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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                  | Obsolete                                                                                                                                                              |
| Programmable Type               | In System Programmable                                                                                                                                                |
| Delay Time tpd(1) Max           | 12 ns                                                                                                                                                                 |
| Voltage Supply - Internal       | 4.5V ~ 5.5V                                                                                                                                                           |
| Number of Logic Elements/Blocks | -                                                                                                                                                                     |
| Number of Macrocells            | 64                                                                                                                                                                    |
| Number of Gates                 | -                                                                                                                                                                     |
| Number of I/O                   | 32                                                                                                                                                                    |
| Operating Temperature           | -40°C ~ 85°C (TA)                                                                                                                                                     |
| Mounting Type                   | Surface Mount                                                                                                                                                         |
| Package / Case                  | 44-LCC (J-Lead)                                                                                                                                                       |
| Supplier Device Package         | 44-PLCC (16.59x16.59)                                                                                                                                                 |
| Purchase URL                    | <a href="https://www.e-xfl.com/product-detail/lattice-semiconductor/m4a5-64-32-12jni">https://www.e-xfl.com/product-detail/lattice-semiconductor/m4a5-64-32-12jni</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             |

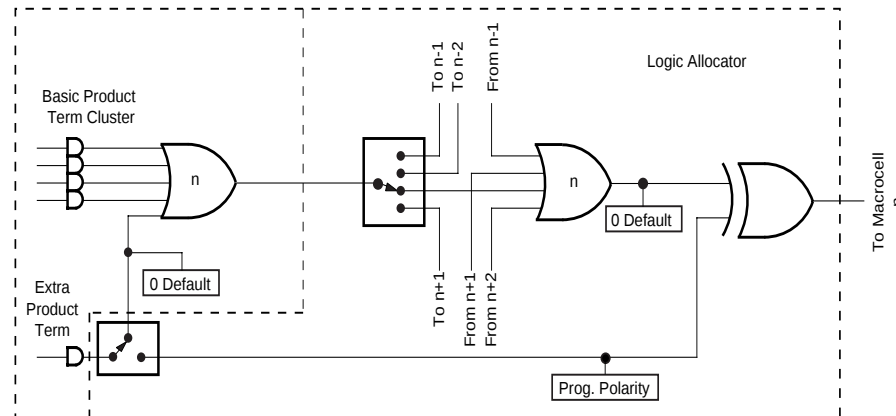
| <b>5 V Devices</b> |                |                |                |                 |                 |                 |
|--------------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|
| <b>Feature</b>     | <b>M4A5-32</b> | <b>M4A5-64</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             |

**Table 6. Logic Allocator for All ispMACH 4A Devices (except M4A(3,5)-32/32)**

| Output Macrocell | Available Clusters                                                | Output Macrocell | Available Clusters                                                    |
|------------------|-------------------------------------------------------------------|------------------|-----------------------------------------------------------------------|
| M <sub>0</sub>   | C <sub>0</sub> , C <sub>1</sub> , C <sub>2</sub>                  | M <sub>8</sub>   | C <sub>7</sub> , C <sub>8</sub> , C <sub>9</sub> , C <sub>10</sub>    |
| M <sub>1</sub>   | C <sub>0</sub> , C <sub>1</sub> , C <sub>2</sub> , C <sub>3</sub> | M <sub>9</sub>   | C <sub>8</sub> , C <sub>9</sub> , C <sub>10</sub> , C <sub>11</sub>   |
| M <sub>2</sub>   | C <sub>1</sub> , C <sub>2</sub> , C <sub>3</sub> , C <sub>4</sub> | M <sub>10</sub>  | C <sub>9</sub> , C <sub>10</sub> , C <sub>11</sub> , C <sub>12</sub>  |
| M <sub>3</sub>   | C <sub>2</sub> , C <sub>3</sub> , C <sub>4</sub> , C <sub>5</sub> | M <sub>11</sub>  | C <sub>10</sub> , C <sub>11</sub> , C <sub>12</sub> , C <sub>13</sub> |
| M <sub>4</sub>   | C <sub>3</sub> , C <sub>4</sub> , C <sub>5</sub> , C <sub>6</sub> | M <sub>12</sub>  | C <sub>11</sub> , C <sub>12</sub> , C <sub>13</sub> , C <sub>14</sub> |
| M <sub>5</sub>   | C <sub>4</sub> , C <sub>5</sub> , C <sub>6</sub> , C <sub>7</sub> | M <sub>13</sub>  | C <sub>12</sub> , C <sub>13</sub> , C <sub>14</sub> , C <sub>15</sub> |
| M <sub>6</sub>   | C <sub>5</sub> , C <sub>6</sub> , C <sub>7</sub> , C <sub>8</sub> | M <sub>14</sub>  | C <sub>13</sub> , C <sub>14</sub> , C <sub>15</sub>                   |
| M <sub>7</sub>   | C <sub>6</sub> , C <sub>7</sub> , C <sub>8</sub> , C <sub>9</sub> | M <sub>15</sub>  | C <sub>14</sub> , C <sub>15</sub>                                     |

