MICROPROCESSES AND MICROCONTROLLERS I

by

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TOPICS

MICROPROCESSORS
MICROCONTROLLERS
DEVELOPMENT
Early Microprocessors and Patents

Note the Architecture on the original Intel Microprocessor
A microcomputer including a video generator and timing means which provides color and high resolution graphics on a standard, raster scanned, cathode ray tube is disclosed. A horizontal synchronization counter is synchronized at an odd-submultiple of the color subcarrier reference frequency. A "delayed" count is employed in the horizontal synchronization counter to compensate for color subcarrier phase reversals between lines for the non-interlaced fields. This permits vertically aligned color graphics without substantially altering the standard horizontal synchronization frequency. Video color signals are generated directly from digital signals by employing a recirculating shift register.
Microcontroller Applications

Number of Microcontrollers

Computing
- PC
- Notebook
- Laptop
- Storage
- Color printer
- Laser printer
- Modem
- Cable modem
- Copier
- Scanner
- Digital camera

Communications
- Wireline phone
- Cellular phone
- PDA
- Pager
- Organizer
- Fax/modem
- Intercom

Consumer
- Set-top cable box
- VCR
- CD-I
- Video and PC games
- Digital video disc
- Stereo
- Camcorder
- Camera
- Remote controls
- Appliances
- Garage door opener
- Security system
- Exercise equipment
- Smoke & CO alarms
- Lighting controls

Connectivity
- Cable TV
- Cable modem
- PCMCIA card
- Router
- Hub

Cars
- Anti-lock brakes
- Airbags
- Engine control
- Transmission control
- Entertainment
- Climate control
- Collision avoidance
- Navigation
- Trip computer
- Instrumentation
- Keyless entry

Cards
- Banking
- Electronic purse
- Health
- Social security
- Cellular phone access/security
- Transportation & tolls
- Electronic purse

Home 190
Auto 55
Office 49
Personal 5
### TABLE 1-2 Many modern Intel and Motorola microprocessors.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Part</th>
<th>Data Bus Width</th>
<th>Memory Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel</td>
<td>8048</td>
<td>8</td>
<td>2K internal</td>
</tr>
<tr>
<td></td>
<td>8051</td>
<td>8</td>
<td>8K internal</td>
</tr>
<tr>
<td></td>
<td>8085A</td>
<td>8</td>
<td>64K</td>
</tr>
<tr>
<td></td>
<td>8086</td>
<td>16</td>
<td>1M</td>
</tr>
<tr>
<td></td>
<td>8088</td>
<td>8</td>
<td>1M</td>
</tr>
<tr>
<td></td>
<td>8096</td>
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<td>1M</td>
</tr>
<tr>
<td></td>
<td>80251</td>
<td>8</td>
<td>18K internal</td>
</tr>
<tr>
<td></td>
<td>80286</td>
<td>16</td>
<td>16M</td>
</tr>
<tr>
<td></td>
<td>80386EX</td>
<td>16</td>
<td>64M</td>
</tr>
<tr>
<td></td>
<td>80386DX</td>
<td>32</td>
<td>4G</td>
</tr>
<tr>
<td></td>
<td>80386SL</td>
<td>16</td>
<td>32M</td>
</tr>
<tr>
<td></td>
<td>80386SLC</td>
<td>16</td>
<td>32M + 1K cache</td>
</tr>
<tr>
<td></td>
<td>80386SX</td>
<td>16</td>
<td>16M</td>
</tr>
<tr>
<td></td>
<td>8048DX/DX2</td>
<td>32</td>
<td>4G + 8K cache</td>
</tr>
<tr>
<td></td>
<td>8048SX</td>
<td>32</td>
<td>4G + 8K cache</td>
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<tr>
<td></td>
<td>8048DX4</td>
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<td>4G + 16K cache</td>
</tr>
<tr>
<td>Pentium</td>
<td>64</td>
<td>4G + 16K cache</td>
<td></td>
</tr>
<tr>
<td>Pentium Overdrive (P24T) (replaces 80486)</td>
<td>32</td>
<td>4G + 16K cache</td>
<td></td>
</tr>
<tr>
<td>Pentium Pro processor</td>
<td>64</td>
<td>64G + 16K L1 cache + 256K L2 cache</td>
<td></td>
</tr>
<tr>
<td>Pentium II</td>
<td>64</td>
<td>64G + 32K L1 cache + 512K L2 cache</td>
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</tr>
<tr>
<td>Pentium II Xeon</td>
<td>64</td>
<td>64G + 32K L1 cache + 512K or 1M L2 cache</td>
<td></td>
</tr>
<tr>
<td>Pentium III, Pentium 4</td>
<td>64</td>
<td>64G + 32K L1 cache + 256K L2 cache</td>
<td></td>
</tr>
<tr>
<td>Motorola</td>
<td>6800</td>
<td>8</td>
<td>64K</td>
</tr>
<tr>
<td></td>
<td>6805</td>
<td>8</td>
<td>2K</td>
</tr>
<tr>
<td></td>
<td>6809</td>
<td>8</td>
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<td>16M</td>
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<tr>
<td></td>
<td>68008Q</td>
<td>8</td>
<td>1M</td>
</tr>
<tr>
<td></td>
<td>68008D</td>
<td>8</td>
<td>4M</td>
</tr>
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<td></td>
<td>68010</td>
<td>16</td>
<td>16M</td>
</tr>
<tr>
<td></td>
<td>68020</td>
<td>32</td>
<td>4G</td>
</tr>
<tr>
<td></td>
<td>68030</td>
<td>32</td>
<td>4G + 256 cache</td>
</tr>
<tr>
<td></td>
<td>68040</td>
<td>32</td>
<td>4G + 8K cache</td>
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<tr>
<td></td>
<td>68050</td>
<td>32</td>
<td>Proposed, but never released</td>
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<tr>
<td></td>
<td>68060</td>
<td>64</td>
<td>4G + 16K cache</td>
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<tr>
<td>PowerPC</td>
<td>64</td>
<td>4G + 32K cache</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Some entries are estimated or based on the proposed specifications.*
## 1H13 Top 20 Semiconductor Sales Leaders ($M, Including Foundries)

