The Ultimate Performance Flash Memory

Macronix Serial Multi I/O(MXSMIO™) Flash
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Ad vant a g e s  o f  M a c r o n i x  S e r i a l  M u l t i - I / O (MXSMIO™) Flash Family

Today more & more application require code execution & fast download functionality in their systems design. The Macronix Serial MXSMIO Flash products are available in Dual & Quad I/O capability to meet these system requirements. These products offer many advantages, such as:

- Read performance comparable to Parallel Flash
- Shorter system boot-up time
- Layout simplification
- Less cross-talk wires
- Lower power consumption
- Reduced pin-count (Controller or ASIC chip)
- Reduce RAM buffer size for code execution (direct access from Serial Flash)
- Lower system BOM cost

Applications Using Multi I/O Serial Flash

MXSMIO Flash Family, ranging from 16Mb~128Mb, are already supported by leading chipset companies for a variety of applications including:

- Optical Disk Drive
- Digital TV
- DVD Player
- Wireless LAN
- Printer
- Camera module
- Keyboard Controller

And several diverse applications will use this new generation "MXSMIO™ Flash Family" as their mainstream NOR Flash such as UWB, GE-PON, PLC, DSL & Set-Top Boxes, high speed servers, PC motherboards, Notebooks, graphic cards, HDDs, electronic dictionary, modems, and etc.
Serial Flash memories are rapidly taking over the code storage market from Parallel Flash in the same densities. The diagram above clearly indicates the benefits of moving to a Serial Flash device. With a parallel interconnect there are 38 external connections with 16 data bus and 19 address bus lines, whereas the SPI bus interface has only 4 interconnect signals. Not only is the layout simplified, the interface of the SPI bus reduces the size of the control chip as well. For example, in the ODD application, the controller size is reduced from a QFP240 to a QFP208 pin package and the routing based on this reduction not only reduces the size of the printed circuit board, but also reduces EMI and cross-talk.

Despite the reduction in pin count and the cost advantage of the smaller package, the new MXSMIO™ Flash family also provides outstanding access time, even better than Parallel Flash, which enables designers to use Serial Flash in speed critical applications.

**Leading Edge Breakthrough:** Macronix is the leading Serial Flash supplier in the industry with largest market share (Web-Feet Research, March 2009). In 2009 Macronix continues to demonstrate its leadership in the Serial Flash market by offering the fastest products in the industry - MXSMIO™ Duplex Family - Quad I/O with Double Transfer Rate (DTR) mode with speeds up to 400MHz.

The above diagram clearly demonstrates the Quad I/O DTR Serial Flash (MXSMIO™ Duplex) can exceed the performance of Parallel Flash. Our customers are already migrating from Parallel to Serial Flash.

Even without DTR, the Macronix Quad I/O Serial Flash provides amazing performance approaching DRAM speeds of 300Mb/s, and even exceeding the 220 Mb/s speed mark of a fast 70ns, 16bit Parallel NOR-Flash.
How to Design with Multi- I/O Works?

Hardware Considerations
Both Dual and Quad I/O Serial Flash from Macronix maintain backward compatibility – occupying exactly the same footprint used by conventional Single I/O Flash in 8-pin SOP packages. In other words, there is no need to modify the PCB or change the socket.

Software Considerations
The device identification should be properly specified to distinguish the traditional Single I/O Serial Flash from the new Multi-I/O ones. The following chart shows the command sets for customers using these devices in their systems. The recommended flow is to do READ ID check first: then to do DTR Quad I/O ID check, to Quad I/O ID check, and then Dual I/O ID and at last to do Single I/O ID check. If the IDs are all correct, it means that the device will support the abovementioned functions.

<table>
<thead>
<tr>
<th>Command Set</th>
<th>Action</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>READ Command</td>
<td>READ</td>
<td>03 Hex</td>
</tr>
<tr>
<td></td>
<td>FAST READ</td>
<td>QB Hex</td>
</tr>
<tr>
<td></td>
<td>Dual I/O READ</td>
<td>BB Hex</td>
</tr>
<tr>
<td></td>
<td>Quad I/O READ</td>
<td>EB Hex</td>
</tr>
<tr>
<td></td>
<td>Quad I/O DTR READ</td>
<td>ED Hex</td>
</tr>
<tr>
<td>PROGRAM Command</td>
<td>Quad I/O PAGE PROGRAM</td>
<td>38 Hex</td>
</tr>
<tr>
<td>READ ID</td>
<td>REM54D(READ ID for Quad I/O DDR Mode)</td>
<td>CF Hex</td>
</tr>
<tr>
<td></td>
<td>REM54(READ ID for Quad I/O Mode)</td>
<td>DF Hex</td>
</tr>
<tr>
<td></td>
<td>REM52(READ ID for Dual I/O Mode)</td>
<td>EF Hex</td>
</tr>
<tr>
<td></td>
<td>REM5(READ ID for Single I/O Mode)</td>
<td>90 Hex</td>
</tr>
</tbody>
</table>