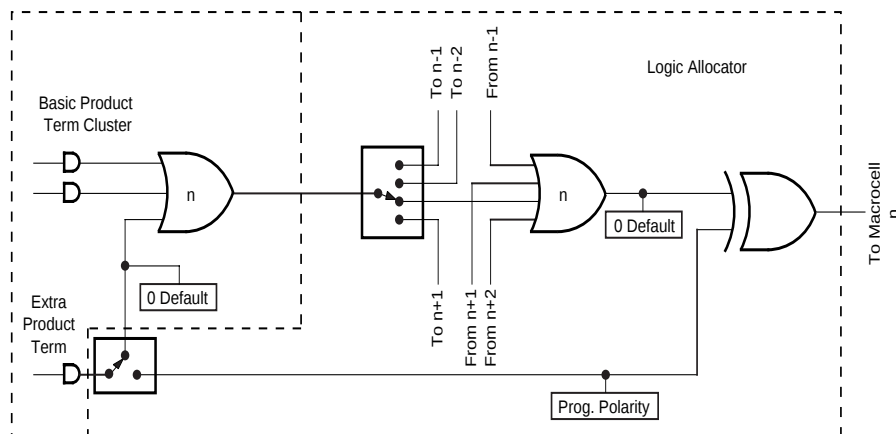
**Table 7. Logic Allocator for M4A(3,5)-32/32**

| Output Macrocell | Available Clusters                                                | Output Macrocell | Available Clusters                                                    |
|------------------|-------------------------------------------------------------------|------------------|-----------------------------------------------------------------------|
| M <sub>0</sub>   | C <sub>0</sub> , C <sub>1</sub> , C <sub>2</sub>                  | M <sub>8</sub>   | C <sub>8</sub> , C <sub>9</sub> , C <sub>10</sub>                     |
| M <sub>1</sub>   | C <sub>0</sub> , C <sub>1</sub> , C <sub>2</sub> , C <sub>3</sub> | M <sub>9</sub>   | C <sub>8</sub> , C <sub>9</sub> , C <sub>10</sub> , C <sub>11</sub>   |
| M <sub>2</sub>   | C <sub>1</sub> , C <sub>2</sub> , C <sub>3</sub> , C <sub>4</sub> | M <sub>10</sub>  | C <sub>9</sub> , C <sub>10</sub> , C <sub>11</sub> , C <sub>12</sub>  |
| M <sub>3</sub>   | C <sub>2</sub> , C <sub>3</sub> , C <sub>4</sub> , C <sub>5</sub> | M <sub>11</sub>  | C <sub>10</sub> , C <sub>11</sub> , C <sub>12</sub> , C <sub>13</sub> |
| M <sub>4</sub>   | C <sub>3</sub> , C <sub>4</sub> , C <sub>5</sub> , C <sub>6</sub> | M <sub>12</sub>  | C <sub>11</sub> , C <sub>12</sub> , C <sub>13</sub> , C <sub>14</sub> |
| M <sub>5</sub>   | C <sub>4</sub> , C <sub>5</sub> , C <sub>6</sub> , C <sub>7</sub> | M <sub>13</sub>  | C <sub>12</sub> , C <sub>13</sub> , C <sub>14</sub> , C <sub>15</sub> |
| M <sub>6</sub>   | C <sub>5</sub> , C <sub>6</sub> , C <sub>7</sub>                  | M <sub>14</sub>  | C <sub>13</sub> , C <sub>14</sub> , C <sub>15</sub>                   |
| M <sub>7</sub>   | C <sub>6</sub> , C <sub>7</sub>                                   | M <sub>15</sub>  | C <sub>14</sub> , C <sub>15</sub>                                     |