<table>
<thead>
<tr>
<th>1H13 Rank</th>
<th>2012 Rank</th>
<th>Company</th>
<th>Headquarters</th>
<th>2012 Tot Semi</th>
<th>1H12 Tot Semi</th>
<th>1Q13 Tot Semi</th>
<th>2Q13 Tot Semi</th>
<th>1H13 Tot Semi</th>
<th>1H13/1H12 % Change</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Intel</td>
<td>U.S.</td>
<td>49,114</td>
<td>24,296</td>
<td>11,555</td>
<td>11,785</td>
<td>23,340</td>
<td>-4%</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Samsung</td>
<td>South Korea</td>
<td>32,251</td>
<td>15,101</td>
<td>7,952</td>
<td>7,771</td>
<td>15,723</td>
<td>4%</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>TSMC*</td>
<td>Taiwan</td>
<td>16,951</td>
<td>7,810</td>
<td>4,460</td>
<td>5,152</td>
<td>9,612</td>
<td>23%</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Qualcomm**</td>
<td>U.S.</td>
<td>13,177</td>
<td>5,928</td>
<td>3,916</td>
<td>4,222</td>
<td>8,138</td>
<td>37%</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>SK Hynix</td>
<td>South Korea</td>
<td>9,057</td>
<td>4,406</td>
<td>2,577</td>
<td>3,521</td>
<td>6,098</td>
<td>38%</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Toshiba</td>
<td>Japan</td>
<td>11,217</td>
<td>5,659</td>
<td>2,938</td>
<td>2,868</td>
<td>5,806</td>
<td>3%</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>TI</td>
<td>U.S.</td>
<td>12,081</td>
<td>6,077</td>
<td>2,718</td>
<td>2,922</td>
<td>5,640</td>
<td>-7%</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>Micron</td>
<td>U.S.</td>
<td>8,002</td>
<td>4,204</td>
<td>2,144</td>
<td>2,450</td>
<td>4,594</td>
<td>9%</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>ST</td>
<td>Europe</td>
<td>8,364</td>
<td>4,126</td>
<td>1,994</td>
<td>2,033</td>
<td>4,027</td>
<td>-2%</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>Broadcom**</td>
<td>U.S.</td>
<td>7,793</td>
<td>3,687</td>
<td>1,954</td>
<td>2,035</td>
<td>3,989</td>
<td>8%</td>
</tr>
<tr>
<td>11</td>
<td>7</td>
<td>Renesas</td>
<td>Japan</td>
<td>9,314</td>
<td>4,480</td>
<td>1,886</td>
<td>1,920</td>
<td>3,806</td>
<td>-15%</td>
</tr>
<tr>
<td>12</td>
<td>15</td>
<td>GlobalFoundries*</td>
<td>U.S.</td>
<td>4,560</td>
<td>2,340</td>
<td>1,240</td>
<td>1,325</td>
<td>2,565</td>
<td>10%</td>
</tr>
<tr>
<td>13</td>
<td>14</td>
<td>Infineon</td>
<td>Europe</td>
<td>4,928</td>
<td>2,564</td>
<td>1,208</td>
<td>1,327</td>
<td>2,535</td>
<td>-1%</td>
</tr>
<tr>
<td>14</td>
<td>16</td>
<td>NXP</td>
<td>Europe</td>
<td>4,325</td>
<td>2,053</td>
<td>1,085</td>
<td>1,188</td>
<td>2,273</td>
<td>11%</td>
</tr>
<tr>
<td>15</td>
<td>13</td>
<td>AMD**</td>
<td>U.S.</td>
<td>5,422</td>
<td>2,998</td>
<td>1,088</td>
<td>1,161</td>
<td>2,249</td>
<td>-25%</td>
</tr>
<tr>
<td>16</td>
<td>12</td>
<td>Sony</td>
<td>Japan</td>
<td>5,709</td>
<td>2,986</td>
<td>1,049</td>
<td>1,148</td>
<td>2,197</td>
<td>-26%</td>
</tr>
<tr>
<td>17</td>
<td>24</td>
<td>Elpida***</td>
<td>Japan</td>
<td>3,075</td>
<td>1,997</td>
<td>945</td>
<td>1,160</td>
<td>2,105</td>
<td>5%</td>
</tr>
<tr>
<td>18</td>
<td>22</td>
<td>MediaTek**</td>
<td>Taiwan</td>
<td>3,366</td>
<td>1,457</td>
<td>817</td>
<td>1,115</td>
<td>1,932</td>
<td>33%</td>
</tr>
<tr>
<td>19</td>
<td>20</td>
<td>UMC*</td>
<td>Taiwan</td>
<td>3,730</td>
<td>1,804</td>
<td>898</td>
<td>1,015</td>
<td>1,913</td>
<td>6%</td>
</tr>
<tr>
<td>20</td>
<td>19</td>
<td>Freescale</td>
<td>U.S.</td>
<td>3,803</td>
<td>1,892</td>
<td>917</td>
<td>988</td>
<td>1,905</td>
<td>1%</td>
</tr>
</tbody>
</table>