Multi I/O Serial Flash memories of the same density have the same device ID and are backward compatible to single I/O products. Applications currently using Single I/O mode can migrate to Multi I/O in the future, since the device IDs are the same. The software will need to be updated to address the Multi I/O commands.

Key Features:
- Quad I/O with Double Transfer Rate Serial Flash has
  - Quad I/O
    - Four I/O signals instead of one I/O signal
    - Double Transfer Rate (DTR)
    - Signals triggered on both rising and falling edge of clock
  - Faster transfer of data from Serial Flash to DRAM or other chips
  - No changes to hardware-command code based operation
  - Backward compatible to Single/Dual/Quad I/O
  - Wide voltage range of 2.7V to 3.6V
  - Temperature range of -40°C to +85°C
  - Fastest clock speed in the industry for serial flash
    - 104MHz for fast read mode
    - 400MHz for Quad I/O DTR operations
  - 8-pin/16-pin SOP (SOIC) and 8-pin WSON (thin) Packages
    - 16-pin SOP (SOIC) package support
    - 16-pin SOP and KGD options.
    - 8 pins for parallel mode programming to speed up production programming
Enhanced Performance

An added feature in the Multi-I/O DTR Serial Flash offers Enhanced Performance by saving 36 clock cycles compared to the Single I/O Flash. This further upgrades performance of the device. This feature eliminates the need to repeat the 8 cycles used for commands when successive operations are performed using the same command with random addresses. This feature advises the device that the current command is to be repeated during the next operation. If this current operation is a Multi-I/O read command, the Flash will be kept in the Multi-I/O Read Mode and the next read operation can be initiated by simply supplying a new address and the required number of dummy cycles.

Pin Assignments

The Macronix Multi-I/O Serial Flash doubles or even quadruples the data rate by changing the conventional Serial Input pin and Serial Out pin from single unidirectional data flow into multiple bi-directional data flows. The Dual I/O version uses SI and SO pins for both serial input and output, while the Quad I/O version uses SI and SO pins along with Write Protect pin and NC pin for both data input and output Functions. This doubling or quadrupling of data rate allows Serial Flash to compete with Parallel Flash for data read performance.
# MXSMIO™ Flash Families

## 3V Standard Serial Flash Families

MXSMIO™ Family includes high performance Serial Flash products with Dual I/O (MX25xx05) and Quad I/O (MX25xx35/45) operations which double and quadruple the read performance of systems for high-end consumer applications. Multiple I/O products range from 16Mb to 128Mb, while Single I/O products are provided from 512Kb to 128Mb densities. These products are offered in 4Kb sectors and 64Kb blocks and this architecture makes these products compatible to Serial Flash from other suppliers’ architecture in the industry. Moreover, the Dual I/O and Quad I/O parts are backward compatible to the Single I/O versions which make them very convenient to use.

### Key Features:
- **Fast read performance**:
  - Dual I/O - 150MHz read (4-dummy cycles)
  - Quad I/O - 300MHz read (6-dummy cycles)
  - Quad I/O DTR - 400MHz read (6-dummy cycles)
- Serial Flash products offer new security options for diverse customer needs: (Dual, Quad I/O option)
  - Flexible write protection
  - Secure OTP
  - Additional special protection