**a. Synchronous Mode**

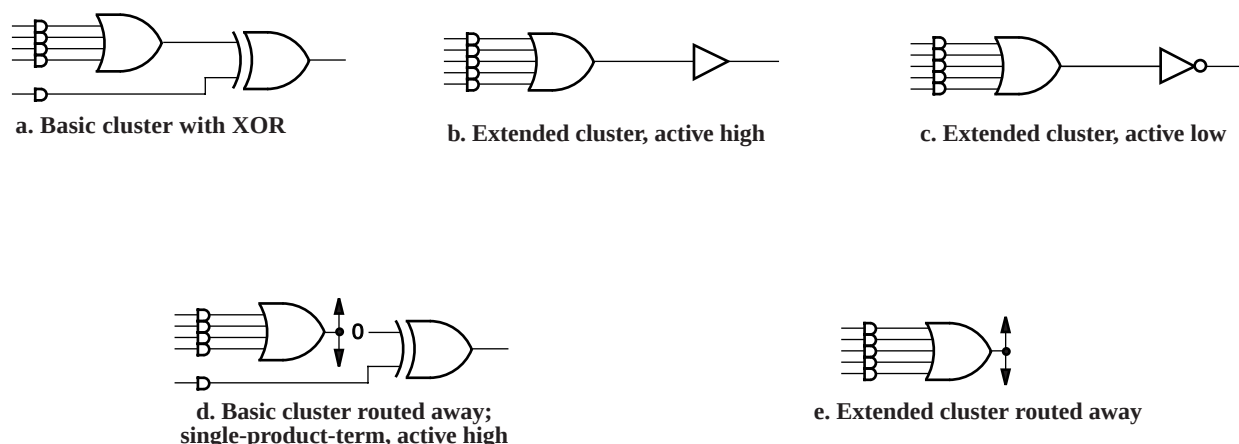
17466G-005



**b. Asynchronous Mode**

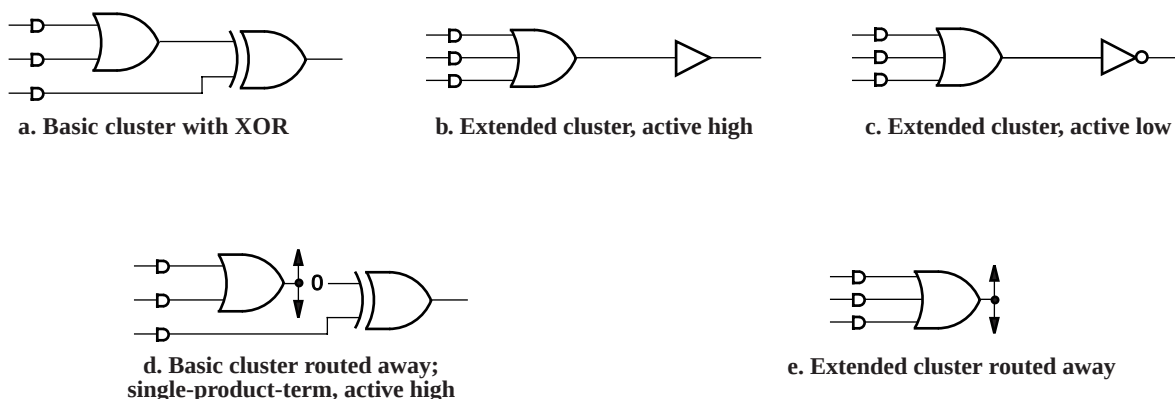
17466G-006

**Figure 2. Logic Allocator: Configuration of Cluster “n” Set by Mode of Macrocell “n”**



17466G-007

**Figure 3. Logic Allocator Configurations: Synchronous Mode**



17466G-008

**Figure 4. Logic Allocator Configurations: Asynchronous Mode**

Note that the configuration of the logic allocator has absolutely no impact on the speed of the signal. All configurations have the same delay. This means that designers do not have to decide between optimizing resources or speed; both can be optimized.

If not used in the cluster, the extra product term can act in conjunction with the basic cluster to provide XOR logic for such functions as data comparison, or it can work with the D-,T-type flip-flop to provide for J-K, and S-R register operation. In addition, if the basic cluster is routed to another macrocell, the extra product term is still available for logic. In this case, the first XOR input will be a logic 0. This circuit has the flexibility to route product terms elsewhere without giving up the use of the macrocell.

Product term clusters do not “wrap” around a PAL block. This means that the macrocells at the ends of the block have fewer product terms available.