| Top 10 Total | | 168,007 | 81,294 | 42,208 | 44,759 | 86,967 | 7% |
| Top 20 Total | | 216,239 | 105,865 | 53,341 | 57,106 | 110,447 | 4% |

*Foundry  **Fabless  ***Purchased by Micron on July 31, 2013

Source: IC Insights' Strategic Reviews Database
ARM Cortex-A8 processor is the first applications processor based on the ARMv7 architecture and is the highest performance, most power-efficient processor available from ARM. With the ability to scale in speed from 600MHz to greater than 1GHz, the Cortex-A8 processor can meet the requirements for power-optimized mobile devices needing operation in less than 300mW, and performance-optimized consumer applications requiring 2000 Dhrystone MIPS. The Cortex-A8 processor is ARM’s first superscalar processor featuring technology for enhanced code density and performance, NEON™ technology for multimedia and signal processing, and Jazelle® RCT (Runtime Compilation Target) technology for efficient support of ahead-of-time and just-in-time compilation of Java and other bytecode languages.
The ATmega256RFR2 Xplained Pro evaluation kit
Key Features
• ATmega256RFR2 microcontroller
• One mechanical reset button
• One mechanical user pushbutton (wake-up, bootloader entry or general purpose)
• One user yellow LED
• 32.768kHz crystal
• 16MHz crystal
• 5 Xplained Pro extension headers (2 headers are duplicates)
• Antenna diversity: Ceramic RF antenna and SMA connector for external antenna
• Temperature sensor
• Embedded debuggerAuto-ID for board identification in Atmel Studio 6.1
• One yellow status LED
• One green board power LED
• Symbolic debug of complex data types including scope information
• Programming
Old Processors stay around

