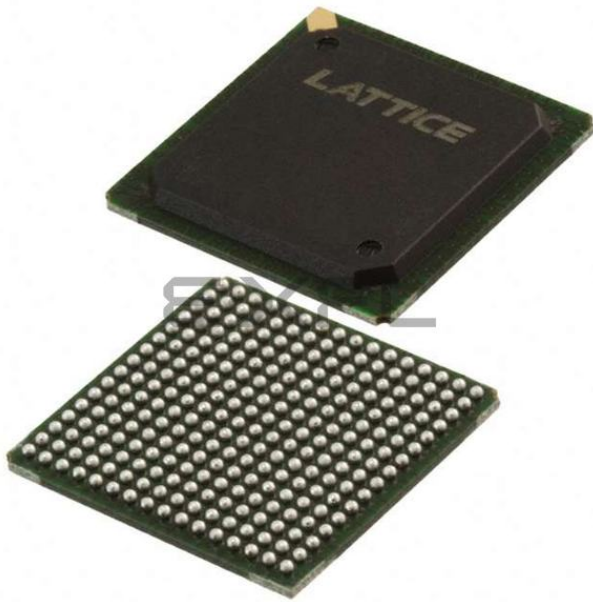




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## Understanding [Embedded - CPLDs \(Complex Programmable Logic Devices\)](#)

Embedded - CPLDs, or Complex Programmable Logic Devices, are highly versatile digital logic devices used in electronic systems. These programmable components are designed to perform complex logical operations and can be customized for specific applications. Unlike fixed-function ICs, CPLDs offer the flexibility to reprogram their configuration, making them an ideal choice for various embedded systems. They consist of a set of logic gates and programmable interconnects, allowing designers to implement complex logic circuits without needing custom hardware.

## Applications of Embedded - CPLDs

### Details

|                                 |                                                                                                                                                                             |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Product Status                  | Not For New Designs                                                                                                                                                         |
| Programmable Type               | In System Programmable                                                                                                                                                      |
| Delay Time tpd(1) Max           | 12 ns                                                                                                                                                                       |
| Voltage Supply - Internal       | 3V ~ 3.6V                                                                                                                                                                   |
| Number of Logic Elements/Blocks | -                                                                                                                                                                           |
| Number of Macrocells            | 512                                                                                                                                                                         |
| Number of Gates                 | -                                                                                                                                                                           |
| Number of I/O                   | 192                                                                                                                                                                         |
| Operating Temperature           | 0°C ~ 70°C (TA)                                                                                                                                                             |
| Mounting Type                   | Surface Mount                                                                                                                                                               |
| Package / Case                  | 256-BGA                                                                                                                                                                     |
| Supplier Device Package         | 256-FPBGA (17x17)                                                                                                                                                           |
| Purchase URL                    | <a href="https://www.e-xfl.com/product-detail/lattice-semiconductor/m4a3-512-192-12fanc">https://www.e-xfl.com/product-detail/lattice-semiconductor/m4a3-512-192-12fanc</a> |

**Table 1. ispMACH 4A Device Features**

| <b>3.3 V Devices</b> |                |                |                |                 |                 |                 |                 |                 |
|----------------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| <b>Feature</b>       | <b>M4A3-32</b> | <b>M4A3-64</b> | <b>M4A3-96</b> | <b>M4A3-128</b> | <b>M4A3-192</b> | <b>M4A3-256</b> | <b>M4A3-384</b> | <b>M4A3-512</b> |
| Macrocells           | 32             | 64             | 96             | 128             | 192             | 256             | 384             | 512             |
| User I/O options     | 32             | 32/64          | 48             | 64              | 96              | 128/160/192     | 160/192         | 160/192/256     |
| $t_{PD}$ (ns)        | 5.0            | 5.5            | 5.5            | 5.5             | 6.0             | 5.5             | 6.5             | 7.5             |
| $f_{CNT}$ (MHz)      | 182            | 167            | 167            | 167             | 160             | 167             | 154             | 125             |
| $t_{COS}$ (ns)       | 4.0            | 4.0            | 4.0            | 4.0             | 4.5             | 4.0             | 4.5             | 5.5             |
| $t_{SS}$ (ns)        | 3.0            | 3.5            | 3.5            | 3.5             | 3.5             | 3.5             | 3.5             | 5.0             |
| Static Power (mA)    | 20             | 25/52          | 40             | 55              | 85              | 110/150         | 149/155         | 179             |
| JTAG Compliant       | Yes            | Yes            | Yes            | Yes             | Yes             | Yes             | Yes             | Yes             |
| PCI Compliant        | Yes            | Yes            | Yes            | Yes             | Yes             | Yes             | Yes             | Yes             |

| <b>5 V Devices</b> |                |                |                |                 |                 |                 |
|--------------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|
| <b>Feature</b>     | <b>M4A5-32</b> | <b>M4A5-64</b> | <b>M4A5-96</b> | <b>M4A5-128</b> | <b>M4A5-192</b> | <b>M4A5-256</b> |
| Macrocells         | 32             | 64             | 96             | 128             | 192             | 256             |
| User I/O options   | 32             | 32             | 48             | 64              | 96              | 128             |
| $t_{PD}$ (ns)      | 5.0            | 5.5            | 5.5            | 5.5             | 6.0             | 6.5             |
| $f_{CNT}$ (MHz)    | 182            | 167            | 167            | 167             | 160             | 154             |
| $t_{COS}$ (ns)     | 4.0            | 4.0            | 4.0            | 4.0             | 4.5             | 5.0             |
| $t_{SS}$ (ns)      | 3.0            | 3.5            | 3.5            | 3.5             | 3.5             | 3.5             |
| Static Power (mA)  | 20             | 25             | 40             | 55              | 74              | 110             |
| JTAG Compliant     | Yes            | Yes            | Yes            | Yes             | Yes             | Yes             |
| PCI Compliant      | Yes            | Yes            | Yes            | Yes             | Yes             | Yes             |

## FUNCTIONAL DESCRIPTION

The fundamental architecture of ispMACH 4A devices (Figure 1) consists of multiple, optimized PAL<sup>®</sup> blocks interconnected by a central switch matrix. The central switch matrix allows communication between PAL blocks and routes inputs to the PAL blocks. Together, the PAL blocks and central switch matrix allow the logic designer to create large designs in a single device instead of having to use multiple devices.

The key to being able to make effective use of these devices lies in the interconnect schemes. In the ispMACH 4A architecture, the macrocells are flexibly coupled to the product terms through the logic allocator, and the I/O pins are flexibly coupled to the macrocells due to the output switch matrix. In addition, more input routing options are provided by the input switch matrix. These resources provide the flexibility needed to fit designs efficiently.

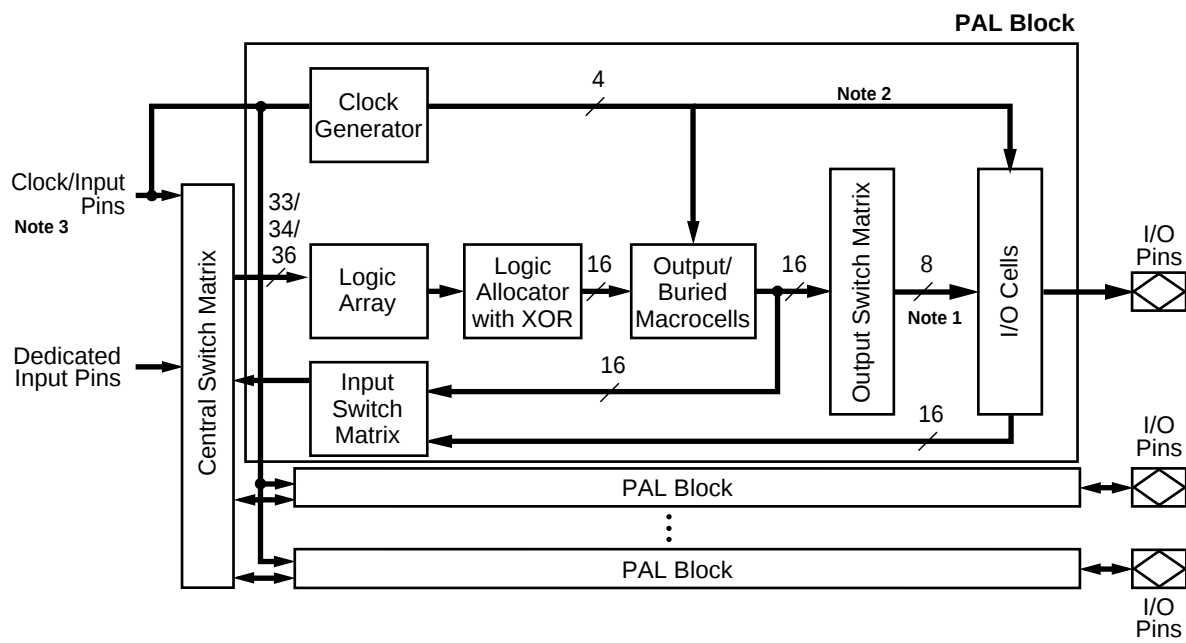
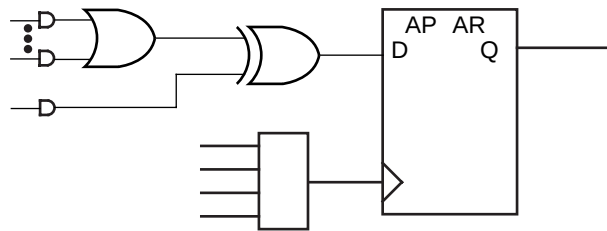


Figure 1. ispMACH 4A Block Diagram and PAL Block Structure

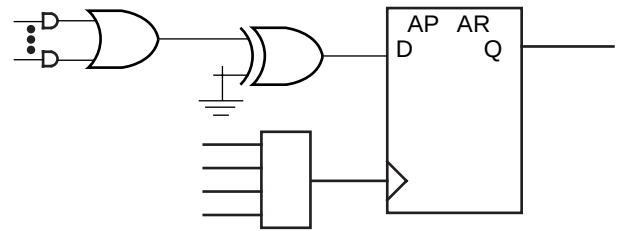
### Notes:

1. 16 for ispMACH 4A devices with 1:1 macrocell-I/O cell ratio (see next page).
2. Block clocks do not go to I/O cells in M4A(3,5)-32/32.
3. M4A(3,5)-192, M4A(3,5)-256, M4A3-384, and M4A3-512 have dedicated clock pins which cannot be used as inputs and do not connect to the central switch matrix.

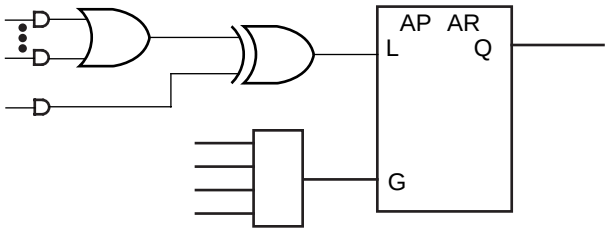
The flip-flop can be configured as a D-type or T-type latch. J-K or S-R registers can be synthesized. The primary flip-flop configurations are shown in Figure 6, although others are possible. Flip-flop functionality is defined in Table 8. Note that a J-K latch is inadvisable as it will cause oscillation if both J and K inputs are HIGH.