**Table 10. Output Switch Matrix Combinations for ispMACH 4A Devices with 2:1 Macrocell-I/O Cell Ratio**

| Macrocell | Routable to I/O Cells  |
|-----------|------------------------|
| M12, M13  | I/O3, I/O4, I/O5, I/O6 |
| M14, M15  | I/O4, I/O5, I/O6, I/O7 |

| I/O Cell | Available Macrocells                 |
|----------|--------------------------------------|
| I/O0     | M0, M1, M2, M3, M4, M5, M6, M7       |
| I/O1     | M2, M3, M4, M5, M6, M7, M8, M9       |
| I/O2     | M4, M5, M6, M7, M8, M9, M10, M11     |
| I/O3     | M6, M7, M8, M9, M10, M11, M12, M13   |
| I/O4     | M8, M9, M10, M11, M12, M13, M14, M15 |
| I/O5     | M0, M1, M10, M11, M12, M13, M14, M15 |
| I/O6     | M0, M1, M2, M3, M12, M13, M14, M15   |
| I/O7     | M0, M1, M2, M3, M4, M5, M14, M15     |

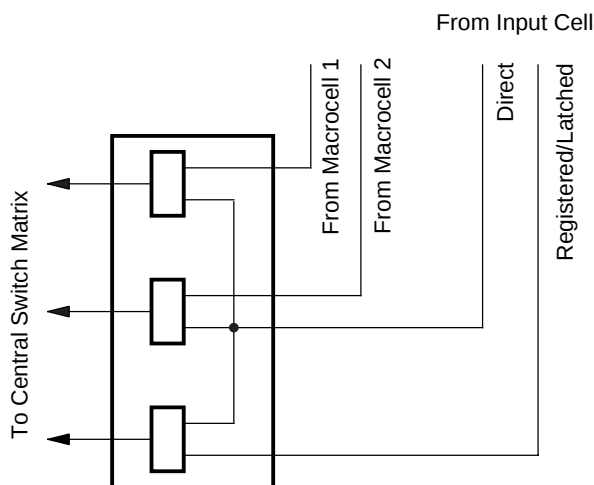
**Table 11. Output Switch Matrix Combinations for M4A3-256/160 and M4A3-256/192**

| Macrocell | Routable to I/O Cells |      |       |       |       |       |       |       |
|-----------|-----------------------|------|-------|-------|-------|-------|-------|-------|
| M0        | I/O0                  | I/O1 | I/O2  | I/O3  | I/O4  | I/O5  | I/O6  | I/O7  |
| M1        | I/O0                  | I/O1 | I/O2  | I/O3  | I/O4  | I/O5  | I/O6  | I/O7  |
| M2        | I/O0                  | I/O1 | I/O2  | I/O3  | I/O4  | I/O5  | I/O6  | I/O7  |
| M3        | I/O0                  | I/O1 | I/O2  | I/O3  | I/O4  | I/O5  | I/O6  | I/O7  |
| M4        | I/O0                  | I/O1 | I/O2  | I/O3  | I/O4  | I/O5  | I/O6  | I/O7  |
| M5        | I/O0                  | I/O1 | I/O2  | I/O3  | I/O4  | I/O5  | I/O6  | I/O7  |
| M6        | I/O0                  | I/O1 | I/O2  | I/O3  | I/O4  | I/O5  | I/O6  | I/O7  |
| M7        | I/O0                  | I/O1 | I/O2  | I/O3  | I/O4  | I/O5  | I/O6  | I/O7  |
| M8        | I/O8                  | I/O9 | I/O10 | I/O11 | I/O12 | I/O13 | I/O14 | I/O15 |
| M9        | I/O8                  | I/O9 | I/O10 | I/O11 | I/O12 | I/O13 | I/O14 | I/O15 |
| M10       | I/O8                  | I/O9 | I/O10 | I/O11 | I/O12 | I/O13 | I/O14 | I/O15 |
| M11       | I/O8                  | I/O9 | I/O10 | I/O11 | I/O12 | I/O13 | I/O14 | I/O15 |
| M12       | I/O8                  | I/O9 | I/O10 | I/O11 | I/O12 | I/O13 | I/O14 | I/O15 |
| M13       | I/O8                  | I/O9 | I/O10 | I/O11 | I/O12 | I/O13 | I/O14 | I/O15 |
| M14       | I/O8                  | I/O9 | I/O10 | I/O11 | I/O12 | I/O13 | I/O14 | I/O15 |
| M15       | I/O8                  | I/O9 | I/O10 | I/O11 | I/O12 | I/O13 | I/O14 | I/O15 |

