16-bit and 32-bit microcontrollers developed for C language code efficiency

The 900 Family is made up of highly functional microcontrollers combining the best of Toshiba technologies.

The microcontrollers in this family are available as the processor core for a wide variety of applications, including office equipment, such as printers and fax machines, complex electronic household appliances, such as VCRs and video cameras, cellular 'phones and other information-based equipment.

### Core expansion keeping pace with applications

![Diagram showing core expansion](image)

- Processing capability doubled
- Processing capability quadrupled
- Upward-compatible
- 16-bit implementation
- Low-voltage operation
- Power consumption halved

### Processor core features

<table>
<thead>
<tr>
<th>Feature</th>
<th>900/H2 Series</th>
<th>900/H &amp; 900/L1 Series</th>
<th>900 &amp; 900/L Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum operating frequency</td>
<td>20 MHz (@10 MHz)</td>
<td>12.5 MHz (@25 MHz)</td>
<td>10 MHz (@20 MHz)</td>
</tr>
<tr>
<td>Minimum instruction execution time</td>
<td>50 ns</td>
<td>160 ns</td>
<td>200 ns</td>
</tr>
<tr>
<td>Address space</td>
<td>16 Mbytes of linear address space (for program and data)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data transfer rate (micro DMA)</td>
<td>0.25 µs</td>
<td>0.64 µs</td>
<td>1.6 µs</td>
</tr>
<tr>
<td>32-bit data-processing instructions</td>
<td>Transfer, arithmetic/logic operations and shift instructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bit-processing instructions</td>
<td>Transfer, logic operations, test, set, reset and search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiplication instruction execution time</td>
<td>600 ns</td>
<td>960 ns</td>
<td>2.6 µs</td>
</tr>
<tr>
<td>Dynamic bus sizing</td>
<td>8-/16-/32-bit</td>
<td>8-/16-bit</td>
<td></td>
</tr>
</tbody>
</table>

### Main applications

- **Office equipment**: Printers, Fax machines
- **Home electronics**: Digital video cameras, DVD players
- **Portable devices**: PICs, Cellular phones e.g. PHS
- **Other applications**: Portable devices, Office equipment, Home electronics

### Register model

- 4 banks of general-purpose registers
- 32-bit wide general-purpose registers
- Can be used for address calculations. Code size reduction is possible.
- Numerous general-purpose registers
- Flexible code generation by compiler
- Code size reduction is possible.
- Register bank method
- Ideal for real-time processing
900 Family

900/H Series

High-performance devices ideally suited to high-end office equipment

- Enhanced TLCS-900 architecture
  - TLCS-900 instruction compatibility
  - 32-bit general-purpose registers / register banks
- Linear address space: 16 MB
- Processing performance doubled (compared to 900 Series)
- Direct connection to various types of DRAM possible
- Because refresh is asynchronous with CPU operations, performance does not degrade as a result of accesses to memory devices other than DRAM.
- Applications
  - Serial printers
  - CD-ROM drives / DVD-ROM drives
  - Electronic musical instruments
  - HDDs

Block diagram of serial printer

900 Family

900/L Series

Low power consumption design ideal for high-performance portable equipment

- Enhanced TLCS-900 architecture
  - TLCS-900 instruction compatibility
  - 32-bit general-purpose registers / register banks
- Linear address space: 16 MB
- Low-voltage operation
  - Operating supply voltage: 4.5 V ~ 5.5 V @ 20 MHz
  - 2.7 V ~ 5.5 V @ 12.5 MHz
- Designed for low power consumption
- Minimum instruction execution time: 200 ns (when operating at 20 MHz)
900 Family

900/L1 Series

Next-generation 16-bit microprocessors
offering both high performance and low-power operation

- Low-voltage operation: 1.8 V ~ 5.5 V
- Low power consumption: 3.0 mA (when operating at 3 V and 16 MHz)
- Low noise (EMC register)
  - EMI: reduced by 30%
  - EMS: noise filter, protection register

■ Low power consumption design

![Graph showing power consumption comparison]