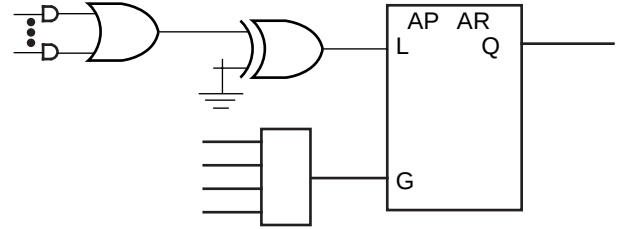
a. D-type with XOR



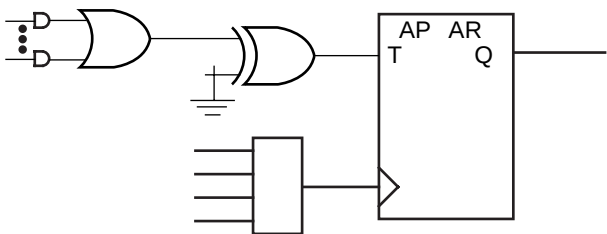
b. D-type with programmable D polarity



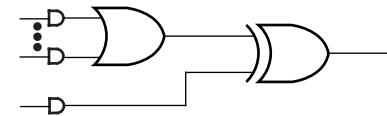
c. Latch with XOR



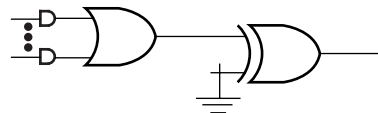
d. Latch with programmable D polarity



e. T-type with programmable T polarity



f. Combinatorial with XOR



g. Combinatorial with programmable polarity

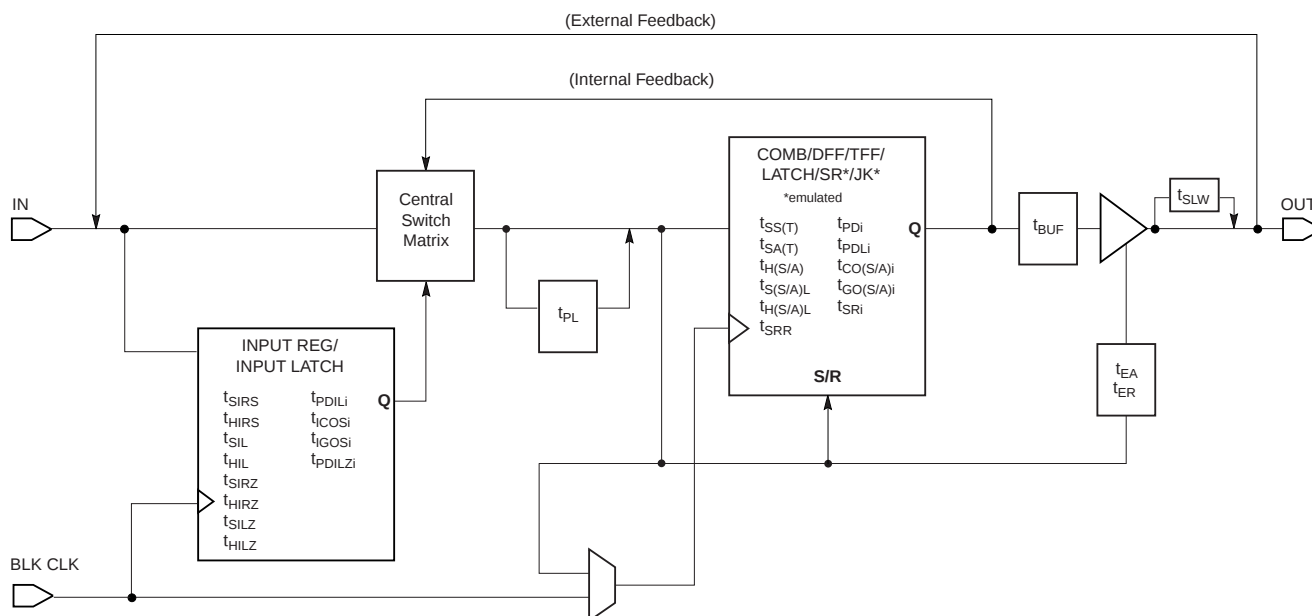
Figure 6. Primary Macrocell Configurations

17466G-011

## ispMACH 4A TIMING MODEL

The primary focus of the ispMACH 4A timing model is to accurately represent the timing in a ispMACH 4A device, and at the same time, be easy to understand. This model accurately describes all combinatorial and registered paths through the device, making a distinction between internal feedback and external feedback. A signal uses internal feedback when it is fed back into the switch matrix or block without having to go through the output buffer. The input register specifications are also reported as internal feedback. When a signal is fed back into the switch matrix after having gone through the output buffer, it is using external feedback.

The parameter,  $t_{BUF}$ , is defined as the time it takes to go from feedback through the output buffer to the I/O pad. If a signal goes to the internal feedback rather than to the I/O pad, the parameter designator is followed by an “i”. By adding  $t_{BUF}$  to this internal parameter, the external parameter is derived. For example,  $t_{PD} = t_{PDi} + t_{BUF}$ . A diagram representing the modularized ispMACH 4A timing model is shown in Figure 15. Refer to the application note entitled *MACH 4 Timing and High Speed Design* for a more detailed discussion about the timing parameters.



17466G-025

Figure 15. ispMACH 4A Timing Model

## SPEEDLOCKING FOR GUARANTEED FIXED TIMING

The ispMACH 4A architecture allows allocation of up to 20 product terms to an individual macrocell with the assistance of an XOR gate without incurring additional timing delays.

The design of the switch matrix and PAL blocks guarantee a fixed pin-to-pin delay that is independent of the logic required by the design. Other competitive CPLDs incur serious timing delays as product terms expand beyond their typical 4 or 5 product term limits. Speed and SpeedLocking combine to give designs easy access to the performance required in today's designs.

## IEEE 1149.1-COMPLIANT BOUNDARY SCAN TESTABILITY

All ispMACH 4A devices have boundary scan cells and are compliant to the IEEE 1149.1 standard. This allows functional testing of the circuit board on which the device is mounted through a serial scan path that can access all critical logic nodes. Internal registers are linked internally, allowing test data to be shifted in and loaded directly onto test nodes, or test node data to be captured and shifted out for verification. In addition, these devices can be linked into a board-level serial scan path for more complete board-level testing.

## IEEE 1149.1-COMPLIANT IN-SYSTEM PROGRAMMING

Programming devices in-system provides a number of significant benefits including: rapid prototyping, lower inventory levels, higher quality, and the ability to make in-field modifications. All ispMACH 4A devices provide In-System Programming (ISP) capability through their Boundary ScanTest Access Ports. This capability has been implemented in a manner that ensures that the port remains compliant to the IEEE 1149.1 standard. By using IEEE 1149.1 as the communication interface through which ISP is achieved, customers get the benefit of a standard, well-defined interface.

ispMACH 4A devices can be programmed across the commercial temperature and voltage range. The PC-based ispVM™ software facilitates in-system programming of ispMACH 4A devices. ispVM takes the JEDEC file output produced by the design implementation software, along with information about the JTAG chain, and creates a set of vectors that are used to drive the JTAG chain. ispVM software can use these vectors to drive a JTAG chain via the parallel port of a PC. Alternatively, ispVM software can output files in formats understood by common automated test equipment. This equipment can then be used to program ispMACH 4A devices during the testing of a circuit board.

## PCI COMPLIANT

ispMACH 4A devices in the -5/-55/-6/-65/-7/-10/-12 speed grades are compliant with the *PCI Local Bus Specification* version 2.1, published by the PCI Special Interest Group (SIG). The 5-V devices are fully PCI-compliant. The 3.3-V devices are mostly compliant but do not meet the PCI condition to clamp the inputs as they rise above  $V_{CC}$  because of their 5-V input tolerant feature.

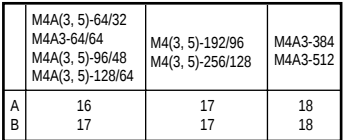
## SAFE FOR MIXED SUPPLY VOLTAGE SYSTEM DESIGNS

Both the 3.3-V and 5-V  $V_{CC}$  ispMACH 4A devices are safe for mixed supply voltage system designs. The 5-V devices will not overdrive 3.3-V devices above the output voltage of 3.3 V, while they accept inputs from other 3.3-V devices. The 3.3-V device will accept inputs up to 5.5 V. Both the 5-V and 3.3-V versions have the same high-speed performance and provide easy-to-use mixed-voltage design capability.

## PULL UP OR BUS-FRIENDLY INPUTS AND I/Os

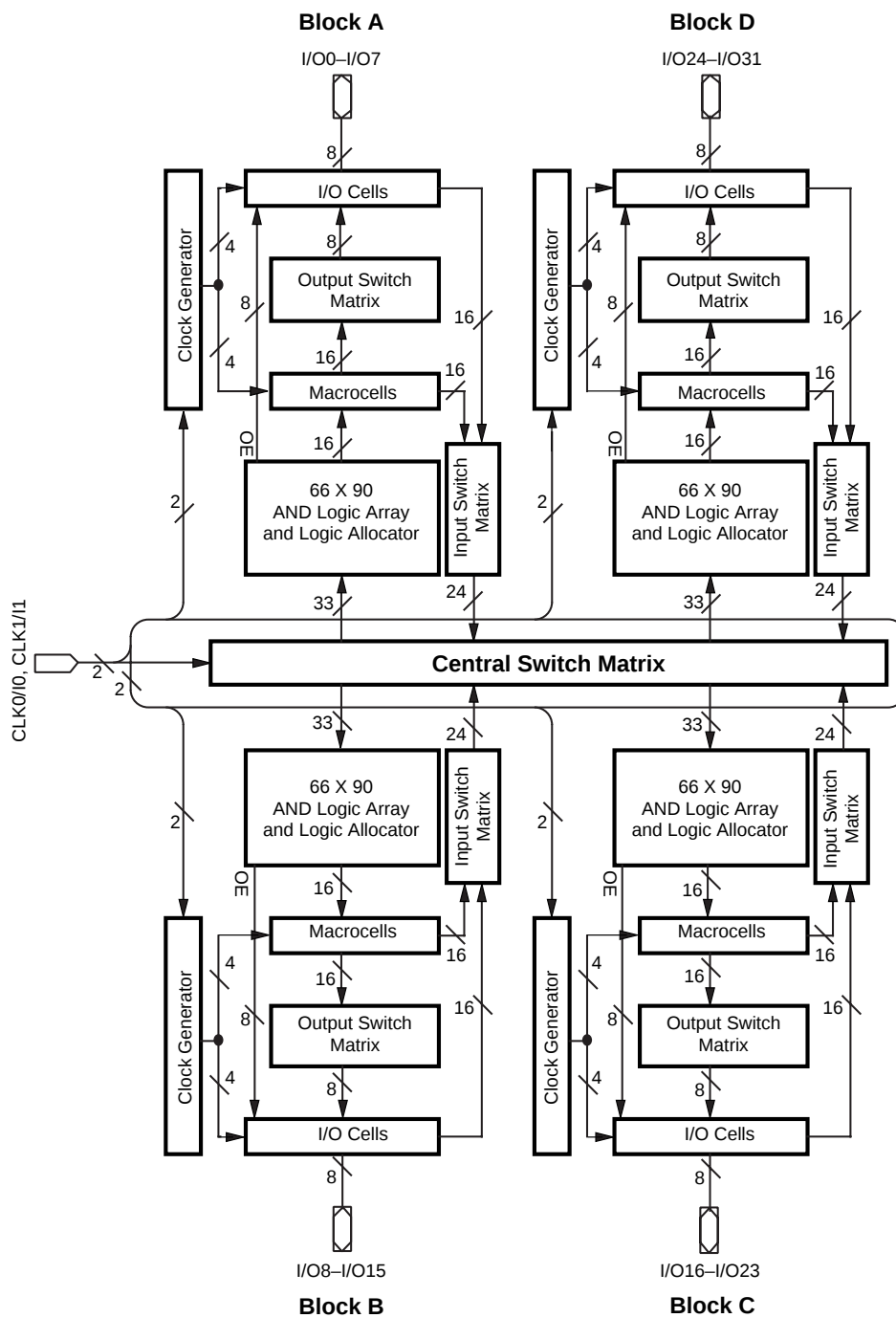
All ispMACH 4A devices have inputs and I/Os which feature the Bus-Friendly circuitry incorporating two inverters in series which loop back to the input. This double inversion weakly holds the input at its last driven logic state. While it is good design practice to tie unused pins to a known state, the Bus-Friendly input structure pulls pins away from the input threshold voltage where noise can cause high-frequency switching. At power-up, the Bus-Friendly latches are reset to a logic level “1.” For the circuit diagram, please refer to the document entitled *MACH Endurance Characteristics* on the Lattice Data Book CD-ROM or Lattice web site.