### Single I/O 3V Family:

<table>
<thead>
<tr>
<th>Part number</th>
<th>Density</th>
<th>Voltage</th>
<th>Clock Speed (MHz)</th>
<th>I/O bus</th>
<th>Package</th>
<th>Mass Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>MX25L512C</td>
<td>512kb</td>
<td>2.7~3.6V</td>
<td>85</td>
<td>Single</td>
<td>8-SOP, 8-USON(2x3mm)</td>
<td>Y</td>
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<tr>
<td>MX25L1005C</td>
<td>1Mb</td>
<td>2.7~3.6V</td>
<td>85</td>
<td>Single</td>
<td>8-SOP, 8-USON(2x3mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L2005C</td>
<td>2Mb</td>
<td>2.7~3.6V</td>
<td>85</td>
<td>Single</td>
<td>8-SOP, 8-WSON(6x5mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L4005C</td>
<td>4Mb</td>
<td>2.7~3.6V</td>
<td>85</td>
<td>Single</td>
<td>8-SOP, 8-USON(4x4mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L8005</td>
<td>8Mb</td>
<td>2.7~3.6V</td>
<td>86</td>
<td>Single</td>
<td>8-SOP, 8-PDIP, 8-USON(6x5mm), 8-USON(4x4mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L1605D</td>
<td>16Mb</td>
<td>2.7~3.6V</td>
<td>86 / 100</td>
<td>Single / Dual</td>
<td>8-SOP, 8-PDIP, 16-SOP</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L3205D</td>
<td>32Mb</td>
<td>2.7~3.6V</td>
<td>86 / 100</td>
<td>Single / Dual</td>
<td>8-SOP, 8-PDIP, 16-SOP, 8-WSON(6x5mm), 8-USON(4x4mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L6405D</td>
<td>64Mb</td>
<td>2.7~3.6V</td>
<td>86 / 100</td>
<td>Single / Dual</td>
<td>8-SOP, 8-PDIP, 16-SOP</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L12805D</td>
<td>128Mb</td>
<td>2.7~3.6V</td>
<td>50</td>
<td>Single</td>
<td>16-SOP</td>
<td>Y**</td>
</tr>
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</table>

*Note: Y* Not recommended for new designs

### Dual I/O 3V Family:

<table>
<thead>
<tr>
<th>Part number</th>
<th>Density</th>
<th>Voltage</th>
<th>Clock Speed (MHz)</th>
<th>I/O bus</th>
<th>Package</th>
<th>Mass Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>MX25L1605D</td>
<td>16Mb</td>
<td>2.7~3.6V</td>
<td>86 / 100</td>
<td>Single / Dual</td>
<td>8-SOP, 8-PDIP, 8-USON(6x5mm), 8-USON(4x4mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L3205D</td>
<td>32Mb</td>
<td>2.7~3.6V</td>
<td>86 / 100</td>
<td>Single / Dual</td>
<td>8-SOP, 8-PDIP, 8-USON(6x5mm), 8-USON(4x4mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L6405D</td>
<td>64Mb</td>
<td>2.7~3.6V</td>
<td>86 / 100</td>
<td>Single / Dual</td>
<td>8-SOP, 8-PDIP, 8-USON(6x5mm), 8-USON(4x4mm)</td>
<td>Y</td>
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</table>

*Note: Y* Not recommended for new designs

### Quad I/O 3V Family:

<table>
<thead>
<tr>
<th>Part number</th>
<th>Density</th>
<th>Voltage</th>
<th>Clock Speed (MHz)</th>
<th>I/O bus</th>
<th>Package</th>
<th>Mass Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>MX25L1635D</td>
<td>16Mb</td>
<td>2.7~3.6V</td>
<td>104/150/300</td>
<td>Single / Dual / Quad</td>
<td>8-SOP, 8-PDIP, 16-SOP, 8-USON(6x5mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L3235D</td>
<td>32Mb</td>
<td>2.7~3.6V</td>
<td>104/150/300</td>
<td>Single / Dual / Quad</td>
<td>8-SOP, 8-PDIP, 16-SOP, 8-USON(6x5mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L6445E</td>
<td>64Mb</td>
<td>2.7~3.6V</td>
<td>104/140/280/400</td>
<td>Single / Dual /Quad / DTR</td>
<td>8-SOP, 8-PDIP, 8-USON(6x8mm)</td>
<td>Y</td>
</tr>
<tr>
<td>MX25L12845E</td>
<td>128Mb</td>
<td>2.7~3.6V</td>
<td>104/140/280/400</td>
<td>Single / Dual /Quad / DTR</td>
<td>16-SOP</td>
<td>Y</td>
</tr>
</tbody>
</table>
**Serial ROM Family**

For fixed software code applications like Printers, Game consoles, Toys, etc. Macronix provides a high performance as well as cost effective Serial ROM Family of products.