| I/O Cell | Available Macrocells |    |    |    |    |    |    |    |
|----------|----------------------|----|----|----|----|----|----|----|
| I/O0     | M0                   | M1 | M2 | M3 | M4 | M5 | M6 | M7 |
| I/O1     | M0                   | M1 | M2 | M3 | M4 | M5 | M6 | M7 |
| I/O2     | M0                   | M1 | M2 | M3 | M4 | M5 | M6 | M7 |
| I/O3     | M0                   | M1 | M2 | M3 | M4 | M5 | M6 | M7 |
| I/O4     | M0                   | M1 | M2 | M3 | M4 | M5 | M6 | M7 |
| I/O5     | M0                   | M1 | M2 | M3 | M4 | M5 | M6 | M7 |
| I/O6     | M0                   | M1 | M2 | M3 | M4 | M5 | M6 | M7 |
| I/O7     | M0                   | M1 | M2 | M3 | M4 | M5 | M6 | M7 |

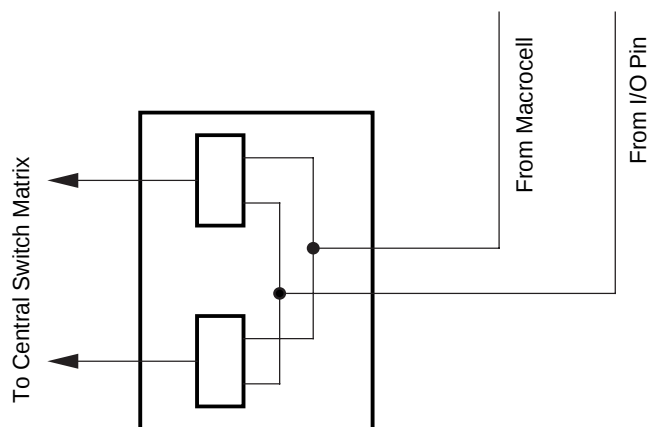
## Input Switch Matrix

The input switch matrix (Figures 12 and 13) optimizes routing of inputs to the central switch matrix. Without the input switch matrix, each input and feedback signal has only one way to enter the central switch matrix. The input switch matrix provides additional ways for these signals to enter the central switch matrix.