All ispMACH 4A devices have a programmable bit that configures all inputs and I/Os with either pull-up or Bus-Friendly characteristics. If the device is configured in pull-up mode, all inputs and I/O pins are



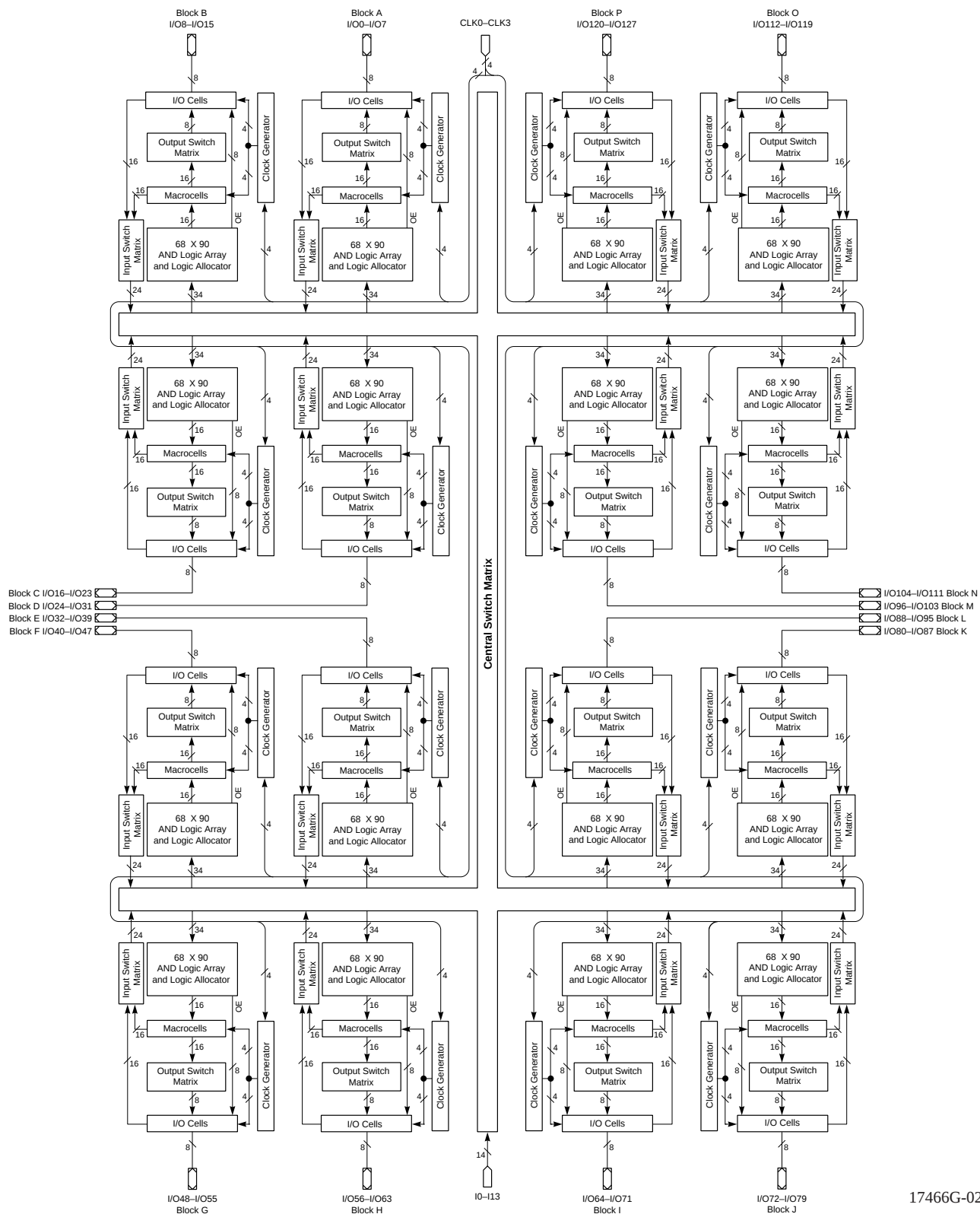
**Figure 16. PAL Block for ispMACH 4A with 2:1 Macrocell - I/O Cell Ratio**

## BLOCK DIAGRAM – M4A(3,5)-64/32



17466H-020

## BLOCK DIAGRAM – M4A(3,5)-256/128



17466G-024

## ABSOLUTE MAXIMUM RATINGS

### M4A5

Storage Temperature. . . . . -65°C to +150°C  
 Ambient Temperature  
 with Power Applied. . . . . -55°C to +100°C  
 Device Junction Temperature. . . . . +130°C  
 Supply Voltage  
 with Respect to Ground . . . . . -0.5 V to +7.0 V  
 DC Input Voltage . . . . . -0.5 V to  $V_{CC} + 0.5$  V  
 Static Discharge Voltage . . . . . 2000 V  
 Latchup Current ( $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ) . . . . . 200 mA

*Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability.*

## OPERATING RANGES

### Commercial (C) Devices

Ambient Temperature ( $T_A$ )  
 Operating in Free Air. . . . .  $0^\circ\text{C}$  to  $+70^\circ\text{C}$   
 Supply Voltage ( $V_{CC}$ )  
 with Respect to Ground. . . . . +4.75 V to +5.25 V

### Industrial (I) Devices

Ambient Temperature ( $T_A$ )  
 Operating in Free Air. . . . .  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$   
 Supply Voltage ( $V_{CC}$ )  
 with Respect to Ground. . . . . +4.50 V to +5.5 V  
*Operating ranges define those limits between which the functionality of the device is guaranteed.*

## 5-V DC CHARACTERISTICS OVER OPERATING RANGES

| Parameter Symbol | Parameter Description                 | Test Conditions                                                                       | Min | Typ | Max  | Unit          |
|------------------|---------------------------------------|---------------------------------------------------------------------------------------|-----|-----|------|---------------|
| $V_{OH}$         | Output HIGH Voltage                   | $I_{OH} = -3.2$ mA, $V_{CC} = \text{Min}$ , $V_{IN} = V_{IH}$ or $V_{IL}$             | 2.4 |     |      | V             |
|                  |                                       | $I_{OH} = -100$ $\mu\text{A}$ , $V_{CC} = \text{Max}$ , $V_{IN} = V_{IH}$ or $V_{IL}$ |     | 3.3 | 3.6  | V             |
| $V_{OL}$         | Output LOW Voltage                    | $I_{OL} = 24$ mA, $V_{CC} = \text{Min}$ , $V_{IN} = V_{IH}$ or $V_{IL}$ (Note 1)      |     |     | 0.5  | V             |
| $V_{IH}$         | Input HIGH Voltage                    | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 2)                         | 2.0 |     |      | V             |
| $V_{IL}$         | Input LOW Voltage                     | Guaranteed Input Logical LOW Voltage for all Inputs (Note 2)                          |     |     | 0.8  | V             |
| $I_{IH}$         | Input HIGH Leakage Current            | $V_{IN} = 5.25$ V, $V_{CC} = \text{Max}$ (Note 3)                                     |     |     | 10   | $\mu\text{A}$ |
| $I_{IL}$         | Input LOW Leakage Current             | $V_{IN} = 0$ V, $V_{CC} = \text{Max}$ (Note 3)                                        |     |     | -10  | $\mu\text{A}$ |
| $I_{OZH}$        | Off-State Output Leakage Current HIGH | $V_{OUT} = 5.25$ V, $V_{CC} = \text{Max}$ , $V_{IN} = V_{IH}$ or $V_{IL}$ (Note 3)    |     |     | 10   | $\mu\text{A}$ |
| $I_{OZL}$        | Off-State Output Leakage Current LOW  | $V_{OUT} = 0$ V, $V_{CC} = \text{Max}$ , $V_{IN} = V_{IH}$ or $V_{IL}$ (Note 3)       |     |     | -10  | $\mu\text{A}$ |
| $I_{SC}$         | Output Short-Circuit Current          | $V_{OUT} = 0.5$ V, $V_{CC} = \text{Max}$ (Note 4)                                     | -30 |     | -160 | mA            |

### Notes:

1. Total  $I_{OL}$  for one PAL block should not exceed 64 mA.
2. These are absolute values with respect to device ground, and all overshoots due to system or tester noise are included.
3. I/O pin leakage is the worst case of  $I_{IL}$  and  $I_{OZL}$  (or  $I_{IH}$  and  $I_{OZH}$ ).
4. Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second.  
 $V_{OUT} = 0.5$  V has been chosen to avoid test problems caused by tester ground degradation.

## ispMACH 4A TIMING PARAMETERS OVER OPERATING RANGES<sup>1</sup>

|                        |                                                       | -5  |     | -55 |     | -6  |     | -65 |     | -7  |      | -10 |      | -12 |      | -14  |      | Unit |
|------------------------|-------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|------|-----|------|------|------|------|
|                        |                                                       | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max  | Min | Max  | Min | Max  | Min  | Max  |      |
| Combinatorial Delay:   |                                                       |     |     |     |     |     |     |     |     |     |      |     |      |     |      |      |      |      |
| t <sub>PDi</sub>       | Internal combinatorial propagation delay              |     | 3.5 |     | 4.0 |     | 4.3 |     | 4.5 |     | 5.0  |     | 7.0  |     | 9.0  |      | 11.0 | ns   |
| t <sub>PD</sub>        | Combinatorial propagation delay                       |     | 5.0 |     | 5.5 |     | 6.0 |     | 6.5 |     | 7.5  |     | 10.0 |     | 12.0 |      | 14.0 | ns   |
| Registered Delays:     |                                                       |     |     |     |     |     |     |     |     |     |      |     |      |     |      |      |      |      |
| t <sub>SS</sub>        | Synchronous clock setup time, D-type register         | 3.0 |     | 3.5 |     | 3.5 |     | 3.5 |     | 5.0 |      | 5.5 |      | 7.0 |      | 10.0 |      | ns   |
| t <sub>SST</sub>       | Synchronous clock setup time, T-type register         | 4.0 |     | 4.0 |     | 4.0 |     | 4.0 |     | 6.0 |      | 6.5 |      | 8.0 |      | 11.0 |      | ns   |
| t <sub>SA</sub>        | Asynchronous clock setup time, D-type register        | 2.5 |     | 2.5 |     | 2.5 |     | 3.0 |     | 3.5 |      | 4.0 |      | 5.0 |      | 8.0  |      | ns   |
| t <sub>SAT</sub>       | Asynchronous clock setup time, T-type register        | 3.0 |     | 3.0 |     | 3.0 |     | 3.5 |     | 4.5 |      | 5.0 |      | 6.0 |      | 9.0  |      | ns   |
| t <sub>HS</sub>        | Synchronous clock hold time                           | 0.0 |     | 0.0 |     | 0.0 |     | 0.0 |     | 0.0 |      | 0.0 |      | 0.0 |      | 0.0  |      | ns   |
| t <sub>HA</sub>        | Asynchronous clock hold time                          | 2.5 |     | 2.5 |     | 2.5 |     | 3.0 |     | 3.5 |      | 4.0 |      | 5.0 |      | 8.0  |      | ns   |
| t <sub>COsi</sub>      | Synchronous clock to internal output                  |     | 2.5 |     | 2.5 |     | 2.8 |     | 3.0 |     | 3.0  |     | 3.0  |     | 3.5  |      | 3.5  | ns   |
| t <sub>COS</sub>       | Synchronous clock to output                           |     | 4.0 |     | 4.0 |     | 4.5 |     | 5.0 |     | 5.5  |     | 6.0  |     | 6.5  |      | 6.5  | ns   |
| t <sub>COAi</sub>      | Asynchronous clock to internal output                 |     | 5.0 |     | 5.0 |     | 5.0 |     | 5.0 |     | 6.0  |     | 8.0  |     | 10.0 |      | 12.0 | ns   |
| t <sub>COA</sub>       | Asynchronous clock to output                          |     | 6.5 |     | 6.5 |     | 6.8 |     | 7.0 |     | 8.5  |     | 11.0 |     | 13.0 |      | 15.0 | ns   |
| Latched Delays:        |                                                       |     |     |     |     |     |     |     |     |     |      |     |      |     |      |      |      |      |
| t <sub>SSL</sub>       | Synchronous latch setup time                          | 4.0 |     | 4.0 |     | 4.0 |     | 4.5 |     | 6.0 |      | 7.0 |      | 8.0 |      | 10.0 |      | ns   |
| t <sub>SAL</sub>       | Asynchronous latch setup time                         | 3.0 |     | 3.0 |     | 3.5 |     | 3.5 |     | 4.0 |      | 4.0 |      | 5.0 |      | 8.0  |      | ns   |
| t <sub>HSL</sub>       | Synchronous latch hold time                           | 0.0 |     | 0.0 |     | 0.0 |     | 0.0 |     | 0.0 |      | 0.0 |      | 0.0 |      | 0.0  |      | ns   |
| t <sub>HAL</sub>       | Asynchronous latch hold time                          | 3.0 |     | 3.0 |     | 3.5 |     | 3.5 |     | 4.0 |      | 4.0 |      | 5.0 |      | 8.0  |      | ns   |
| t <sub>PDLi</sub>      | Transparent latch to internal output                  |     | 5.5 |     | 5.5 |     | 5.8 |     | 6.0 |     | 7.5  |     | 9.0  |     | 11.0 |      | 12.0 | ns   |
| t <sub>PDL</sub>       | Propagation delay through transparent latch to output |     | 7.0 |     | 7.0 |     | 7.5 |     | 8.0 |     | 10.0 |     | 12.0 |     | 14.0 |      | 15.0 | ns   |
| t <sub>GOSi</sub>      | Synchronous gate to internal output                   |     | 3.0 |     | 3.0 |     | 3.0 |     | 3.0 |     | 3.5  |     | 4.5  |     | 7.0  |      | 8.0  | ns   |
| t <sub>GOS</sub>       | Synchronous gate to output                            |     | 4.5 |     | 4.5 |     | 4.8 |     | 5.0 |     | 6.0  |     | 7.5  |     | 10.0 |      | 11.0 | ns   |
| t <sub>GOAi</sub>      | Asynchronous gate to internal output                  |     | 6.0 |     | 6.0 |     | 6.0 |     | 6.0 |     | 8.5  |     | 10.0 |     | 13.0 |      | 15.0 | ns   |
| t <sub>GOA</sub>       | Asynchronous gate to output                           |     | 7.5 |     | 7.5 |     | 7.8 |     | 8.0 |     | 11.0 |     | 13.0 |     | 16.0 |      | 18.0 | ns   |
| Input Register Delays: |                                                       |     |     |     |     |     |     |     |     |     |      |     |      |     |      |      |      |      |
| t <sub>SIRS</sub>      | Input register setup time                             | 1.5 |     | 1.5 |     | 2.0 |     | 2.0 |     | 2.0 |      | 2.0 |      | 2.0 |      | 2.0  |      | ns   |
| t <sub>HIRS</sub>      | Input register hold time                              | 2.5 |     | 2.5 |     | 3.0 |     | 3.0 |     | 3.0 |      | 3.0 |      | 3.0 |      | 4.0  |      | ns   |
| t <sub>ICOSi</sub>     | Input register clock to internal feedback             |     | 3.0 |     | 3.0 |     | 3.0 |     | 3.0 |     | 3.5  |     | 4.5  |     | 6.0  |      | 6.0  | ns   |
| Input Latch Delays:    |                                                       |     |     |     |     |     |     |     |     |     |      |     |      |     |      |      |      |      |
| t <sub>SIL</sub>       | Input latch setup time                                | 1.5 |     | 1.5 |     | 1.5 |     | 2.0 |     | 2.0 |      | 2.0 |      | 2.0 |      | 2.0  |      | ns   |
| t <sub>HIL</sub>       | Input latch hold time                                 | 2.5 |     | 2.5 |     | 2.5 |     | 3.0 |     | 3.0 |      | 3.0 |      | 3.0 |      | 4.0  |      | ns   |
| t <sub>IGOSi</sub>     | Input latch gate to internal feedback                 |     | 3.5 |     | 3.5 |     | 3.8 |     | 4.0 |     | 4.0  |     | 4.0  |     | 4.0  |      | 5.0  | ns   |
| t <sub>PDILi</sub>     | Transparent input latch to internal feedback          |     | 1.5 |     | 1.5 |     | 1.5 |     | 1.5 |     | 2.0  |     | 2.0  |     | 2.0  |      | 2.0  | ns   |