Featuring the same read performance as MXSIMO™ Family, yet taking advantage of low-cost OTP process technology, the Serial ROM Family products range from 16Mb to 128Mb and above with Dual and Quad I/O read capability with the same memory sector and block structure as MXSIMO™ Flash family.

**Key Features:**
- Fast read performance:
  - Dual I/O - 50MHz read (4-dummy cycles)
  - Quad I/O - 75MHz read (6-dummy cycles)

**Secure Serial Flash**

- Individual Block Permanent Lock
- Individual Block Lock
- Secured OTP area
- Flexible Write Protection
- Additional Special Protection
- Write Protection
  - HPM (Hardware Protection Mode)
    - “WP# pin” + “SRWD bit” to protect the pre-set sectors
  - SPM (Software Protection Mode)
    - BP0-BP3 bits to define the protected sectors

**Secure 3V Flash**

Modern electronic systems are susceptible to unauthorized or accidental alteration of code and data. Non-volatile memory such as Mask-ROM or NOR flash contains critical information that could be altered or cloned. Systems manufacturers require innovative ways to secure their intellectual property and investment. New versions of Macronix Serial Flash are available as Secure Flash, offering various means of write protection (OTP and Temporary/Permanent Lock) and read protection within certain parts of the memory.

**Macronix Security Features**

- Individual Block Permanent Lock
- Individual Block Lock
- Secured OTP area
- Flexible Write Protection
- Additional Special Protection
- Write Protection
  - HPM (Hardware Protection Mode)
    - “WP# pin” + “SRWD bit” to protect the pre-set sectors
  - SPM (Software Protection Mode)
    - BP0-BP3 bits to define the protected sectors

**Part number** | **Density** | **Organization** | **Clock Speed (MHz)** | **I/O Bus** | **Package** | **Mass Production**
--- | --- | --- | --- | --- | --- | ---
MX23L1635D | 16Mb | 16M x 1 / 8M x 2 / 4M x 4 | 104 / 140 / 150 | Single / Dual / Quad | 8-SOP | TBD
MX23L3235D | 32Mb | 32M x 1 / 16M x 2 / 8M x 4 | 104 / 150 / 300 | Single / Dual / Quad | 8-SOP | TBD
MX23L6445E | 64Mb | 64M x 1 / 32M x 2 | 100 / 140 / 280 / 400 | Single / Dual / Quad / DTR | 8-SOP | TBD
MX23L12845E | 128Mb | 128M x 1 / 64M x 2 / 32M x 4 | 100 / 140 / 280 / 400 | Single / Dual / Quad / DTR | 16-SOP | TBD
### Low Voltage Serial Multi-I/O Flash

For low power consumption devices such as GPS, Bluetooth, HDD and cordless phones, Macronix offers 25U(1.8V) series and 25V(2.5V) series components enabling system designer to design for tight power budgets. By lowering the operating voltage and reducing operating current, Macronix Flash provides low power consumption which makes it a truly ideal product for battery-powered portable applications.

### 1.8V /2.5V Serial Flash- Major Specifications

**VCC range**
- 1.65V to 2.0V; -40°C to 85°C
- 2.35V to 3.6V or 2.25V to 2.75V; -40°C to 85°C

**Density**
- 4Mb, 8Mb, 16Mb, 32Mb

Fastest clock speed in the industry for 1.8V serial flash
- 25MHz (Normal read mode)
- 40MHz (Fast read mode)
- 80/132 MHz (Dual/Quad I/O read mode)