17466G-002

**Figure 12. ispMACH 4A with 2:1 Macrocell-I/O Cell Ratio - Input Switch Matrix**



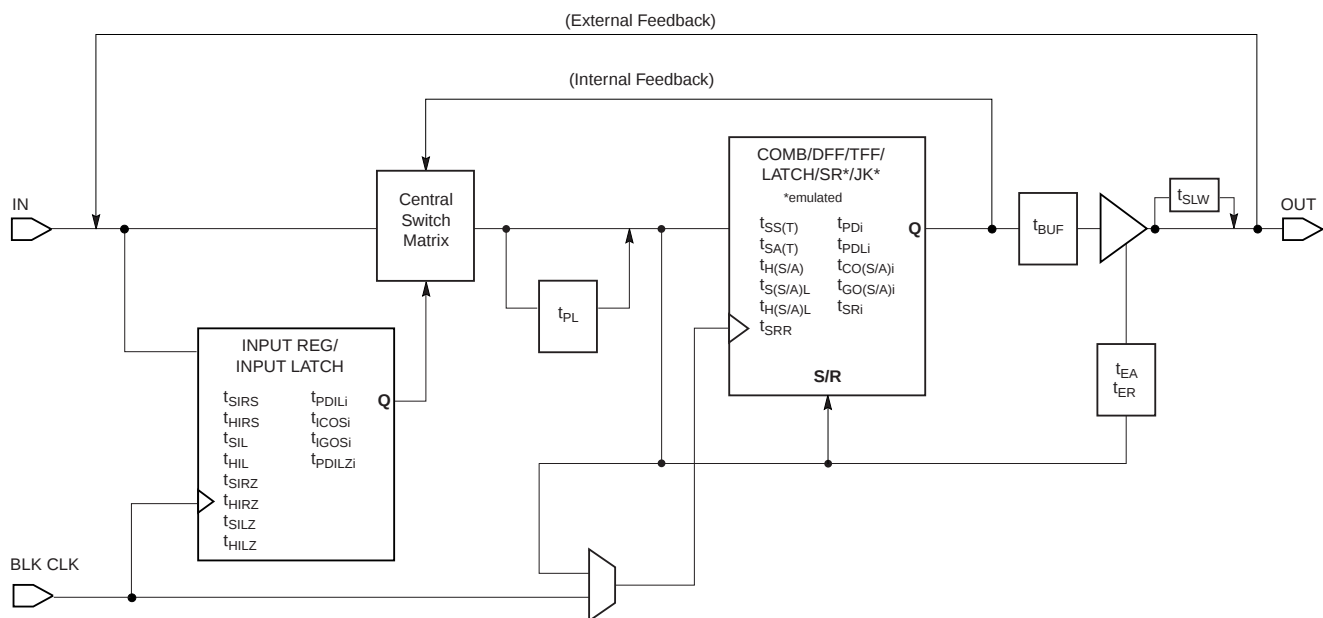
17466G-003

**Figure 13. ispMACH 4A with 1:1 Macrocell-I/O Cell Ratio - Input Switch Matrix**

## 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

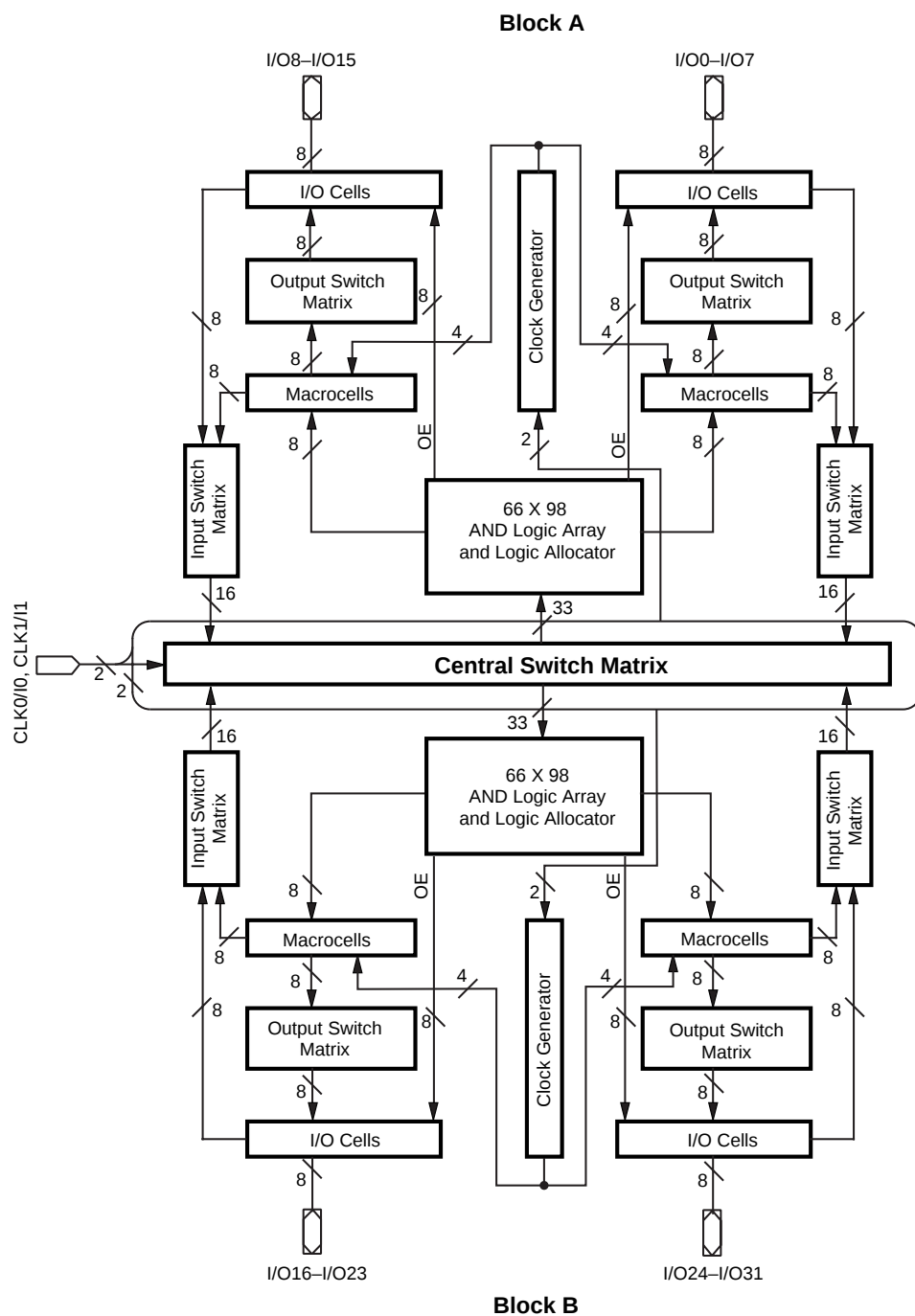
Figure 15. ispMACH 4A Timing Model