## ispMACH 4A TIMING PARAMETERS OVER OPERATING RANGES<sup>1</sup>

|                   |                                                                                                                                                               | -5  |     | -55 |     | -6  |     | -65  |     | -7   |     | -10  |     | -12  |     | -14  |     | Unit |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|
|                   |                                                                                                                                                               | Min | Max | Min | Max | Min | Max | Min  | Max | Min  | Max | Min  | Max | Min  | Max | Min  | Max |      |
| Frequency:        |                                                                                                                                                               |     |     |     |     |     |     |      |     |      |     |      |     |      |     |      |     |      |
| f <sub>MAXS</sub> | External feedback, D-type, Min of 1/(t <sub>WLS</sub> + t <sub>WHS</sub> ) or 1/(t <sub>SS</sub> + t <sub>COS</sub> )                                         | 143 |     | 133 |     | 125 |     | 118  |     | 95.2 |     | 87.0 |     | 74.1 |     | 60.6 |     | MHz  |
|                   | External feedback, T-type, Min of 1/(t <sub>WLS</sub> + t <sub>WHS</sub> ) or 1/(t <sub>SST</sub> + t <sub>COS</sub> )                                        | 125 |     | 125 |     | 118 |     | 111  |     | 87.0 |     | 80.0 |     | 69.0 |     | 57.1 |     | MHz  |
|                   | Internal feedback (f <sub>CNT</sub> ), D-type, Min of 1/(t <sub>WLS</sub> + t <sub>WHS</sub> ) or 1/(t <sub>SS</sub> + t <sub>COSi</sub> )                    | 182 |     | 167 |     | 160 |     | 154  |     | 125  |     | 118  |     | 95.0 |     | 74.1 |     | MHz  |
|                   | Internal feedback (f <sub>CNT</sub> ), T-type, Min of 1/(t <sub>WLS</sub> + t <sub>WHS</sub> ) or 1/(t <sub>SST</sub> + t <sub>COSi</sub> )                   | 154 |     | 154 |     | 148 |     | 143  |     | 111  |     | 105  |     | 87.0 |     | 69.0 |     | MHz  |
|                   | No feedback <sup>2</sup> , Min of 1/(t <sub>WLS</sub> + t <sub>WHS</sub> ), 1/(t <sub>SS</sub> + t <sub>HS</sub> ) or 1/(t <sub>SST</sub> + t <sub>HS</sub> ) | 250 |     | 250 |     | 200 |     | 200  |     | 154  |     | 125  |     | 100  |     | 83.3 |     | MHz  |
| f <sub>MAXA</sub> | External feedback, D-type, Min of 1/(t <sub>WLA</sub> + t <sub>WHA</sub> ) or 1/(t <sub>SA</sub> + t <sub>COA</sub> )                                         | 111 |     | 111 |     | 108 |     | 100  |     | 83.3 |     | 66.7 |     | 55.6 |     | 43.5 |     | MHz  |
|                   | External feedback, T-type, Min of 1/(t <sub>WLA</sub> + t <sub>WHA</sub> ) or 1/(t <sub>SAT</sub> + t <sub>COA</sub> )                                        | 105 |     | 105 |     | 102 |     | 95.2 |     | 76.9 |     | 62.5 |     | 52.6 |     | 41.7 |     | MHz  |
|                   | Internal feedback (f <sub>CNTA</sub> ), D-type, Min of 1/(t <sub>WLA</sub> + t <sub>WHA</sub> ) or 1/(t <sub>SA</sub> + t <sub>COAi</sub> )                   | 133 |     | 133 |     | 125 |     | 125  |     | 105  |     | 83.3 |     | 66.7 |     | 50.0 |     | MHz  |
|                   | Internal feedback (f <sub>CNTA</sub> ), T-type, Min of 1/(t <sub>WLA</sub> + t <sub>WHA</sub> ) or 1/(t <sub>SAT</sub> + t <sub>COAi</sub> )                  | 125 |     | 125 |     | 125 |     | 118  |     | 95.2 |     | 76.9 |     | 62.5 |     | 47.6 |     | MHz  |
|                   | No feedback <sup>2</sup> , Min of 1/(t <sub>WLA</sub> + t <sub>WHA</sub> ), 1/(t <sub>SA</sub> + t <sub>HA</sub> ) or 1/(t <sub>SAT</sub> + t <sub>HA</sub> ) | 167 |     | 167 |     | 143 |     | 143  |     | 125  |     | 100  |     | 62.5 |     | 55.6 |     | MHz  |
| f <sub>MAXI</sub> | Maximum input register frequency, Min of 1/(t <sub>WIRH</sub> + t <sub>WIRL</sub> ) or 1/(t <sub>SIRS</sub> + t <sub>HIRS</sub> )                             | 167 |     | 167 |     | 143 |     | 143  |     | 125  |     | 100  |     | 83.3 |     | 83.3 |     | MHz  |

### Notes:

- See "Switching Test Circuit" document on the Literature Download page of the Lattice web site.
- This parameter does not apply to flip-flops in the emulated mode since the feedback path is required for emulation.

## CAPACITANCE<sup>1</sup>

| Parameter Symbol | Parameter Description | Test Conditions        |                           | Typ | Unit |
|------------------|-----------------------|------------------------|---------------------------|-----|------|
| $C_{IN}$         | Input capacitance     | $V_{IN}=2.0\text{ V}$  | 3.3 V or 5 V, 25°C, 1 MHz | 6   | pF   |
| $C_{I/O}$        | Output capacitance    | $V_{OUT}=2.0\text{ V}$ | 3.3 V or 5 V, 25°C, 1 MHz | 8   | pF   |

### Note:

- These parameters are not 100% tested, but are calculated at initial characterization and at any time the design is modified where this parameter may be affected.

## $I_{CC}$ vs. FREQUENCY

These curves represent the typical power consumption for a particular device at system frequency. The selected “typical” pattern is a 16-bit up-down counter. This pattern fills the device and exercises every macrocell. Maximum frequency shown uses internal feedback and a D-type register. Power/Speed are optimized to obtain the highest counter frequency and the lowest power. The highest frequency (LSBs) is placed in common PAL blocks, which are set to high power. The lowest frequency signals (MSBs) are placed in a common PAL block and set to lowest power.