Motorola

Apple
Thompson 16 MHz
68-lead plastic LCC
Bytom, June the 28th, 2012 -- Digital Core Design, IP Core and SoC design laboratories from Poland have introduced the newest version of the Motorola’s 68000 16/32-bit microprocessor. D68000 is the industry’s low cost 32-bit MCU, offering not only a low cost entry point but also effective performance. Improved architecture enables this IP Core to run with uCLinux, so it can be easily used as HTTP server or FTP client.
C68000 Microprocessor

Overview
The C68000 is a powerful 16-/32-bit microprocessor core, executes instruction list compatible with MC68000 microprocessor. The C68000 could be used as equivalent of the MC68000. The C68000 serves interrupts and exceptions, and provides an interface for the M6800 family peripherals. The C68000 is a microcode-free design developed for reuse in ASIC and FPGA implementations. The design is strictly synchronous without internal tri-states and with synchronous reset.

Applications
- 32-bit data processing applications
- High speed control systems
- Microcomputer systems
- Professional audio and video

Implementation Results

<table>
<thead>
<tr>
<th>Device</th>
<th>Area</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclone 1C12C-6</td>
<td>6152 Lcs</td>
<td>50.98 MHz</td>
</tr>
<tr>
<td>Stratix 1S10C-5</td>
<td>6026 Lcs</td>
<td>61.2 MHz</td>
</tr>
<tr>
<td>Apex II 2A15</td>
<td>2239 LEs</td>
<td>52.58 MHz</td>
</tr>
<tr>
<td>Virtex II Pro -7</td>
<td>2785 SLICEs</td>
<td>60.14 MHz</td>
</tr>
<tr>
<td>Virtex II 1000-6</td>
<td>2621 SLICEs</td>
<td>54.2 MHz</td>
</tr>
<tr>
<td>Spartan II 300E-7</td>
<td>2792 SLICEs</td>
<td>30.55 MHz</td>
</tr>
<tr>
<td>TSMC 0.35 um 3.3V</td>
<td>19558 g.</td>
<td>33 MHz</td>
</tr>
<tr>
<td>Atmel 0.25 um 2.5V</td>
<td>16946</td>
<td>80.7 MHz</td>
</tr>
</tbody>
</table>

Features
- Control Unit
  - 16-bit two levels instruction decoder
  - Three levels instruction queue
- Instruction and address
  - 55-instructions (87 assembler mnemonics)
  - 14-address modes
- Modes
  - Supervisor mode
  - User mode
- Users registers
  - Eight 32-bit data registers
  - Eight 32-bit address register
  - 16-bit status register
- Data format
  - Integer 8, 16 or 32 bit
  - BCD packet
  - Bit
- Memory interface
  - Independent data and address buses
  - Asynchronous bus control
  - 4 GB address space
  - 23-bit address bus (optional 32-bit)
  - 8-address spaces (used 5)
- 16-bit data bus
- Interrupt Controller
  - Seven Priority Levels
  - Virtually an unlimited number of interrupt sources
  - Vectored or auto-vectoried interrupt modes
- Arithmetic-Logic Unit
  - 8, 16, 32-bit arithmetic operations
  - 8, 16, 32-bit logical operations
  - Boolean manipulations
  - 16 x 16 bit multiplication (sign or unsigned)
  - 32 / 16 bit division (sign or unsigned)
- 6800 peripherals family synchronous interface
- Two or Three wire bus arbitration interface
- Operations executions is the same for data or address

June 25, 2007
Functional Description

The C68000 core is partitioned into modules as shown in figure above and described below.