## 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.

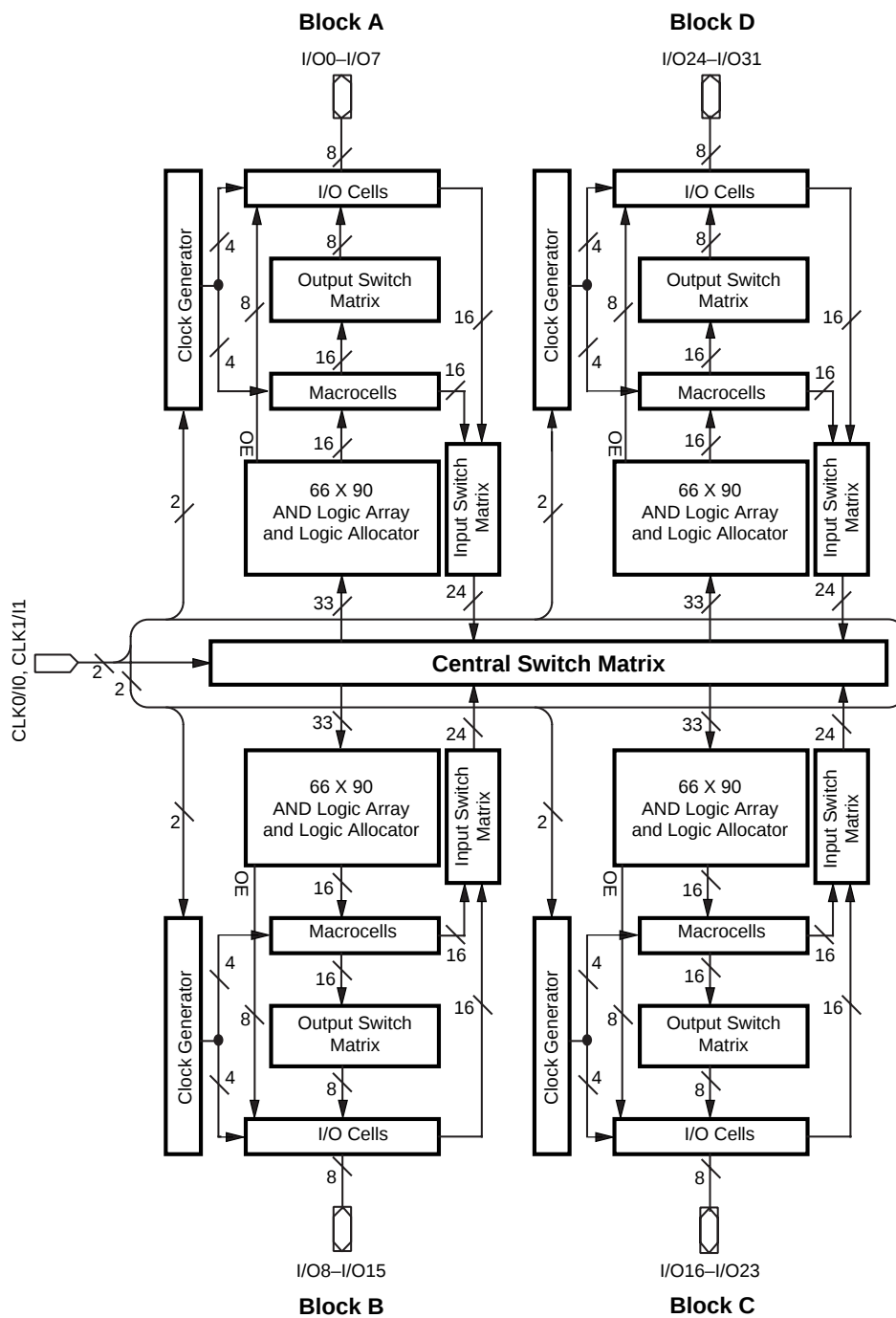
The design of the switch matrix and PAL blocks guarantee a fixed pin-to-pin delay that is independent of the logic required by the design. Other competitive CPLDs incur serious timing delays as product terms expand beyond their typical 4 or 5 product term limits. Speed and SpeedLocking combine to give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