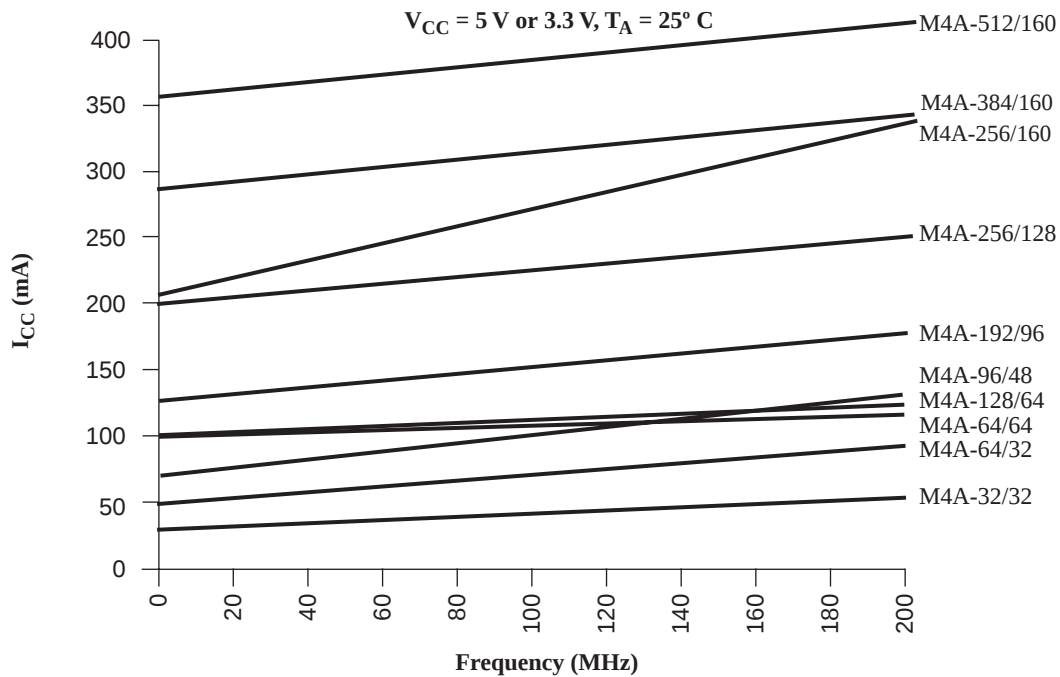


Figure 19. ispMACH 4A  $I_{CC}$  Curves at High Speed Mode

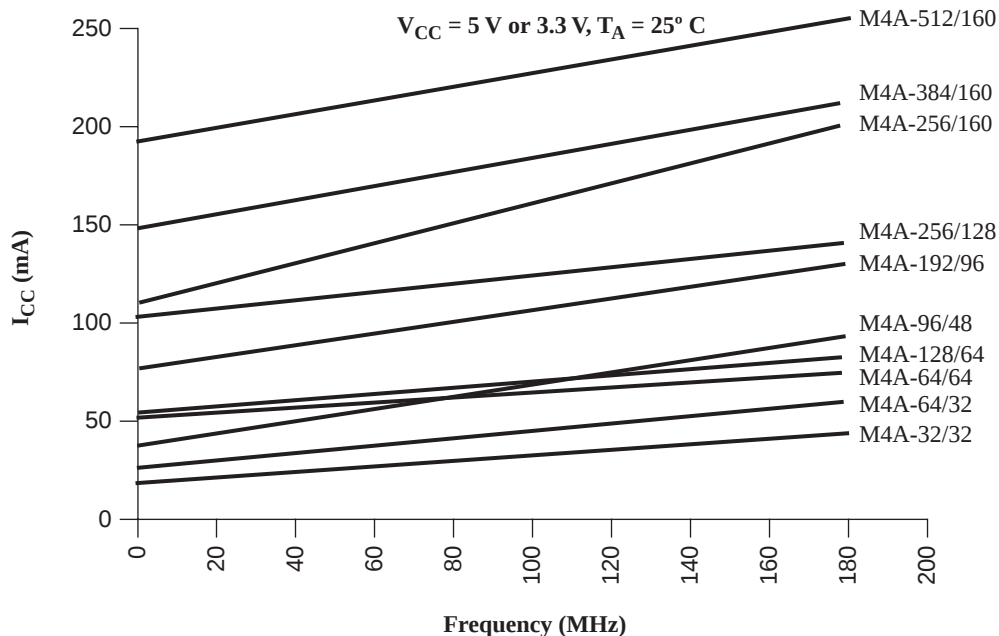
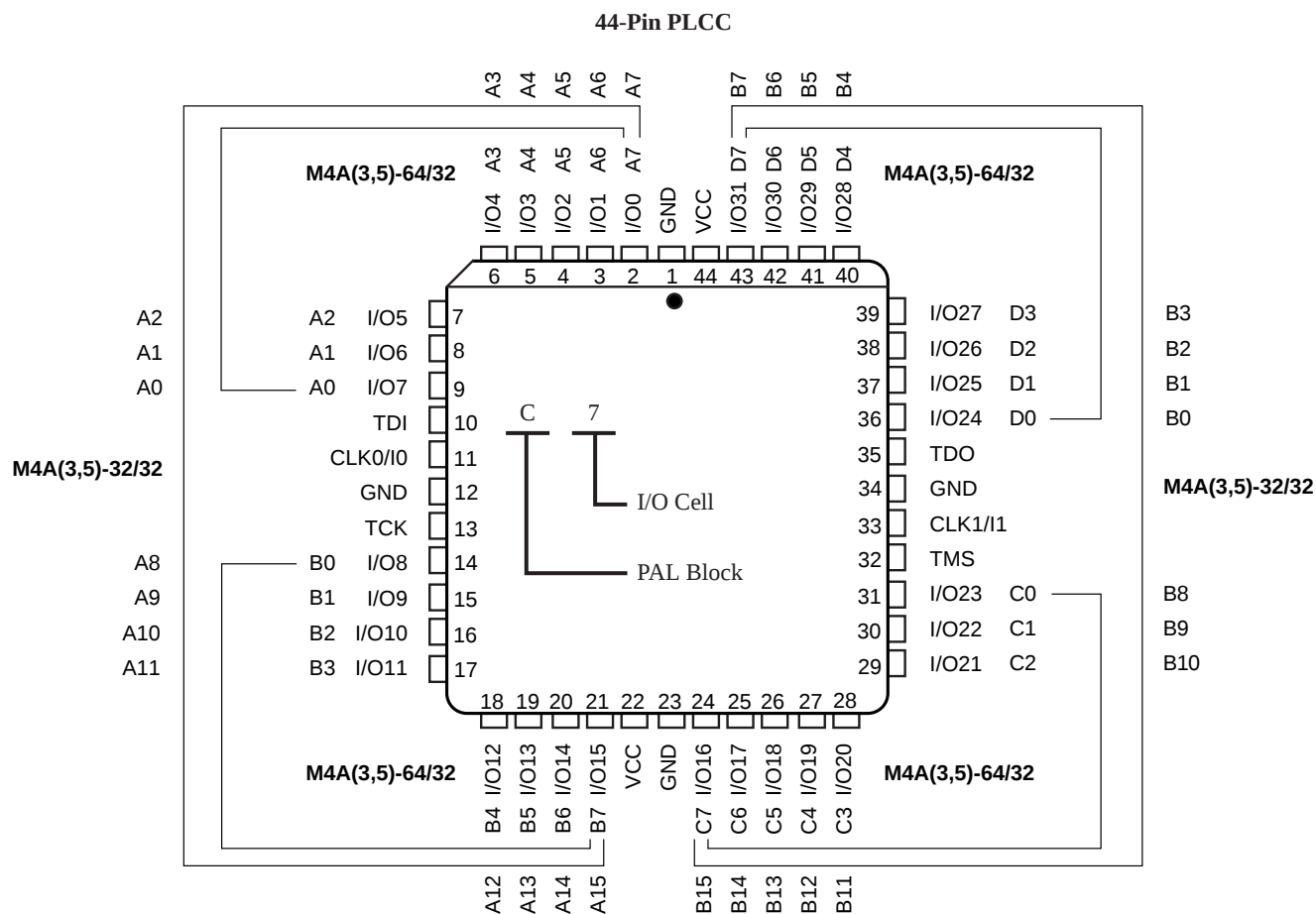


Figure 20. ispMACH 4A  $I_{CC}$  Curves at Low Power Mode

## 44-PIN PLCC CONNECTION DIAGRAM (M4A(3,5)-32/32 AND M4A(3,5)-64/32)

### Top View



17466G-026

## PIN DESIGNATIONS

CLK/I = Clock or Input

GND = Ground

I/O = Input/Output

V<sub>CC</sub> = Supply Voltage

TDI = Test Data In

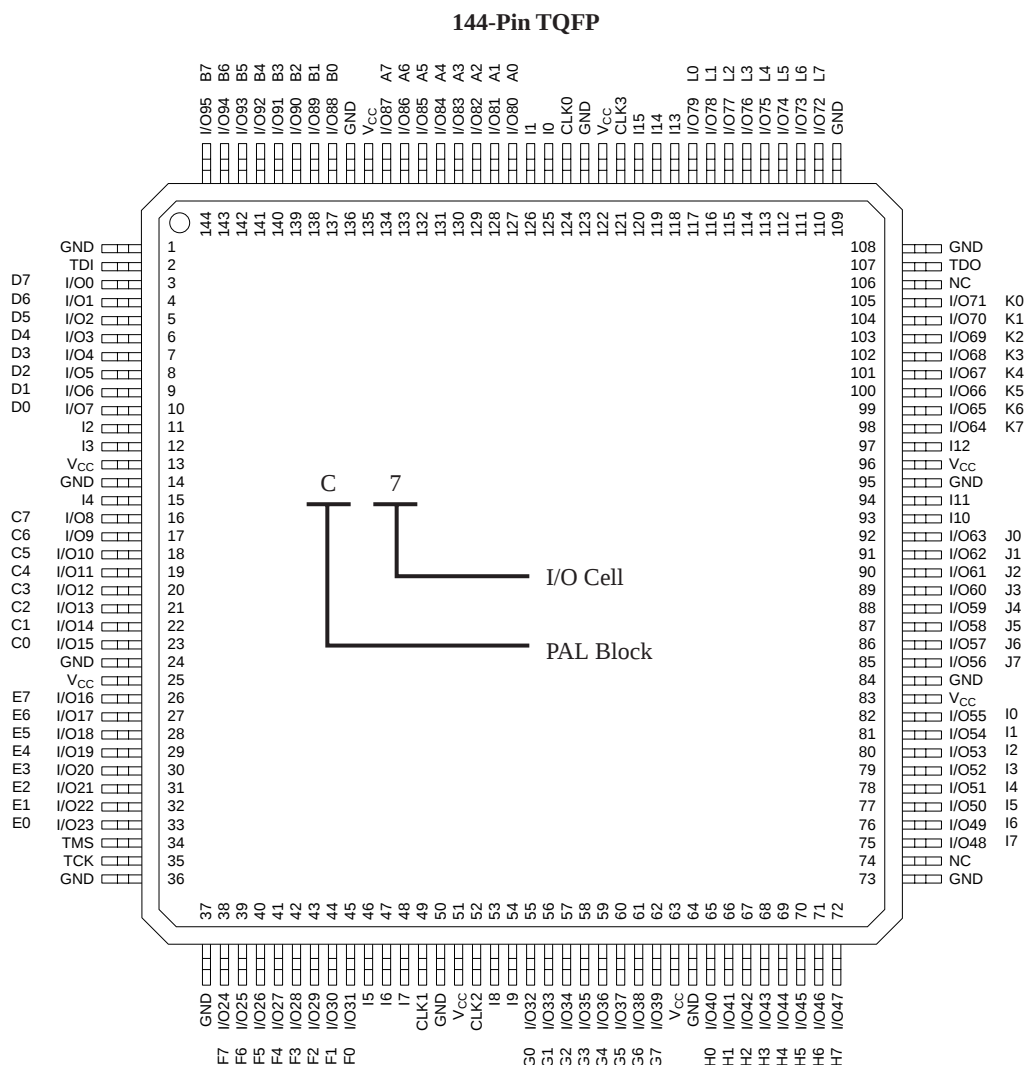
TCK = Test Clock

TMS = Test Mode Select

TDO = Test Data Out

## 144-PIN TQFP CONNECTION DIAGRAM (M4A(3,5)-192/96)

### Top View



17466G-033

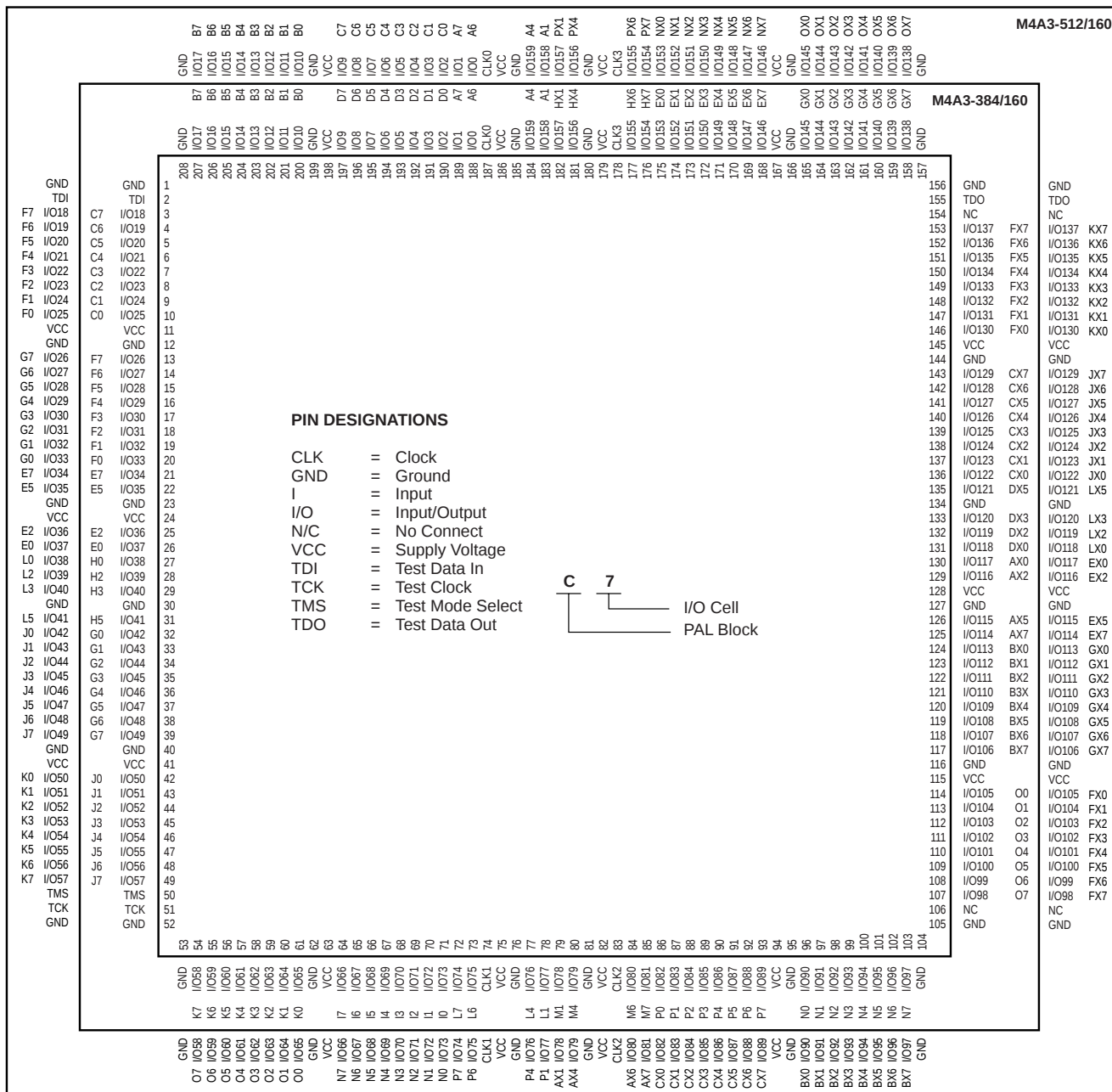
## PIN DESIGNATIONS

- CLK = Clock
- GND = Ground
- I = Input
- I/O = Input/Output
- V<sub>CC</sub> = Supply Voltage
- TDI = Test Data In
- TCK = Test Clock
- TMS = Test Mode Select
- TDO = Test Data Out

