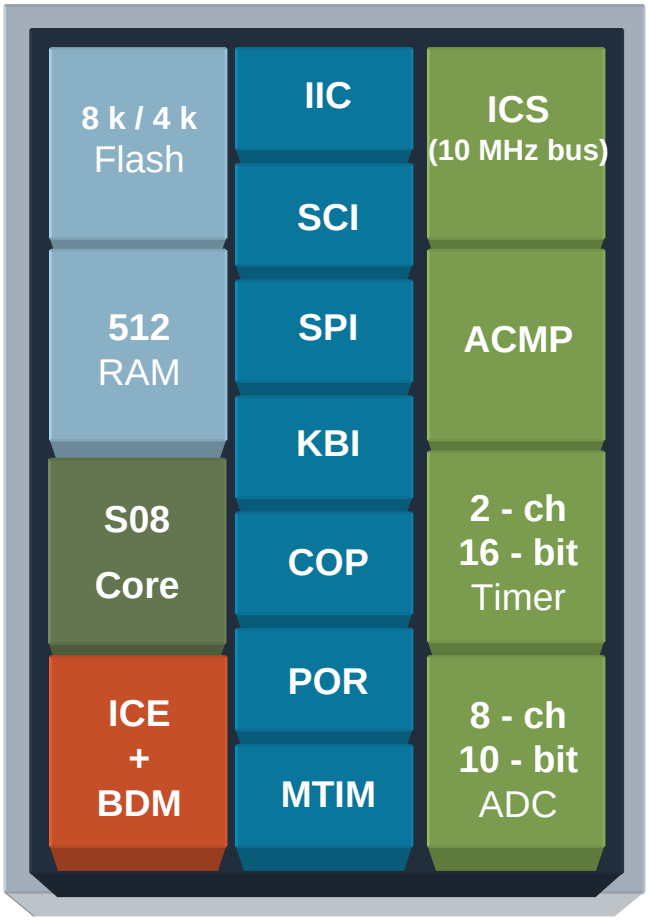
Features	Benefits
• Watchdog computer operating properly (COP) reset with option to run from dedicated 1kHz internal clock source or from bus clock	• Resets device in instance of runaway or corrupted code • Independent clock source provides additional protection in case of loss of clock
• Low-voltage detection (LVD) generates reset, interrupt or flag with two software selectable trip points • Low-voltage warning (LVW) sets flag, with higher trip points than LVD	• On power-up, holds device in reset until a reliable voltage level is applied to the part • Prevents MCU from operating at lower-than-spec voltage when reset is enabled • Flexibility to allow system to write/save important variables before voltage drops too low
• Illegal op code and illegal address resets	• Resets device in instance of runaway or corrupted code
• Flexible Flash block protection	• Option to protect Flash in 512 byte blocks, allowing for a bootloader routine in protected space, while remaining flash can be reprogrammed • Secures code sections cannot be accidentally modified by runaway code • Optional hardware vector redirection makes field upgrades easier by keeping all vectors except reset in unprotected flash
• Security feature for Flash and RAM	• Prevents unauthorized access to memory to protect a customer's valuable software IP
• Always-on POR circuitry	• Significantly reduces risk of code runaway due to "brown-out" situations

MC9S08QG8/4 – Background Debug System and On-chip ICE



Features	Benefits
• Background debugging system and on-chip in-circuit emulation (ICE) with real-time bus capture	• Provides single wire debugging and emulation interface, eliminates need for expensive emulation tools
• Breakpoint capability to allow single breakpoint during in-circuit debugging plus two more breakpoints comparators in on-chip ICE module	• Single step, run or trace through code execution using actual device instead of H/W approximation • Flexible triggering mechanisms allow for trigger on read access, write access or code execution at address
• On-Chip ICE has 8 stage change-of-flow FIFO with 9 trigger modes	• Allows for internal address and data bus visibility during real-time, at-speed code execution • Flexible bus capture modes such as capture until trigger occurs or capture after trigger and run until trace buffer is full.