Control Unit

Performance

The C68000 is faster than the original MC68000. The average speed advantage is about 30%. Some of the instructions are speeded up (shift operations, multiplication, division) and address calculation phase is
Roadmap for Growing Application Needs

The need to provide cost-effective, compatible product families to embedded control engineers has always been at the core of Microchip’s strategy. The addition of the PIC24 16-bit product line provides an effective migration path for current 8-bit designers as their design requirements grow. The PIC24 family also provides competitive alternatives to new customers who are looking for 16-bit microcontroller suppliers with a proven track record of innovation, a broad portfolio of products that are easy to use, and outstanding development tools and support to ensure their success.

As the PIC24 family grows, additional peripheral support is planned including integrated Ethernet, USB and Display capabilities.

<table>
<thead>
<tr>
<th>Product</th>
<th>Pins</th>
<th>Flash (Kbytes)</th>
<th>SRAM (Bytes)</th>
<th>Timer</th>
<th>Capture</th>
<th>Output Comp</th>
<th>PWM</th>
<th>Real Time Clock</th>
<th>Calendar</th>
<th>A/D 10-bit 500 kSPS</th>
<th>A/D 12-bit 500 kSPS</th>
<th>UART</th>
<th>SPI™</th>
<th>CAN</th>
<th>Parallel Master Port</th>
<th>JTAG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PIC24F Family – 16 MIPS, Lowest Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>PIC24FJ64GA006</td>
<td>64</td>
<td>64</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>Y</td>
<td>16 5</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
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<tr>
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<td>5</td>
<td>5</td>
<td>5</td>
<td>Y</td>
<td>16 5</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
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<tr>
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<td>8</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>Y</td>
<td>16 5</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
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<td>95</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>Y</td>
<td>16 5</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>PIC24FJ64GA008</td>
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<td>95</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>Y</td>
<td>16 5</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>PIC24FJ64GA10</td>
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<td>95</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>Y</td>
<td>16 5</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
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<tr>
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<td>128</td>
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*PIC24H features a user selectable 500 kSPS 12-bit A/D or 1.1 Mips 10-bit A/D
Notice the Characteristics for different family members

### PIC24 Product Family

<table>
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<tr>
<th>Product</th>
<th>Pins</th>
<th>Flash Kbytes</th>
<th>SRAM Bytes</th>
<th>Timer</th>
<th>Capture</th>
<th>Output Comp. PWM</th>
<th>Real Time Clock Calendar</th>
<th>A/D 10-bit 500 kSPS</th>
<th>A/D 12-bit 500 kSPS</th>
<th>UART</th>
<th>SPI™</th>
<th>PIC™</th>
<th>CAN</th>
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PIC® MICROCONTROLLER MIGRATION STRATEGY

As part of an inherent strategy to offer customers a low-risk development environment, the PIC microcontroller family offers easy migration within the complete range of products. Migration between the different PIC microcontrollers enables several advantages such as future cost reductions, feature enhancements and later development changes with minimal impact to the existing hardware, software and the engineering development environment.

The PIC microcontroller family is pin compatible within a given pin count as well as code compatible between the different architectures. This offers a seamless migration path between the different PIC microcontrollers that protects investments made in software development and design tools.

EXAMPLE OF PIC® MICROCONTROLLER MIGRATION

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Pin and Code Compatibility also for 8, 14, 18, 28, 64 and 80/84-pin packages
Microchip offers flexible programming options that allow engineers to choose the most appropriate memory technology for their applications. These programming options address procurement issues by reducing and limiting work-in-process liability and facilitating finished goods code revisions. Microchip's worldwide distributors stock Flash and OTP device inventory, allowing designers to respond to immediate sales opportunities or accommodate engineering changes off the shelf.