# 208-PIN PQFP CONNECTION DIAGRAM (M4A3-384/160 AND M4A3-512/160)

## Top View

### 208-Pin PQFP



17466Ga-044

## 256-BALL BGA CONNECTION DIAGRAM - (M4A3-384/192)

### Bottom View

#### 256-Ball BGA

|   | 20          | 19           | 18           | 17           | 16                                                                                                                                                                                                                                                                                                                                                                                              | 15           | 14           | 13           | 12           | 11           | 10           | 9             | 8             | 7             | 6             | 5             | 4            | 3            | 2            | 1            |              |              |   |
|---|-------------|--------------|--------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|--------------|--------------|---|
| A | GND         | I/O11<br>FX7 | GND          | I/O44<br>FX6 | I/O58<br>CX6                                                                                                                                                                                                                                                                                                                                                                                    | GND          | I/O70<br>CX2 | I/O76<br>DX6 | GND          | GND          | GND          | GND           | I/O108<br>AX5 | I/O116<br>BX0 | GND           | I/O128<br>BX7 | I/O134<br>O3 | GND          | GND          | GND          | A            |              |   |
| B | GND         | I/O12<br>GX7 | I/O28<br>FX5 | I/O45<br>FX3 | I/O59<br>CX7                                                                                                                                                                                                                                                                                                                                                                                    | I/O64<br>CX5 | I/O71<br>CX3 | I/O77<br>DX7 | I/O84<br>DX5 | I/O90<br>DX2 | I/O96<br>AX0 | I/O102<br>AX3 | I/O109<br>AX6 | I/O117<br>BX1 | I/O122<br>BX4 | I/O129<br>BX6 | I/O135<br>O4 | I/O148<br>O6 | I/O164<br>O7 | GND          | B            |              |   |
| C | I/O0<br>GX6 | I/O13<br>GX5 | VCC          | I/O46<br>FX4 | I/O60<br>FX2                                                                                                                                                                                                                                                                                                                                                                                    | I/O65<br>FX1 | I/O72<br>CX4 | I/O78<br>CX0 | I/O85<br>DX4 | I/O91<br>DX1 | I/O97<br>AX1 | I/O103<br>AX4 | I/O110<br>BX2 | I/O118<br>BX5 | I/O123<br>O0  | I/O130<br>O1  | I/O136<br>O5 | VCC          | I/O165<br>N7 | I/O181<br>N6 | C            |              |   |
| D | I/O1<br>EX7 | I/O14<br>GX3 | I/O29<br>GX4 | VCC          | VCC                                                                                                                                                                                                                                                                                                                                                                                             | I/O66<br>FX0 | VCC          | I/O79<br>CX1 | I/O86<br>DX3 | I/O92<br>DX0 | I/O98<br>AX2 | I/O104<br>AX7 | I/O111<br>B3X | VCC           | I/O124<br>O2  | VCC           | VCC          | I/O149<br>N4 | I/O166<br>N5 | I/O182<br>P7 | D            |              |   |
| E | I/O2<br>EX0 | I/O15<br>GX0 | I/O30<br>GX1 | TDI          | <div><div>PIN DESIGNATIONS</div><div><div>CLK = Clock</div><div>GND = Ground</div><div>I = Input</div><div>I/O = Input/Output</div><div>N/C = No Connect</div><div>VCC = Supply Voltage</div><div>TDI = Test Data In</div><div>TCK = Test Clock</div><div>TMS = Test Mode Select</div><div>TDO = Test Data Out</div></div><div><div>C7</div><div>I/O Cell</div><div>PAL Block</div></div></div> |              |              |              |              |              |              |               |               |               |               |               |              |              | TDO          | I/O150<br>N2 | I/O167<br>N3 | I/O183<br>P6 | E |
| F | GND         | I/O16<br>EX1 | I/O31<br>EX6 | I/O47<br>GX2 |                                                                                                                                                                                                                                                                                                                                                                                                 |              |              |              |              |              |              |               |               |               |               |               |              |              | I/O137<br>N1 | I/O151<br>N0 | I/O168<br>P5 | GND          | F |
| G | I/O3<br>HX6 | I/O17<br>EX4 | I/O32<br>EX5 | VCC          |                                                                                                                                                                                                                                                                                                                                                                                                 |              |              |              |              |              |              |               |               |               |               |               |              |              | VCC          | I/O152<br>P4 | I/O169<br>P3 | I/O184<br>M7 | G |
| H | GND         | I/O18<br>HX5 | I/O33<br>EX2 | I/O48<br>EX3 |                                                                                                                                                                                                                                                                                                                                                                                                 |              |              |              |              |              |              |               |               |               |               |               |              |              | I/O138<br>P2 | I/O153<br>P1 | I/O170<br>P0 | GND          | H |
| J | I/O4<br>HX0 | I/O19<br>HX1 | I/O34<br>HX4 | I/O49<br>HX7 |                                                                                                                                                                                                                                                                                                                                                                                                 |              |              |              |              |              |              |               |               |               |               |               |              |              | I/O139<br>M6 | I/O154<br>M5 | I/O171<br>M4 | I/O185<br>M3 | J |
| K | GND         | CLK3         | I/O35<br>HX2 | I/O50<br>HX3 |                                                                                                                                                                                                                                                                                                                                                                                                 |              |              |              |              |              |              |               |               |               |               |               |              |              | I/O140<br>M0 | I/O155<br>M1 | CLK2         | I/O186<br>M2 | K |
| L | I/O5<br>A2  | CLK0         | I/O36<br>A0  | I/O51<br>A1  |                                                                                                                                                                                                                                                                                                                                                                                                 |              |              |              |              |              |              |               |               |               |               |               |              |              | I/O141<br>L3 | I/O156<br>L4 | CLK1         | GND          | L |
| M | I/O6<br>A4  | I/O20<br>A3  | I/O37<br>A5  | I/O52<br>A6  |                                                                                                                                                                                                                                                                                                                                                                                                 |              |              |              |              |              |              |               |               |               |               |               |              |              | I/O142<br>L6 | I/O157<br>L5 | I/O172<br>L0 | I/O187<br>L1 | M |
| N | GND         | I/O21<br>A7  | I/O38<br>D0  | I/O53<br>D1  | I/O143<br>I5                                                                                                                                                                                                                                                                                                                                                                                    | I/O158<br>I0 | I/O173<br>L7 | GND          | N            |              |              |               |               |               |               |               |              |              |              |              |              |              |   |
| P | I/O7<br>D2  | I/O22<br>D3  | I/O39<br>D4  | VCC          | VCC                                                                                                                                                                                                                                                                                                                                                                                             | I/O159<br>I4 | I/O174<br>I1 | I/O188<br>L2 | P            |              |              |               |               |               |               |               |              |              |              |              |              |              |   |
| R | GND         | I/O23<br>D5  | I/O40<br>D6  | I/O54<br>D7  | I/O144<br>K5                                                                                                                                                                                                                                                                                                                                                                                    | I/O160<br>K0 | I/O175<br>I3 | GND          | R            |              |              |               |               |               |               |               |              |              |              |              |              |              |   |
| T | I/O8<br>B3  | I/O24<br>B0  | I/O41<br>B7  | TCK          | TMS                                                                                                                                                                                                                                                                                                                                                                                             | I/O161<br>K4 | I/O176<br>K1 | I/O189<br>I2 | T            |              |              |               |               |               |               |               |              |              |              |              |              |              |   |
| U | I/O9<br>B4  | I/O25<br>B1  | I/O42<br>B6  | VCC          | VCC                                                                                                                                                                                                                                                                                                                                                                                             | I/O67<br>C0  | VCC          | I/O80<br>F0  | I/O87<br>E5  | I/O93<br>E2  | I/O99<br>H2  | I/O105<br>H5  | I/O112<br>G0  | VCC           | I/O125<br>J1  | VCC           | VCC          | I/O162<br>K7 | I/O177<br>K2 | I/O190<br>I6 | U            |              |   |
| V | I/O10<br>B5 | I/O26<br>B2  | VCC          | I/O55<br>C5  | I/O61<br>C2                                                                                                                                                                                                                                                                                                                                                                                     | I/O68<br>C1  | I/O73<br>F4  | I/O81<br>F1  | I/O88<br>E4  | I/O94<br>E1  | I/O100<br>H1 | I/O106<br>H4  | I/O113<br>G1  | I/O119<br>G4  | I/O126<br>J0  | I/O131<br>J2  | I/O145<br>J5 | VCC          | I/O178<br>K3 | I/O191<br>I7 | V            |              |   |
| W | GND         | I/O27<br>C7  | I/O43<br>C6  | I/O56<br>C3  | I/O62<br>F7                                                                                                                                                                                                                                                                                                                                                                                     | I/O69<br>F5  | I/O74<br>F3  | I/O82<br>E7  | I/O89<br>E3  | I/O95<br>E0  | I/O101<br>H0 | I/O107<br>H3  | I/O114<br>H7  | I/O120<br>G3  | I/O127<br>G5  | I/O132<br>G7  | I/O146<br>J4 | I/O163<br>J6 | I/O179<br>J7 | GND          | W            |              |   |
| Y | GND         | GND          | GND          | I/O57<br>C4  | I/O63<br>F6                                                                                                                                                                                                                                                                                                                                                                                     | GND          | I/O75<br>F2  | I/O83<br>E6  | GND          | GND          | GND          | GND           | I/O115<br>H6  | I/O121<br>G2  | GND           | I/O133<br>G6  | I/O147<br>J3 | GND          | I/O180<br>K6 | GND          | Y            |              |   |
|   | 20          | 19           | 18           | 17           | 16                                                                                                                                                                                                                                                                                                                                                                                              | 15           | 14           | 13           | 12           | 11           | 10           | 9             | 8             | 7             | 6             | 5             | 4            | 3            | 2            | 1            |              |              |   |