MC9S08QG8/4 – Packaging Options



Features	Benefits
• 16 - pin plastic dual in-line package (PDIP)	• PDIP packaging option for lowest cost manufacturing process and easy development
• 8 - pin PDIP	• Pin compatible with 16 PDIP, such that both can be used in the same footprint (top 4 - pins on each side of the 16 pin map to the respective 4 pins on each side of the 8 pin); same pitch as 16 pin PDIP
• 16 quad flat no lead (QFN) package	• Smallest 16-pin package, leadless footprint with full functionality and feature set for real estate-sensitive applications
• 8 dual flat no lead (DFN) package	• Smallest 8-pin package, leadless footprint for extremely real estate-sensitive applications
• 16 - pin thin shrink small outline package (TSSOP)	• Economical, surface mount small footprint for price- and real estate-sensitive applications, requiring full functionality and feature set
• 8 - pin narrow body small outline integrated circuit (NB-SOIC)	• Economical, surface mount small footprint for price- and real estate-sensitive applications

9S08QG8/4
Support, Tools, and Collateral

CodeWarrior Development Studio, Special Edition

Features:

- CodeWarrior ™ IDE with project wizard
- Project management for up to 32 files
- Emulator-like debug capability
- Highly optimized ANSI C compiler and C source level debugger
- 16 KB (HCS08) or 32 KB (HCS12X) free C Compiler
- Fast Flash programming
- Full Chip Simulator
- Auto C code generation peripherals via Processor Expert™ from Unis
- Supports Serial, Ethernet, USB, and Parallel PC interfaces

Licensing Procedure:

- Key is permanent and free of charge
- Customer registers via the WEB
- Email with information is sent automatically to customer's email address or activated via WEB

Cost:

- $2000+ value ***at no cost to user***

Additional Information Available @
www.metrowerks.com or www.freescale.com

HCS08 Demo and Promotional Boards

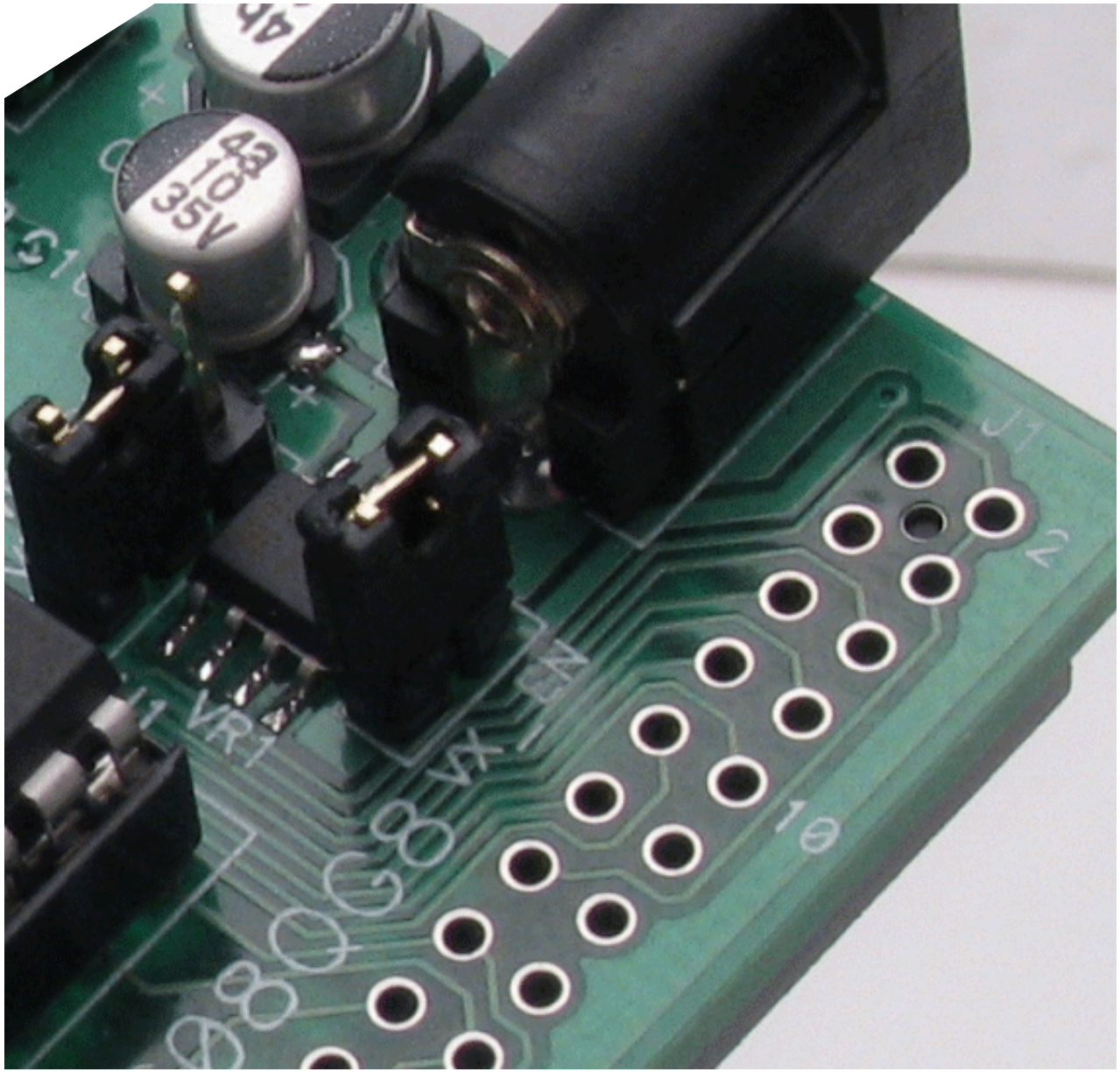
- **DEMO9S08QG8 – MSRP: $50**
  - **The 9S08QG8 demonstration kit contains everything a designer needs to develop and evaluate application code.**
    - > Integrated BDM Multilink requires ONLY a USB cable to connect to the board to begin development
    - > Program and debug code using free CodeWarrior Development Studio for HC08, Special Edition through DB9 serial port and included RS232 serial cable or USB
    - > PDIP socket allows customer to program multiple devices serially for prototypes without having to solder and de-solder any parts from the board or purchase a separate programming adapter board