**FLEXIBLE PROGRAMMING OPTIONS**

**PRODUCTION PROGRAMMING OPTIONS**

**In-Circuit Serial Programming™ (ICSP™) Technology**

Microchip's Flash and OTP PIC microcontrollers feature Microchip's proprietary ICSP capability. ICSP technology allows the microcontroller to be programmed after being placed on a circuit board, offering tremendous flexibility, reduced development time, increased manufacturing efficiency and improved time to market. This popular technology enables cost-reduced field upgrades, system calibration during manufacturing and the addition of unique identification codes to the system. Microchip offers the most non-intrusive programming methodology in the industry requiring only two I/O pins for most devices.

**Self Programming**

Some of Microchip's Flash microcontroller families feature a self-programming capability. Self programming enables remote upgrades to the Flash program memory and the end equipment through a variety of mediums, ranging from Internet and modem to RF and infrared. Microchip's Self-Write Flash allows for easy code revisions in the end user's application.

**One-Time Programmable (OTP)**

OTP PIC microcontrollers are manufactured in high volumes without specific software and can be shipped immediately for custom programming.

**Quick-Turn Programming (QTP)**

Microchip offers a QTP programming service for factory production orders. This service is ideal for designers who choose not to program devices in their own factories and whose production code patterns have stabilized.

**Serialized Quick-Turn Programming (SQTP™)**

The SQTP service is a unique, flexible programming option that allows Microchip to program serialized, random or pseudo-random numbers into each device. Serial programming allows each device to have a unique number that can serve as an entry code, password or identification number.

**Read-Only Memory (ROM)**

Microchip offers masked ROM versions of many of its most popular PIC microcontrollers, providing engineers with the lowest cost option for high-volume products with stable firmware.
1.3 Embedded Emulation

Dedicated embedded emulation logic resides on the device itself and is accessed via JTAG using no additional system resources.

The benefits of embedded emulation include:

- Unobtrusive development and debug with full-speed execution, breakpoints, and single-steps in an application are supported.
- Development is in-system subject to the same characteristics as the final application.
- Mixed-signal integrity is preserved and not subject to cabling interference.
MCU Selection Tool - TI

Select Device Parameters

Program Memory Type
- Flash
- ROM

Program Memory (KB)
- 0, 1, 4, 8, 16, 32, 48, 64, 128, 256, 512

RAM (KB)
- 0, 1, 4, 8, 16, 32, 64

Max Speed (MHz)
- 8, 16, 18, 20, 40, 60, 100, 150, 300

CPU Features
- MPY
- FPU
- CLA
- DMA
- LCD

Standby Current (μA)
- <.5
- .5-1.5
- >1.5

Active Current (μA/MHz)
- <200
- 200-300
- >300

Pins
- ≤30
- 31-60
- 61-100
- >100

Package Type
- SSOP
- SOIC
- QFP
- QFN
- BGA
- DIP

Package area (mm²)
- <25
- 25-75
- 76-150
- >150

Timers
- ≥2
- ≥3
- ≥4
- ≥5

PWM Channels
- ≥1
- ≥2
- ≥4
- ≥6
- ≥8
- ≥10

Capture Pins
- ≥1
- ≥2
- ≥3
- ≥4
- ≥5
- ≥6

Quad Encoder
- ≥1
- ≥2

ADC Channels
- ≥4
- ≥8
- ≥12
- ≥16

ADC Resolution (bits)
- ≥10
- ≥12
- ≥16

Other Analog
- 12-bit DAC
- Comparators
- Op Amps

CAN
- ≥1
- ≥2

Buffered Serial Port
- ≥1
- ≥2

UART
- ≥1
- ≥2
- ≥3
- ≥4

SPI
- ≥1
- ≥2
- ≥3
- ≥4
- 8

I2C
- ≥1
- ≥2
- ≥4

Approx. Price (US$) 1ku
- $10
- $2
- $5
- $7
- $10
- $13
- $17

Temp. Range
- I
- T
- S
- E

ADC Sample Rate
- <500k
- <1M
- <5M
- >5M

Ethernet (10/100 MAC+...)
- Yes

IEEE 1588
- Yes

I2S
- Yes

Battery-Backed Hibernate...
- Yes

EPI/EMIF
- Yes

USB
- H/D
- O/H/D
Freescale Consumer and Industrial MicroSelector
version June 2009