17466G-046

## 256-BALL fpBGA CONNECTION DIAGRAM (M4A3-384/192)

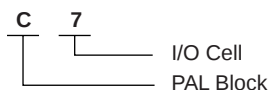
### Bottom View

#### 256-Ball fpBGA

|   | 16            | 15            | 14            | 13            | 12            | 11            | 10            | 9             | 8             | 7           | 6           | 5           | 4           | 3           | 2           | 1           |   |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---|
| A | I/O175<br>FX7 | I/O181<br>GX5 | I/O180<br>GX4 | I/O177<br>GX1 | I/O166<br>EX6 | I/O164<br>EX4 | I/O191<br>HX7 | I/O186<br>HX2 | I/O1<br>A1    | I/O3<br>A3  | CLK0        | I/O25<br>D1 | I/O29<br>D5 | I/O31<br>D7 | I/O10<br>B2 | I/O12<br>B4 | A |
| B | I/O173<br>FX5 | I/O174<br>FX6 | I/O182<br>GX6 | I/O179<br>GX3 | I/O167<br>EX7 | I/O165<br>EX5 | I/O160<br>EX0 | I/O187<br>HX3 | I/O0<br>A0    | I/O5<br>A5  | I/O7<br>A7  | I/O26<br>D2 | I/O8<br>B0  | I/O11<br>B3 | I/O13<br>B5 | N/C         | B |
| C | I/O171<br>FX3 | I/O172<br>FX4 | N/C           | I/O183<br>GX7 | I/O178<br>GX2 | I/O162<br>EX2 | I/O163<br>EX3 | I/O189<br>HX5 | I/O184<br>HX0 | I/O6<br>A6  | I/O28<br>D4 | I/O30<br>D6 | I/O15<br>B7 | I/O14<br>B6 | TDI         | I/O23<br>C7 | C |
| D | I/O150<br>CX6 | I/O151<br>CX7 | TDO           | GND           | GND           | VCC           | GND           | VCC           | GND           | GND         | VCC         | GND         | VCC         | I/O9<br>B1  | I/O22<br>C6 | I/O21<br>C5 | D |
| E | I/O148<br>CX4 | N/C           | I/O170<br>FX2 | VCC           | I/O168<br>FX0 | 169<br>FX1    | I/O190<br>HX6 | CLK3          | I/O188<br>HX4 | I/O2<br>A2  | I/O24<br>D0 | N/C         | GND         | I/O20<br>C4 | I/O19<br>C3 | I/O47<br>F7 | E |
| F | I/O144<br>CX0 | I/O149<br>CX5 | I/O147<br>CX3 | GND           | I/O146<br>CX2 | I/O145<br>CX1 | I/O176<br>GX0 | I/O161<br>EX1 | I/O185<br>HX1 | I/O4<br>A4  | I/O27<br>D3 | I/O18<br>C2 | VCC         | I/O16<br>C0 | I/O46<br>F6 | I/O45<br>F5 | F |
| G | I/O155<br>DX3 | I/O158<br>DX6 | I/O157<br>DX5 | VCC           | I/O156<br>DX4 | I/O159<br>DX7 | VCC           | GND           | GND           | VCC         | I/O17<br>C1 | I/O44<br>F4 | GND         | I/O42<br>F2 | I/O41<br>F1 | I/O39<br>E7 | G |
| H | I/O152<br>DX0 | I/O154<br>DX2 | I/O153<br>DX1 | GND           | I/O128<br>AX0 | I/O129<br>AX1 | GND           | VCC           | VCC           | GND         | I/O43<br>F3 | I/O40<br>F0 | VCC         | I/O36<br>E4 | I/O35<br>E3 | I/O34<br>E2 | H |
| J | I/O130<br>AX2 | I/O131<br>AX3 | I/O132<br>AX4 | GND           | I/O134<br>AX6 | I/O133<br>AX5 | GND           | VCC           | VCC           | GND         | I/O38<br>E6 | I/O37<br>E5 | GND         | I/O57<br>H1 | I/O56<br>H0 | I/O58<br>H2 | J |
| K | I/O135<br>AX7 | I/O136<br>BX0 | I/O137<br>BX1 | VCC           | I/O139<br>BX3 | I/O138<br>BX2 | VCC           | GND           | GND           | VCC         | I/O33<br>E1 | I/O32<br>E0 | VCC         | I/O63<br>H7 | I/O62<br>H6 | I/O48<br>G0 | K |
| L | I/O140<br>BX4 | I/O141<br>BX5 | I/O143<br>BX7 | GND           | I/O114<br>O2  | I/O142<br>BX6 | I/O98<br>M2   | I/O91<br>L3   | I/O67<br>I3   | I/O69<br>I5 | I/O60<br>H4 | I/O59<br>H3 | GND         | I/O51<br>G3 | I/O52<br>G4 | I/O49<br>G1 | L |
| M | I/O112<br>O0  | I/O113<br>O1  | I/O115<br>O3  | GND           | I/O123<br>P3  | I/O121<br>P1  | I/O100<br>M4  | I/O90<br>L2   | I/O66<br>I2   | I/O80<br>K0 | I/O83<br>K3 | I/O61<br>H5 | VCC         | I/O76<br>J4 | I/O55<br>G7 | I/O50<br>G2 | M |
| N | I/O116<br>O4  | I/O117<br>O5  | I/O119<br>O7  | VCC           | GND           | VCC           | GND           | VCC           | GND           | GND         | VCC         | GND         | GND         | TCK         | I/O72<br>J0 | I/O53<br>G5 | N |
| P | I/O118<br>O6  | I/O109<br>N5  | I/O110<br>N6  | I/O111<br>N7  | I/O124<br>P4  | I/O122<br>P2  | I/O101<br>M5  | I/O89<br>L1   | I/O93<br>L5   | I/O94<br>L6 | I/O71<br>I7 | I/O84<br>K4 | I/O87<br>K7 | TMS         | I/O73<br>J1 | I/O54<br>G6 | P |
| R | I/O108<br>N4  | I/O107<br>N3  | I/O104<br>N0  | I/O127<br>P7  | I/O120<br>P0  | I/O102<br>M6  | I/O99<br>M3   | I/O96<br>M0   | I/O92<br>L4   | I/O64<br>I0 | I/O68<br>I4 | I/O81<br>K1 | I/O85<br>K5 | I/O79<br>J7 | I/O75<br>J3 | I/O74<br>J2 | R |
| T | I/O106<br>N2  | I/O105<br>N1  | I/O126<br>P6  | I/O125<br>P5  | I/O103<br>M7  | CLK2          | I/O97<br>M1   | I/O88<br>L0   | CLK1          | I/O95<br>L7 | I/O65<br>I1 | I/O70<br>I6 | I/O82<br>K2 | I/O86<br>K6 | I/O78<br>J6 | I/O77<br>J5 | T |
|   | 16            | 15            | 14            | 13            | 12            | 11            | 10            | 9             | 8             | 7           | 6           | 5           | 4           | 3           | 2           | 1           |   |

#### PIN DESIGNATIONS

CLK = Clock  
 GND = Ground  
 I = Input  
 I/O = Input/Output  
 N/C = No Connect  
 VCC = Supply Voltage  
 TDI = Test Data In  
 TCK = Test Clock  
 TMS = Test Mode Select  
 TDO = Test Data Out



m4a3.384.192\_256bga

## 256-BALL fpBGA CONNECTION DIAGRAM (M4A3-512/192)

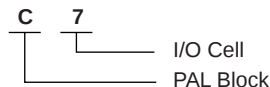
### Bottom View

#### 256-Ball fpBGA

|   | 16            | 15            | 14            | 13            | 12            | 11            | 10            | 9             | 8             | 7           | 6           | 5           | 4           | 3           | 2           | 1           |   |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---|
| A | I/O159<br>KX7 | I/O181<br>OX5 | I/O180<br>OX4 | I/O177<br>OX1 | I/O174<br>NX6 | I/O172<br>NX4 | I/O191<br>PX7 | I/O186<br>PX2 | I/O1<br>A1    | I/O3<br>A3  | CLK0        | I/O17<br>C1 | I/O21<br>C5 | I/O23<br>C7 | I/O10<br>B2 | I/O12<br>B4 | A |
| B | I/O157<br>KX5 | I/O158<br>KX6 | I/O182<br>OX6 | I/O179<br>OX3 | I/O175<br>NX7 | I/O173<br>NX5 | I/O168<br>NX0 | I/O187<br>PX3 | I/O0<br>A0    | I/O5<br>A5  | I/O7<br>A7  | I/O18<br>C2 | I/O8<br>B0  | I/O11<br>B3 | I/O13<br>B5 | N/C         | B |
| C | I/O155<br>KX3 | I/O156<br>KX4 | N/C           | I/O183<br>OX7 | I/O178<br>OX2 | I/O170<br>NX2 | I/O171<br>NX3 | I/O189<br>PX5 | I/O184<br>PX0 | I/O6<br>A6  | I/O20<br>C4 | I/O22<br>C6 | I/O15<br>B7 | I/O14<br>B6 | TDI         | I/O39<br>F7 | C |
| D | I/O150<br>JX6 | I/O151<br>JX7 | TDO           | GND           | GND           | VCC           | GND           | VCC           | GND           | GND         | VCC         | GND         | VCC         | I/O9<br>B1  | I/O38<br>F6 | I/O37<br>F5 | D |
| E | I/O148<br>JX4 | N/C           | I/O154<br>KX2 | VCC           | I/O152<br>KX0 | I/O153<br>KX1 | I/O190<br>PX6 | CLK3          | I/O188<br>PX4 | I/O2<br>A2  | I/O16<br>C0 | N/C         | GND         | I/O36<br>F4 | I/O35<br>F3 | I/O47<br>G7 | E |
| F | I/O144<br>JX0 | I/O149<br>JX5 | I/O147<br>JX3 | GND           | I/O146<br>JX2 | I/O145<br>JX1 | I/O176<br>OX0 | I/O169<br>NX1 | I/O185<br>PX1 | I/O4<br>A4  | I/O19<br>C3 | I/O34<br>F2 | VCC         | I/O32<br>F0 | I/O46<br>G6 | I/O45<br>G5 | F |
| G | I/O163<br>LX3 | I/O166<br>LX6 | I/O165<br>LX5 | VCC           | I/O164<br>LX4 | I/O167<br>LX7 | VCC           | GND           | GND           | VCC         | I/O33<br>F1 | I/O44<br>G4 | GND         | I/O42<br>G2 | I/O41<br>G1 | I/O31<br>E7 | G |
| H | I/O160<br>LX0 | I/O162<br>LX2 | I/O161<br>LX1 | GND           | I/O120<br>EX0 | I/O121<br>EX1 | GND           | VCC           | VCC           | GND         | I/O43<br>G3 | I/O40<br>G0 | VCC         | I/O28<br>E4 | I/O27<br>E3 | I/O26<br>E2 | H |
| J | I/O122<br>EX2 | I/O123<br>EX3 | I/O124<br>EX4 | GND           | I/O126<br>EX6 | I/O125<br>EX5 | GND           | VCC           | VCC           | GND         | I/O30<br>E6 | I/O29<br>E5 | GND         | I/O65<br>L1 | I/O64<br>L0 | I/O66<br>L2 | J |
| K | I/O127<br>EX7 | I/O136<br>GX0 | I/O137<br>GX1 | VCC           | I/O139<br>GX3 | I/O138<br>GX2 | VCC           | GND           | GND           | VCC         | I/O25<br>E1 | I/O24<br>E0 | VCC         | I/O71<br>L7 | I/O70<br>L6 | I/O48<br>J0 | K |
| L | I/O140<br>GX4 | I/O141<br>GX5 | I/O143<br>GX7 | GND           | I/O130<br>FX2 | I/O142<br>GX6 | I/O98<br>AX2  | I/O91<br>P3   | I/O75<br>N3   | I/O77<br>N5 | I/O68<br>L4 | I/O67<br>L3 | GND         | I/O51<br>J3 | I/O52<br>J4 | I/O49<br>J1 | L |
| M | I/O128<br>FX0 | I/O129<br>FX1 | I/O131<br>FX3 | GND           | I/O115<br>CX3 | I/O113<br>CX1 | I/O100<br>AX4 | I/O90<br>P2   | I/O74<br>N2   | I/O80<br>O0 | I/O83<br>O3 | I/O69<br>L5 | VCC         | I/O60<br>K4 | I/O55<br>J7 | I/O50<br>J2 | M |
| N | I/O132<br>FX4 | I/O133<br>FX5 | I/O135<br>FX7 | VCC           | GND           | VCC           | GND           | VCC           | GND           | GND         | VCC         | GND         | GND         | TCK         | I/O56<br>K0 | I/O53<br>J5 | N |
| P | I/O134<br>FX6 | I/O109<br>BX5 | I/O110<br>BX6 | I/O111<br>BX7 | I/O116<br>CX4 | I/O114<br>CX2 | I/O101<br>AX5 | I/O89<br>P1   | I/O93<br>P5   | I/O94<br>P6 | I/O79<br>N7 | I/O84<br>O4 | I/O87<br>O7 | TMS         | I/O57<br>K1 | I/O54<br>J6 | P |
| R | I/O108<br>BX4 | I/O107<br>BX3 | I/O104<br>BX0 | I/O119<br>CX7 | I/O112<br>CX0 | I/O102<br>AX6 | I/O99<br>AX3  | I/O96<br>AX0  | I/O92<br>P4   | I/O72<br>N0 | I/O76<br>N4 | I/O81<br>O1 | I/O85<br>O5 | I/O63<br>K7 | I/O59<br>K3 | I/O58<br>K2 | R |
| T | I/O106<br>BX2 | I/O105<br>BX1 | I/O118<br>CX6 | I/O117<br>CX5 | I/O103<br>AX7 | CLK2          | I/O97<br>AX1  | I/O88<br>P0   | CLK1          | I/O95<br>P7 | I/O73<br>N1 | I/O78<br>N6 | I/O82<br>O2 | I/O86<br>O6 | I/O62<br>K6 | I/O61<br>K5 | T |
|   | 16            | 15            | 14            | 13            | 12            | 11            | 10            | 9             | 8             | 7           | 6           | 5           | 4           | 3           | 2           | 1           |   |

#### PIN DESIGNATIONS

CLK = Clock  
 GND = Ground  
 I = Input  
 I/O = Input/Output  
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 VCC = Supply Voltage  
 TDI = Test Data In  
 TCK = Test Clock  
 TMS = Test Mode Select  
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m4a3.512.192\_256bga