Complete List of HCS08 Tools is Available in the Development Tool Sector Guide.

HCS08 Programming and Debugging Tools

- **USBMULTILINKBDM – MSRP: $99**
  - **The BDM Multilink is an easy-to-use, cost-effective universal development tool for all HCS08 and HCS12 MCUs.**
    - > Real-time, in-circuit Flash programmer and debugger
    - > Access to HCS08 or HCS12 ON-CHIP ICE
    - > View and change internal registers and memory while running an application
    - > Single step, run, or trace application code
    - > USB PC interface
    - > ***Integrated into DEMO9S08QG8 at no additional cost***
- **M68CYCLONEPRO – MSRP: $495**
  - **The CyclonePRO provides all the capabilities of the MON08 Multilink, MON08 Cyclone, and HCS08/HCS12 BDM cables.**
    - > Standalone Flash Programmer
    - > Push buttons and LEDs to control the standalone operation
    - > Provide target out power for the target system
    - > Real-time, in-circuit Flash programmer and debugger
    - > USB, Serial, and Ethernet PC interfaces
- **CPA08xxxxx – MSRP: $99 to $195**
  - **Cost Effective programming adapters designed to be used with MON08 or BDM programmers**
    - > Package support for QFP, DIP, SDIP, TSSOP, and SOIC packages

Complete List of HCS08 Tools is Available in the Development Tool Sector Guide.



9S08QG8/4
Summary and Wrap-Up

So Highly Integrated, It's a Shame to Call This One Low-End.

- **The QG-family extends the general purpose family of S08 devices into the low pin-count space, while improving the low-power story and utilizing the latest low-voltage capabilities**
- **Low pin-count does NOT mean "low end". High level of integration and value is the key to the QG-family.**
  - Multiple new FSL modules are making their debut on the QG8/4, including the accurate, low-power ICS and improved ADC
  - Other modules have been integrated and assigned to ports in order to take maximum advantage of the low pin count (i.e. serial communication modules)
  - QG-family offers the benefits of Flash with the security of ROM with the multiple system protection features
- **Starting up development with this device is extremely simple and inexpensive with the low-cost demo board (with integrated USB BDM Multilink) and CodeWarrior Special Edition**
  - In addition, there will be a promotional clock with minimal evaluation capabilities and programming adapters to aid development and prototyping
- **Attractive price - General purpose use is only the beginning!**