**Low standby current**
- Standby current 1μA(typ.), 5μA(max.) (resume time: 30μs)

**Interface**
- Standard Serial Peripheral Interface (SPI)
- Multi-I/O -- Dual, Quad Input/Output

**Command**
- Industry standard commands for basic operations
- Enhanced commands for Macronix proprietary features

**Hardware pins**
- CS#, SCLK, SIO0, SIO1, WP#/SIO2, SIO3

### 2.5V Family

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Density</th>
<th>Organization</th>
<th>Clock Speed (MHz)</th>
<th>I/O bus</th>
<th>Package</th>
<th>Mass Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>25V4005C</td>
<td>4Mb</td>
<td>x 1</td>
<td>50MHz</td>
<td>Single</td>
<td>8-SOP</td>
<td>Q32009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B-WSON(6×5mm)</td>
<td></td>
</tr>
<tr>
<td>25V4035</td>
<td>4Mb</td>
<td>x 1 / x 2 / x 4</td>
<td>66/100/200</td>
<td>Single/Dual/Quad</td>
<td>8-SOP</td>
<td>Q32009</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>B-WSON(6×5mm)</td>
<td></td>
</tr>
<tr>
<td>25V8005</td>
<td>8Mb</td>
<td>x 1</td>
<td>50MHz</td>
<td>Single</td>
<td>8-SOP</td>
<td>Y</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B-WSON(8×5mm)</td>
<td></td>
</tr>
<tr>
<td>25V8035</td>
<td>8Mb</td>
<td>x 1 / x 2 / x 4</td>
<td>66/100/200</td>
<td>Single/Dual/Quad</td>
<td>8-SOP</td>
<td>Q32009</td>
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### 1.8V Family

<table>
<thead>
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<th>Part Number</th>
<th>Density</th>
<th>Organization</th>
<th>Clock Speed (MHz)</th>
<th>I/O bus</th>
<th>Package</th>
<th>Mass Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>25U4035</td>
<td>4Mb</td>
<td>4M x 1 / 2M x 2 / 1M x 4</td>
<td>40/80/132</td>
<td>Single/Dual/Quad</td>
<td>8-SOP</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BUSON(4x4mm)</td>
<td></td>
</tr>
<tr>
<td>25U8035</td>
<td>8Mb</td>
<td>8M x 1 / 4M x 2 / 2M x 4</td>
<td>40/80/132</td>
<td>Single/Dual/Quad</td>
<td>8-SOP</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BUSON(4x4mm)</td>
<td></td>
</tr>
<tr>
<td>25U1635E</td>
<td>16Mb</td>
<td>16M x 1 / 8M x 2 / 4M x 4</td>
<td>104/168/336</td>
<td>Single/Dual/Quad</td>
<td>8-SOP</td>
<td>2010</td>
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<td>BUSON(4x4mm)</td>
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</tr>
<tr>
<td>25U3235E</td>
<td>32Mb</td>
<td>32M x 1 / 16M x 2 / 8M x 4</td>
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<td>Single/Dual/Quad</td>
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<td>2010</td>
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<td>B-WSON(6x5mm)</td>
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</table>
Macronix provides Flash products with small form-factor packages, for space-constrained applications. Apart from industry standard packages, Known Good Die (KGD) solutions for System in Package (SiP) applications are also available.

### Thin & Small Packages

<table>
<thead>
<tr>
<th>Package Type</th>
<th>Length</th>
<th>Width</th>
<th>Thickness</th>
<th>Pitch</th>
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</thead>
<tbody>
<tr>
<td>8-SOP (150 mil)</td>
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<td>5</td>
<td>1.75</td>
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<td>8-SOP (200 mil)</td>
<td>7.9</td>
<td>5.23</td>
<td>2.16</td>
<td>1.27</td>
</tr>
<tr>
<td>8-SON (0.8mm height)</td>
<td>6x5</td>
<td>6x5</td>
<td>6x5</td>
<td>6x5</td>
</tr>
<tr>
<td>8-USON (0.6mm height)</td>
<td>2x3</td>
<td>2x3</td>
<td>4x4</td>
<td>4x4</td>
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<tr>
<td>8 WSON (8x6)</td>
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<td>6</td>
<td>0.8</td>
<td>1.27</td>
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<tr>
<td>8 WSON (6x5)</td>
<td>6</td>
<td>5</td>
<td>0.8</td>
<td>1.27</td>
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<tr>
<td>8 USON (4x4)</td>
<td>4</td>
<td>4</td>
<td>0.6</td>
<td>0.6</td>
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<td>8 USON (2x3)</td>
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<td>2</td>
<td>0.6</td>
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### Multiple Package Options

PCB Space a Problem? **Macronix** Has the Perfect Solution
About Macronix International Co., Ltd.

Founded in 1989, Macronix International Co., Ltd. (TSE: 2337.TT) is a leading provider of innovative non-volatile memory (NVM) solutions. Macronix is the largest worldwide manufacturer of ROM products, and also provides a wide range of NOR Flash products across various densities. These are used in embedded systems, consumer, communication and enterprise applications.

For more information, please visit the Company website at www.macronix.com.