- **900/H**:
  - 0.6 µm
  - Approx. 19 mA
- **900/L1**:
  - 0.6 µm
  - 6 mA
  - Approx. 3 mA
- **900/L1**:
  - 0.4 µm
  - 3 mA

Conditions: 3 V, 16 MHz, 25°C

- **95CW64 or equivalent**
- **91CW12**
- **91CW12A**

■ Typical techniques
for low power consumption design

![Diagram showing gated clock system]

- **Reduced power consumption for ROM and RAM**
- **Gated clock system**
  - **SIO**: Gated
  - **Timer**: Gated
  - **INTC**: Clock stopped

■ Core expansion plan

![Diagram showing core expansion]

- **900/H**
- **900/L1**
- **900/L**

- **Advanced version**
- **High-speed core**
- **ASIC microcomputer**
- **ASIC-ready**
- **Low-voltage operation**
- **Reduced power consumption**
- **Reduced noise level**

■ Comparison of core performance (with 900/L)

![Graph showing performance comparison]

- **900/L1**
- **900/L**

(Unit: Toshiba MCU MIPS)
900 Family

900/H2 Series

High-performance microcontrollers incorporating a 32-bit CPU core

- Approximately four times the processing performance of conventional products (e.g. the 900/H Series)

### Comparison of instruction execution times

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Operand Size</th>
<th>8-bit</th>
<th>16-bit</th>
<th>32-bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data transfer 1</td>
<td>900/H2 Series</td>
<td>50</td>
<td>160</td>
<td>900/H2 Series</td>
</tr>
<tr>
<td>Data transfer 2</td>
<td>900/H2 Series</td>
<td>100</td>
<td>320</td>
<td>900/H2 Series</td>
</tr>
<tr>
<td>Arithmetic operation</td>
<td>900/H2 Series</td>
<td>50</td>
<td>240</td>
<td>900/H2 Series</td>
</tr>
<tr>
<td>Bit manipulation</td>
<td>900/H2 Series</td>
<td>50</td>
<td>240</td>
<td>900/H2 Series</td>
</tr>
<tr>
<td>Branching</td>
<td>900/H2 Series</td>
<td>100</td>
<td>400</td>
<td>900/H2 Series</td>
</tr>
</tbody>
</table>

Unit: ns

- Enhanced high-speed data transfer function (micro DMA)

900/H2 Series microcontrollers come with a high-speed data transfer function, equivalent to that of a DMAC (direct memory access controller), as standard.

- Diverse memory types fully utilized

The 900/H2 Series architecture allows various kinds of external memory chip to be connected directly to the CPU core without the need for an external circuit. Furthermore, the internal memory is connected to the CPU core via a 32-bit data bus and the internal RAM can be accessed in a single clock cycle.

#### Parameter Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>900 Series</th>
<th>900/H Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of channels</td>
<td>4 channels</td>
<td>8 channels</td>
</tr>
<tr>
<td>Minimum transfer time</td>
<td>1600 ns (2 bytes)</td>
<td>640 ns (2 bytes)</td>
</tr>
<tr>
<td>Initiated by</td>
<td>Interrupt</td>
<td>Interrupt and software trigger</td>
</tr>
<tr>
<td>Continuous Transfer Mode</td>
<td>NA</td>
<td>Available</td>
</tr>
</tbody>
</table>

- 32-bit data bus
- 8/-16/-32-bit data bus
### 900 Family Selection Guide

#### 900 Series

<table>
<thead>
<tr>
<th>Product No.</th>
<th>Min. Instruction Execution Time (ns)</th>
<th>Version with Built-in OTP</th>
<th>Packages (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMP96C041BF</td>
<td>47</td>
<td>QFP80 (14 x 20)</td>
<td></td>
</tr>
<tr>
<td>TMP96C031ZF</td>
<td>37</td>
<td>QFP80 (14 x 20)</td>
<td></td>
</tr>
<tr>
<td>32K</td>
<td>65</td>
<td>QFP80 (14 x 20)</td>
<td></td>
</tr>
<tr>
<td>TMP96C141BF</td>
<td>47</td>
<td>QFP80 (14 x 20)</td>
<td></td>
</tr>
<tr>
<td>TMP96CM40F</td>
<td>65</td>
<td>QFP80 (14 x 20)</td>
<td></td>
</tr>
</tbody>
</table>