Select features:
- MCU
- DSC
- MPU

OS:
- uCLINUX
- LINUX
- WinCE
- FSL MQX
- Other

Voltage:
- below 1.8V
- 1.8 to 3.6V
- 1.8 to 5.5V
- 2.7 to 5.5V
- 3.0 to 3.6V
- 3.0 to 5.5V
- 4.5 to 5.5V

Temp range:
- 0 to 70°C
- 0 to 20°C
- 0 to 85°C
- 0 to 105°C

Pin count available:
- 6 pin
- 48 pin
- 144 pin
- 324 pin
- 668 pin
- 8 pin
- 52 pin
- 160 pin
- 360 pin
- 672 pin
- 16 pin
- 64 pin
- 176 pin
- 388 pin
- 740 pin
- 20 pin
- 80 pin
- 196 pin
- 400 pin
- 783 pin
- 24 pin
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- 404 pin
- 1023 pin
- 23 pin
- 100 pin
- 225 pin
- 416 pin
- 32 pin
- 112 pin
- 256 pin
- 457 pin
- 517 pin
- 42 pin
- 121 pin
- 272 pin
- 516 pin
- 44 pin
- 128 pin
- 289 pin
- 620 pin

Mouse Action: Quick View

Key:
- 8-bit
- 16-bit
- 32-bit

Flash size:
- 1k
- 2k
- 4k
- 8k
- 16k
- 32k
- 64k
- 64k
- 128k
- 256k
- 256k
- 256k
- 512k

MC9R508KA

MC9R508LE
MC9R508LA
MC9R508LG
MC9R508LL
MC9R508QD
MC9R508QA
MC9R508QG
MC9R508S5
MC9R508SH
MC9R508SG
MC9R508EL/SL
MC9R508JS
MC9R508RE/GR/RE
MC9R508GB/GT

WEB SITE TO SELECT PROCESSOR
My current embedded project's main processor is a:

<table>
<thead>
<tr>
<th>Processor</th>
<th>2008 (N = 1067)</th>
<th>2007 (N = 938)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-bit processor</td>
<td>13%</td>
<td>16%</td>
</tr>
<tr>
<td>16-bit processor</td>
<td>19%</td>
<td>18%</td>
</tr>
<tr>
<td>32-bit processor</td>
<td>58%</td>
<td>61%</td>
</tr>
<tr>
<td>64-bit processor</td>
<td>7%</td>
<td>4%</td>
</tr>
<tr>
<td>Don't know</td>
<td>3%</td>
<td>1%</td>
</tr>
</tbody>
</table>

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Figure 1: Responses to “My current embedded project’s main processor is ...”.
Microcontroller Sources

What is Microcontroller?

A highly integrated chip that contains all the components comprising a controller. Typically this includes a CPU, RAM, some form of ROM, I/O ports, and timers. Unlike a general-purpose computer, which also includes all of these components, a microcontroller is designed for a very specific task -- to control a particular system. As a result, the parts can be simplified and reduced, which cuts down on production costs.

Microcontrollers are sometimes called embedded microcontrollers, which just means that they are part of an embedded system -- that is, one part of a larger device or system.

Technical Archives related to Microcontroller:

- How to design a microcontroller-based three-channel LED driver (1)
  A microcontroller-based current-mode supply can effectively drive light-emitting diodes (LEDs)
- How to design a microcontroller-based three-channel LED driver
  A microcontroller-based current-mode supply can effectively drive LEDs
- Assessing the Centinel management system
  This technical article discusses the efficiency of accurately managing oil mixture content in a diesel engine using a microcontroller-based control system
- Designing MCU applications for use in high voltage environments (1)
  This article is the first in a two-part series on MCU design for high voltage environments. It provides useful tips for microcontroller applications in high voltage using a shunt regulator
- Create a compact Ethernet PCB system
  Learn how to integrate Ethernet functionality within a microcontroller in a small package
- Improve transient immunity in MCU-based embedded design (4)
  This article is part of a tutorial series on how to improve transient immunity in microcontroller-based embedded design. It focuses on

Source: Webopedia
Microprocessor
versus
Microcontroller
Figure 2.1  Simplified microcomputer organization.