# 388-BALL fpBGA CONNECTION DIAGRAM (M4A3-512/256)

## Bottom View

### 388-Ball fpBGA

|    | 22         | 21         | 20         | 19         | 18         | 17         | 16         | 15         | 14         | 13         | 12         | 11         | 10        | 9         | 8         | 7         | 6         | 5         | 4         | 3         | 2         | 1        |    |
|----|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----|
| A  | GND        | I/O243 OX3 | I/O240 OX0 | I/O241 OX1 | I/O236 NX4 | I/O231 MX7 | I/O228 MX4 | I/O226 MX2 | I/O255 PX7 | I/O251 PX3 | I/O248 PX0 | I/O0 A0    | I/O5 A5   | I/O6 A6   | I/O27 D3  | I/O30 D6  | I/O17 C1  | I/O22 C6  | I/O8 B0   | I/O10 B2  | N/C       | GND      | A  |
| B  | N/C        | GND        | I/O245 OX5 | I/O242 OX2 | I/O238 NX6 | I/O234 NX2 | I/O232 NX0 | I/O229 MX5 | I/O224 MX0 | I/O253 PX5 | I/O249 PX1 | I/O2 A2    | CLK0      | I/O26 D2  | I/O29 D5  | I/O31 D7  | I/O20 C4  | I/O9 B1   | I/O12 B4  | I/O13 B5  | GND       | TDI      | B  |
| C  | I/O213 KX5 | TDO        | GND        | I/O247 OX7 | I/O244 OX4 | I/O239 NX7 | I/O235 NX3 | I/O230 MX6 | I/O227 MX3 | CLK3       | I/O250 PX2 | I/O1 A1    | I/O7 A7   | I/O25 D1  | I/O16 C0  | I/O18 C2  | I/O23 C7  | I/O11 B3  | I/O15 B7  | GND       | I/O47 F7  | I/O44 F4 | C  |
| D  | I/O210 KX2 | I/O212 KX4 | I/O215 KX7 | GND        | I/O246 OX6 | VCC        | I/O237 NX5 | I/O233 NX1 | VCC        | I/O254 PX6 | VCC        | I/O3 A3    | I/O24 D0  | VCC       | I/O19 C3  | I/O21 C5  | VCC       | I/O14 B6  | GND       | I/O46 F6  | I/O43 F3  | I/O41 F1 | D  |
| E  | I/O207 JX7 | I/O209 KX1 | I/O211 KX3 | I/O214 KX6 |            |            |            |            |            |            |            |            |           |           |           |           |           |           | I/O45 F5  | I/O42 F2  | I/O40 F0  | I/O54 G6 | E  |
| F  | I/O203 JX3 | I/O205 JX5 | I/O208 KX0 | VCC        |            |            |            |            |            |            |            |            |           |           |           |           |           |           | VCC       | I/O55 G7  | I/O52 G4  | I/O50 G2 | F  |
| G  | I/O200 JX0 | I/O202 JX2 | I/O204 JX4 | I/O206 JX6 |            |            | VCC        | VCC        | N/C        | I/O225 MX1 | I/O252 PX4 | I/O4 A4    | I/O28 D4  | N/C       | VCC       | VCC       |           |           | I/O53 G5  | I/O51 G3  | I/O49 G1  | I/O39 E7 | G  |
| H  | I/O221 LX5 | I/O222 LX6 | I/O223 LX7 | I/O201 JX1 |            |            | VCC        | N/C        | GND        | GND        | GND        | GND        | GND       | GND       | N/C       | VCC       |           |           | I/O48 G0  | I/O38 E6  | I/O37 E5  | I/O36 E4 | H  |
| J  | I/O218 LX2 | I/O219 LX3 | I/O220 LX4 | VCC        |            |            | N/C        | GND        | GND        | GND        | GND        | GND        | GND       | GND       | GND       | N/C       |           |           | VCC       | I/O35 E3  | I/O34 E2  | I/O32 E0 | J  |
| K  | I/O197 IX5 | I/O198 IX6 | I/O199 IX7 | I/O216 LX0 |            |            | I/O217 LX1 | GND        | GND        | GND        | GND        | GND        | GND       | GND       | GND       | I/O33 E1  |           |           | I/O63 H7  | I/O62 H6  | I/O61 H5  | I/O60 H4 | K  |
| L  | I/O192 IX0 | I/O194 IX2 | I/O195 IX3 | I/O196 IX4 |            |            | I/O193 IX1 | GND        | GND        | GND        | GND        | GND        | GND       | GND       | GND       | I/O58 H2  |           |           | VCC       | I/O59 H3  | I/O57 H1  | I/O56 H0 | L  |
| M  | I/O184 HX0 | I/O185 HX1 | I/O187 HX3 | VCC        |            |            | I/O186 HX2 | GND        | GND        | GND        | GND        | GND        | GND       | GND       | GND       | I/O69 I5  |           |           | I/O67 I3  | I/O65 I1  | I/O66 I2  | I/O64 I0 | M  |
| N  | I/O188 HX4 | I/O189 HX5 | I/O191 HX7 | I/O190 HX6 |            |            | I/O162 EX2 | GND        | GND        | GND        | GND        | GND        | GND       | GND       | GND       | I/O89 L1  |           |           | I/O88 L0  | I/O71 I7  | I/O70 I6  | I/O68 I4 | N  |
| P  | I/O160 EX0 | I/O161 EX1 | I/O163 EX3 | VCC        |            |            | N/C        | GND        | GND        | GND        | GND        | GND        | GND       | GND       | GND       | N/C       |           |           | VCC       | I/O92 L4  | I/O91 L3  | I/O90 L2 | P  |
| R  | I/O164 EX4 | I/O165 EX5 | I/O166 EX6 | I/O177 GX1 |            |            | VCC        | N/C        | GND        | GND        | GND        | GND        | GND       | GND       | N/C       | VCC       |           |           | I/O74 J2  | I/O95 L7  | I/O94 L6  | I/O93 L5 | R  |
| T  | I/O167 EX7 | I/O176 GX0 | I/O179 GX3 | I/O181 GX5 |            |            | VCC        | VCC        | N/C        | I/O152 DX0 | I/O131 AX3 | I/O122 P2  | I/O98 M2  | N/C       | VCC       | VCC       |           |           | I/O78 J6  | I/O76 J4  | I/O73 J1  | I/O72 J0 | T  |
| U  | I/O178 GX2 | I/O180 GX4 | I/O183 GX7 | VCC        |            |            |            |            |            |            |            |            |           |           |           |           |           |           | VCC       | I/O80 K0  | I/O77 J5  | I/O75 J3 | U  |
| V  | I/O182 GX6 | N/C        | I/O169 FX1 | I/O172 FX4 |            |            |            |            |            |            |            |            |           |           |           |           |           |           | I/O86 K6  | I/O83 K3  | I/O81 K1  | I/O79 J7 | V  |
| W  | I/O168 FX0 | I/O170 FX2 | I/O173 FX5 | GND        | I/O143 BX7 | VCC        | I/O150 CX6 | I/O145 CX1 | VCC        | I/O153 DX1 | I/O123 P3  | VCC        | I/O96 M0  | VCC       | I/O104 N0 | I/O111 N7 | VCC       | I/O119 O7 | GND       | I/O87 K7  | I/O84 K4  | I/O82 K2 | W  |
| Y  | I/O171 FX3 | I/O174 FX6 | GND        | I/O141 BX5 | I/O138 BX2 | I/O136 BX0 | I/O147 CX3 | I/O158 DX6 | I/O156 DX4 | CLK2       | I/O132 AX4 | I/O121 P1  | I/O125 P5 | I/O99 M3  | I/O101 M5 | I/O106 N2 | I/O110 N6 | I/O115 O3 | I/O118 O6 | GND       | TMS       | I/O85 K5 | Y  |
| AA | I/O175 FX7 | GND        | I/O142 BX6 | I/O140 BX4 | I/O151 CX7 | I/O149 CX5 | I/O144 CX0 | I/O157 DX5 | I/O154 DX2 | I/O134 AX6 | I/O130 AX2 | I/O128 AX0 | CLK1      | I/O127 P7 | I/O100 M4 | I/O103 M7 | I/O108 N4 | I/O109 N5 | I/O113 O1 | I/O116 O4 | GND       | TCK      | AA |
| AB | GND        | N/C        | I/O139 BX3 | I/O137 BX1 | I/O148 CX4 | I/O146 CX2 | I/O159 DX7 | I/O155 DX3 | I/O135 AX7 | I/O133 AX5 | I/O129 AX1 | I/O120 P0  | I/O124 P4 | I/O126 P6 | I/O97 M1  | I/O102 M6 | I/O105 N1 | I/O107 N3 | I/O112 O0 | I/O114 O2 | I/O117 O5 | GND      | AB |

### PIN DESIGNATIONS

CLK = Clock  
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m4a3.512.256\_388bga

## ispMACH 4A PRODUCT ORDERING INFORMATION

### ispMACH 4A Devices Commercial and Industrial - 3.3V and 5V

Lattice programmable logic products are available with several ordering options. The order number (Valid Combination) is formed by a combination of:

| M4A3- 256 / 128 -7 Y C                                                   |  | L48                                                                       |  |
|--------------------------------------------------------------------------|--|---------------------------------------------------------------------------|--|
| <b>FAMILY TYPE</b>                                                       |  | = 48-pin TQFP for<br>M4A3-32/32 or M4A3-64/32<br>M4A5-32/32 or M4A5-64/32 |  |
| M4A3- = ispMACH 4A Family Low Voltage Advanced Feature (3.3-V $V_{CC}$ ) |  | <b>OPERATING CONDITIONS</b>                                               |  |
| M4A5- = ispMACH 4A Family Advanced Feature (5-V $V_{CC}$ )               |  | C = Commercial (0°C to +70°C)                                             |  |
| <b>MACROCELL DENSITY</b>                                                 |  | I = Industrial (-40°C to +85°C)                                           |  |
| 32 = 32 Macrocells      192 = 192 Macrocells                             |  | <b>PACKAGE TYPE</b>                                                       |  |
| 64 = 64 Macrocells      256 = 256 Macrocells                             |  | SA = Ball Grid Array (BGA)                                                |  |
| 96 = 96 Macrocells      384 = 384 Macrocells                             |  | J = Plastic Leaded Chip Carrier (PLCC)                                    |  |
| 128 = 128 Macrocells      512 = 512 Macrocells                           |  | JN = Lead-free Plastic Leaded Chip Carrier (PLCC)                         |  |
| <b>I/Os</b>                                                              |  | V = Thin Quad Flat Pack (TQFP)                                            |  |
| /32 = 32 I/Os in 44-pin PLCC, 44-pin TQFP or 48-pin TQFP                 |  | VN = Lead-free Thin Quad Flat Pack (TQFP)                                 |  |
| /48 = 48 I/Os in 100-pin TQFP                                            |  | Y = Plastic Quad Flat Pack (PQFP)                                         |  |
| /64 = 64 I/Os in 100-pin TQFP, 100-pin PQFP, or 100-ball caBGA           |  | YN = Lead-free Plastic Quad Flat Pack (PQFP)                              |  |
| /96 = 96 I/Os in 144-pin TQFP or 144-ball fpBGA                          |  | FA = Fine-pitch Ball Grid Array (fpBGA)                                   |  |
| /128 = 128 I/Os in 208-pin PQFP, 256-ball BGA or 256-ball fpBGA          |  | FAN = Lead-free Fine-pitch Ball Grid Array (fpBGA)                        |  |
| /160 = 160 I/Os in 208-pin PQFP                                          |  | CA = Chip-array Ball Grid Array (caBGA)                                   |  |
| /192 = 192 I/Os in 256-ball BGA or 256-ball fpBGA                        |  | <b>SPEED</b>                                                              |  |
| /256 = 256 I/Os in 388-ball fpBGA                                        |  | -5 = 5.0 ns $t_{PD}$                                                      |  |
|                                                                          |  | -55 = 5.5 ns $t_{PD}$                                                     |  |
|                                                                          |  | -6 = 6.0 ns $t_{PD}$                                                      |  |
|                                                                          |  | -65 = 6.5 ns $t_{PD}$                                                     |  |
|                                                                          |  | -7 = 7.5 ns $t_{PD}$                                                      |  |
|                                                                          |  | -10 = 10 ns $t_{PD}$                                                      |  |
|                                                                          |  | -12 = 12 ns $t_{PD}$                                                      |  |
|                                                                          |  | -14 = 14 ns $t_{PD}$                                                      |  |

\*Package obsolete, contact factory.

### Conventional Packaging

| 3.3V Commercial Combinations |                                 |              | 3.3V Industrial Combinations |               |              |
|------------------------------|---------------------------------|--------------|------------------------------|---------------|--------------|
| M4A3-32/32                   | -5, -7, -10                     | JC, VC, VC48 | M4A3-32/32                   | -7, -10, -12  | JI, VI, VI48 |
| M4A3-64/32                   | -55, -7, -10                    | JC, VC, VC48 | M4A3-64/32                   |               | JI, VI, VI48 |
| M4A3-64/64                   |                                 | VC           | M4A3-64/64                   |               | VI           |
| M4A3-96/48                   |                                 | VC           | M4A3-96/48                   |               | VI           |
| M4A3-128/64                  |                                 | YC, VC, CAC  | M4A3-128/64                  |               | YI, VI, CAI  |
| M4A3-192/96                  | -6, -7, -10                     | VC, FAC      | M4A3-192/96                  |               | VI, FAI      |
| M4A3-256/128                 | -55, -65 <sup>1</sup> , -7, -10 | YC, FAC, SAC | M4A3-256/128                 | -10, -12      | YI, FAI, SAI |
| M4A3-256/160                 | -7, -10                         | YC           | M4A3-256/160                 |               | YI           |
| M4A3-256/192                 |                                 | FAC          | M4A3-256/192                 | -10, -12, -14 | FAI          |
| M4A3-384/160                 | -65, -10, -12                   | YC           | M4A3-384/160                 |               | YI           |
| M4A3-384/192                 |                                 | SAC, FAC     | M4A3-384/192                 |               | FAI          |
| M4A3-512/160                 | -7, -10, -12                    | YC           | M4A3-512/160                 |               | YI           |
| M4A3-512/192                 |                                 | FAC          | M4A3-512/192                 |               | FAI          |
| M4A3-512/256                 |                                 | FAC          | M4A3-512/256                 |               | FAI          |

1. Use 5.5ns for new designs.