#### 900/L Series

<table>
<thead>
<tr>
<th>Product No.</th>
<th>Min. Instruction Execution Time (ns)</th>
<th>Version with Built-in OTP</th>
<th>Packages (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMP93CS41F/DF</td>
<td>320</td>
<td>QFP100 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP93CS45F</td>
<td>320</td>
<td>QFP100 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP93CW41DF</td>
<td>320</td>
<td>QFP100 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP93CS40F/DF</td>
<td>320</td>
<td>QFP100 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP93CS42AF</td>
<td>320</td>
<td>QFP100 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP93CS44F</td>
<td>320</td>
<td>QFP100 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP93CT7F</td>
<td>320</td>
<td>QFP100 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>32K</td>
<td>88</td>
<td>QFP120 (28 x 28)</td>
<td></td>
</tr>
<tr>
<td>TMP93CW40F</td>
<td>400</td>
<td>QFP120 (28 x 28)</td>
<td></td>
</tr>
<tr>
<td>TMP93CM40F</td>
<td>400</td>
<td>QFP120 (28 x 28)</td>
<td></td>
</tr>
<tr>
<td>TMP93CS20F</td>
<td>400</td>
<td>QFP120 (28 x 28)</td>
<td></td>
</tr>
<tr>
<td>TMP93CS32F</td>
<td>400</td>
<td>QFP120 (28 x 28)</td>
<td></td>
</tr>
<tr>
<td>TMP93CS42AF</td>
<td>400</td>
<td>QFP120 (28 x 28)</td>
<td></td>
</tr>
<tr>
<td>TMP93CS44F</td>
<td>400</td>
<td>QFP120 (28 x 28)</td>
<td></td>
</tr>
</tbody>
</table>

#### 900/H Series

<table>
<thead>
<tr>
<th>Product No.</th>
<th>Min. Instruction Execution Time (ns)</th>
<th>Version with Built-in OTP</th>
<th>Packages (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMP95CS01F</td>
<td>160</td>
<td>QFP64 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP95CS01BF</td>
<td>160</td>
<td>QFP64 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP95CS063F</td>
<td>160</td>
<td>QFP64 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP95CS265F</td>
<td>160</td>
<td>QFP64 (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>64K</td>
<td>55</td>
<td>QFP144 (20 x 20)</td>
<td></td>
</tr>
<tr>
<td>TMP95CS54F</td>
<td>160</td>
<td>QFP144 (20 x 20)</td>
<td></td>
</tr>
<tr>
<td>TMP95CS64F</td>
<td>160</td>
<td>QFP144 (20 x 20)</td>
<td></td>
</tr>
<tr>
<td>TMP95CW64F</td>
<td>160</td>
<td>QFP144 (20 x 20)</td>
<td></td>
</tr>
<tr>
<td>TMP95PW64F</td>
<td>160</td>
<td>QFP144 (20 x 20)</td>
<td></td>
</tr>
</tbody>
</table>

#### 900/L1 Series

<table>
<thead>
<tr>
<th>Product No.</th>
<th>Min. Instruction Execution Time (ns)</th>
<th>Version with Built-in OTP</th>
<th>Packages (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMP91CS14F</td>
<td>160</td>
<td>QFP91FY14F (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP91CU10F</td>
<td>160</td>
<td>QFP91PW10F (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>128K</td>
<td>80</td>
<td>QFP91PW12F (14 x 14)</td>
<td></td>
</tr>
<tr>
<td>TMP91CW14F</td>
<td>160</td>
<td>QFP91FY14F (14 x 14)</td>
<td></td>
</tr>
</tbody>
</table>