Figure 2.3  Typical microcontroller organization.
Development
Which of the following are your favorite/most important software/hardware tools?

- Compiler/assembler: 55% (2009), 56% (2008)
- Debugger: 53% (2009), 56% (2008)
- Oscilloscope: 37% (2009), 56% (2008)
- IDE: 29% (2009), 36% (2008)
- JTAG/BDM: 21% (2009), 28% (2008)
- Logic analyzer: 19% (2009), 22% (2008)
- Configuration management tools: 13% (2009), 14% (2008)
- Linux tools: 9% (2009), 9% (2008)
- Software libraries: 8% (2009), 9% (2008)
- Automatic code generation: 6% (2009), 9% (2008)
- Co-development tools: 8% (2009), 7% (2008)
- Simulation modeling tools: 8% (2009), 7% (2008)
- Source code analysis/timing analysis tools: 8% (2009), 6% (2008)
- Graphical design tools: 6% (2009), 6% (2008)
- UML tools: 6% (2009), 6% (2008)
- Software testing tools: 5% (2009), 6% (2008)

Survey results for 2009 (N = 1,446) and 2008 (N = 975).
Development Tools Home Page

Microchip provides award-winning development tool solutions to fit every embedded design application. Our MPLAB® X programming platform is compatible with all our microcontrollers, including 8-bit, 16-bit and 32-bit, DSC and periphery products. Support for your embedded designs begin here with free tutorials and webinars, a full range of documentation, free software downloads and evaluations, and 24/7 support center.

### Software
- Compilers
- MPLAB® X IDE
- Application Libraries
- RTOS
- Software Libraries
- Code Examples
- Embedded Code Source
- Archive
- MPLAB® 16-Bit Device Blocks for Simulink

### Emulators & Debuggers
- MPLAB® REAL ICE
  - Power Monitor
- MPLAB® ICD 3
- PICKit™ 3
- Accessories

### Production Programmers
- MPLAB® REAL ICE
- MPLAB® ICD 3
- MPLAB® PM 3

### Third Party
- MPLAB® Starter Kit

### Demo & Evaluation
- 8-bit PIC® MCUs
- 16-bit PIC® MCUs
- 32-bit PIC® MCUs
- Amplifiers & Linear
- Audio & Speech
- Battery Management
- Bluetooth
- CAN
- CoaXPress
- Energy Measurement
- Data Converters
- Ethernet - Devices
- Ethernet - PIC® MCUs
THE TOP 10 PROGRAMMING LANGUAGES
SPECTRUM'S 2014 RANKING

Working with computational journalist Nick Diakopoulos, IEEE Spectrum has weighted and combined 12 metrics from 10 sources (including IEEE Xplora, Google, and GitHub) to rank the most popular programming languages. If you don’t agree with our weighting, want to see more languages, or are interested in what’s dominant in a specific subsector, such as mobile, go to our online interactive version. There you can adjust the weight of each metric and create your own custom ranking. —STEPHEN CASS

KEY | W - Web | M - Mobile
D - Desktop and Enterprise
E - Embedded

Scores are normalized so that the top-ranked language’s score is set to 100.
Programming languages used in embedded software projects.

Figure 1
Overview

CodeWarrior™ Development Tools for 68K Embedded Systems, version 3 is a powerful development tool that quickly gets you up and running on your new projects. With one well-integrated edit, build, troubleshoot and deploy process, CodeWarrior tools enable your engineering team to save time and increase the quality of your finished products. CodeWarrior tools also simplify collaboration between developers on the same project team and allow developers on multiple projects to share design information, code and troubleshooting results.
Joint Test Action Group (JTAG) is the common name for the IEEE 1149.1 Standard Test Access Port and Boundary-Scan Architecture. It was initially devised by electronic engineers for testing printed circuit boards using boundary scan and is still widely used for this application.

Today, JTAG is also widely used for IC debug ports. In the embedded processor market, essentially all modern processors implement JTAG when they have enough pins. Embedded systems development relies on debuggers communicating with chips with JTAG to perform operations like single stepping and breakpointing.
END OF MICROPROCESSORS

I- First Lecture