#### 900/H2 Series

<table>
<thead>
<tr>
<th>Product No.</th>
<th>Min. Instruction Execution Time (ns)</th>
<th>Version with Built-in OTP</th>
<th>Packages (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMP94C241CF</td>
<td>50</td>
<td>QFP160 (28 x 28)</td>
<td></td>
</tr>
<tr>
<td>TMP94C251AF</td>
<td>50</td>
<td>QFP160 (28 x 28)</td>
<td></td>
</tr>
</tbody>
</table>
Low-noise 900/L Series microcontrollers with I2C bus interface

**NEW**

**TMP93CU44DF/CW44DF/PW44ADF**

- **Multi-function, high-capacity, low-noise, low-voltage, low power dissipation 16-bit microcontrollers**

The TMP93CU44DF/CW44DF/PW44ADF are low-voltage, low power dissipation 16-bit microcontrollers based on the 900/H CPU and incorporating an I2C bus interface and a high-capacity memory. To reduce unnecessary radiated noise and to enable low-noise operation, a decoupling capacitor has been incorporated and the number of wiring harnesses has been optimized. With lower noise levels than existing products, these microcontrollers are suitable for a wider range of applications.

- **Internal ROM**
  - TMP93CU44DF: mask ROM, 96 Kbytes
  - TMP93CW44DF: mask ROM, 128 Kbytes
  - TMP93PW44ADF: OTP ROM, 128 Kbytes

- **Internal RAM**
  - TMP93CU44DF: 3 Kbytes
  - TMP93CW44DF/PW44ADF: 4 Kbytes

- **I2C bus / SIO**: 1 channel
- **SIO/UART**: 2 channels
- **10-bit AD converter**: 8 channels
- **High-current output port**: 8 pins
- **Clock gear/Dual clock function**
- **Watchdog timer**
- **16-bit timer/counter**: 2 channels
- **8-bit timer/counter**: 4 channels
- **80-pin miniflat package**
  - (14 x 20 mm, 0.8-mm pitch, 2.7 mm thick)

- **Purchase of Toshiba I2C components conveys a license under the Philips I2C Patent Rights to use these components in an I2C system, provided that the system conforms to the I2C Standard Specification as defined by Philips.**

---

**NEW**

**TMP93CT76F*/CU76F/CW76F/PW76F**  *Under development*

- **16-bit microcontroller incorporating a VCR servo controller and fluorescent display tube driver**

The TMP93CT76F/CU76F/CW76F/PW76F are low power consumption, high-speed, advanced-function 16-bit microcontrollers built around the original Toshiba TLCS-900/L CPU core. They incorporate a fluorescent display tube driver and peripheral circuits ideal for controlling VCR systems and servos. These microcontrollers can be connected to multiple memory devices and can enhance the capability of dedicated VCR system control hardware; thus they are suitable for a wide range of applications.

- **Internal ROM**
  - TMP93CT76F: 72 Kbytes
  - TMP93CU76F: 96 Kbytes
  - TMP93CW76F/PW76F: 128 Kbytes

- **Internal RAM**
  - TMP93CT76F: 2 Kbytes
  - TMP93CU76F/CW76F/PW76F: 2.5 Kbytes

- **16-bit timer/counter**: 5 channels
- **8-bit timer/counter**: 1 channel
- **Timing pulse generator**: 2 channels
- **Time-base capture**: 3 channels
- **8-bit/14-bit PWM output**: 1/3 channels
- **VISS/VASS detector**
- **Sync. signal separator**
- **Pseudo sync. signal output**
- **Color rotary controller for head amp**
- **Standby modes**: 4
- **I2C bus / SIO**: 1 channel each
- **P-ch high breakdown voltage output ports**: 24
- **8-bit AD converter inputs**: 10 channels
- **100-pin flat package**
  - (14 x 20 mm, 0.65-mm pitch, 2.7 mm thick)
16-bit microcontrollers with built-in CAN controller

The TMP95FW54AF is 16-bit microcontroller based on the 900/H CPU, incorporating a single 5-V flash memory and the controller area network (CAN) communications protocol, the standard European protocol for vehicle LANs. The CAN has a maximum transfer rate of 1 Mbps.

The TMP95FW54AF also offer enhanced communications functions in the shape of a built-in serial expansion interface (SEI) for synchronous serial communications.

- Internal ROM: flash E²PROM, 128 Kbytes
- Internal RAM: 4 Kbytes
- CAN controller: 1 channel
  - supports version 2.0B (standard and extended formats)
  - 16 mailboxes built in
- SEI: 1 channel
- 16-bit timer/counter: 2 channels
- 8-bit timer/counter: 8 channels
- SIO/UART: 2 channels
- 10-bit AD converter: 8 channels
- Operating voltage: 4.5 V ~ 5.5 V
- Operating temperature: –40°C ~ +85°C
- 100-pin miniflat package
  - (14 × 14 mm, 0.5-mm pitch, 2.7 mm thick)

16-bit microcontrollers with built-in flash E²PROM

The TMP95FY64F is a 16-bit microcontroller based on the 900/H CPU and incorporating a single 5-V flash memory.

This microcontroller incorporates all of the 900 Family’s standard functions. It is easy to reprogram the microcontroller without removing it from the PCB on which it is mounted.

- Internal ROM: flash E²PROM, 256 Kbytes
  - Memory block organization
    - (16KB, 8KB X 2, 32KB, 64KB X 3)
- Internal RAM: 8 Kbytes
- 16-bit timer/counter: 2 channels
- 8-bit timer/counter: 8 channels
- SIO/UART: 3 channels
- 10-bit AD converter: 8 channels
- 8-bit DA converter: 2 channels
- CS/Wait controller: 4 blocks
- 100-pin miniflat package
  - (14 × 14 mm, 0.5-mm pitch, 2.7 mm thick)
900/L1 Series product with ultra-low power consumption and low noise

**TMP91CW12AF**

* Under development

- **Low-voltage operation, low power consumption and low-noise technology combined in one device**

The **TMP91CW12AF** is a new product which improves still further on the low-voltage performance of the **TMP91CW12F**. Low-voltage operation is 1.7× faster than the **TMP91CW12F**. The supply voltage can range from 1.8 V (f_{max} = 10 MHz) to 2.7 V (f_{max} = 27 MHz), while power consumption is about half that of the **TMP91CW12F**. This device is ideal for battery-driven equipment, particularly portable equipment like personal intelligent communicators (PICs), cellular phones, and digital cameras.

- Internal ROM: mask ROM, 128 Kbytes
- Internal RAM: 4 Kbytes
- Timer
- Programmable Idle Mode
- Clock to any peripheral can be stopped to achieve low-power operation.
- 16-bit timer/counter: 2 channels
- 8-bit timer/counter: 8 channels
- SIO / UART: 2 channels
- I^2C bus / SIO: 1 channel
- 10-bit AD converter: 8 channels
- 100-pin miniflat package
  - (14 × 14 mm, 0.5-mm pitch, 1.4 mm thick)

900/L1 Series low power consumption microcontrollers

**TMP91CY13F/FY13F**

- **16-bit microcontrollers with high-capacity flash E^2PROM**

The **TMP91CY13F** is a low-voltage, low power consumption 16-bit microcontroller built around a 900/L1 CPU core. It incorporates 8 KB of RAM and 256 KB of ROM. Features such as a 6-channel serial interface, a 12-channel 10-bit AD converter and a real-time clock make this product ideal for multimedia devices such as digital cameras. The **TMP91FY13F**’s on-board program can be rewritten.

- Internal ROM: mask ROM, 256 Kbytes
- **TMP91FY13F**: flash ROM, 256 Kbytes
- Internal RAM: 8 Kbytes
- I^2C bus / SIO: 1 channel
- 10-bit AD converter: 12 channels
- Clock gear / Dual clock function
- 120-pin miniflat package
  - **TMP91CY13F**
    - (14 × 14 mm, 0.4-mm pitch, 1.4 mm thick)
  - **TMP91FY13F**
    - (14 × 14 mm, 0.4-mm pitch, 2.0 mm thick)

Purchase of Toshiba I^2C components conveys a license under the Philips I^2C Patent Rights to use these components in an I^2C system, provided that the system conforms to the I^2C Standard Specification as defined by Philips.