## BLOCK DIAGRAM – M4A(3,5)-32/32



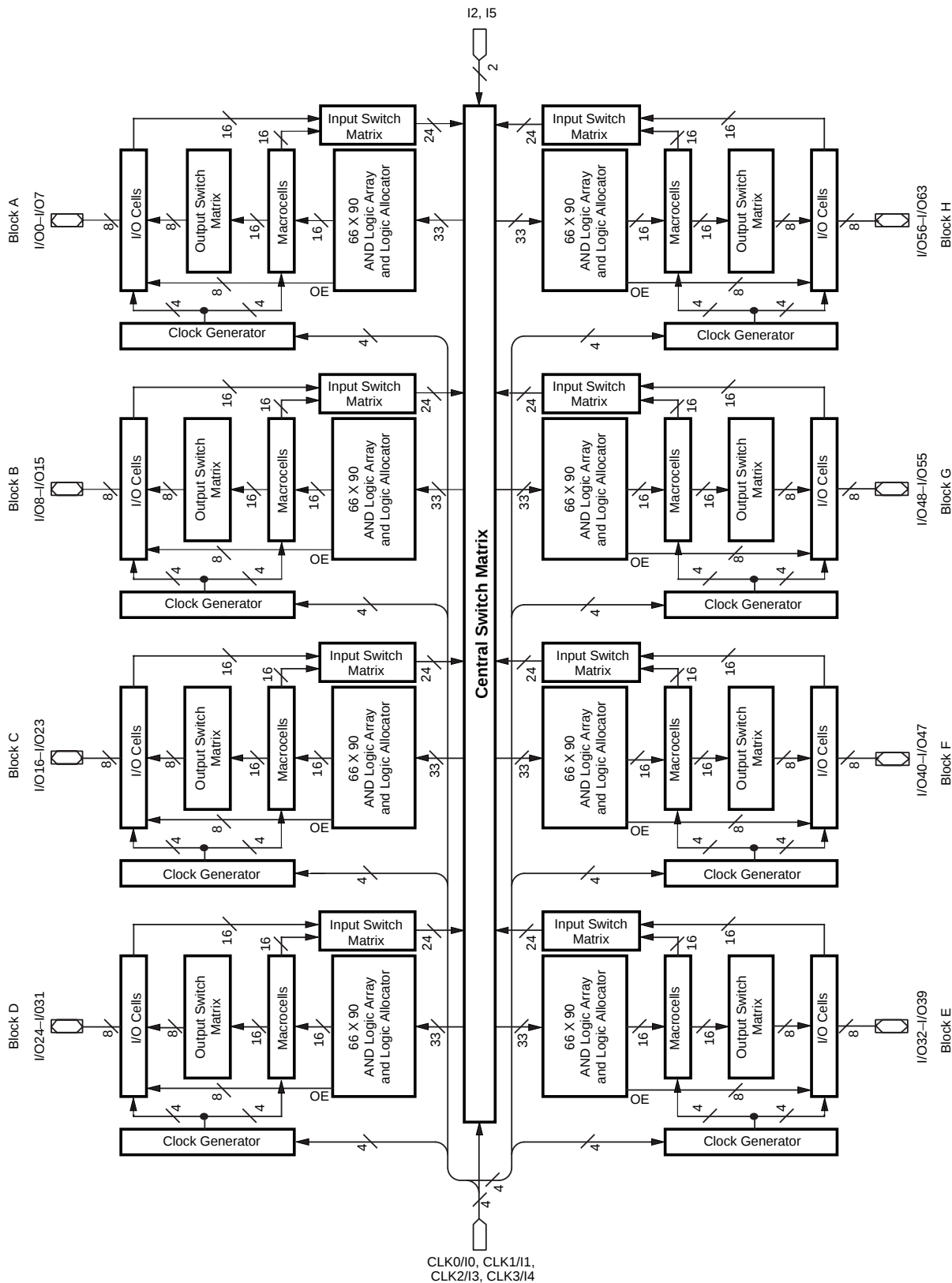
17466H-019

## BLOCK DIAGRAM – M4A(3,5)-64/32



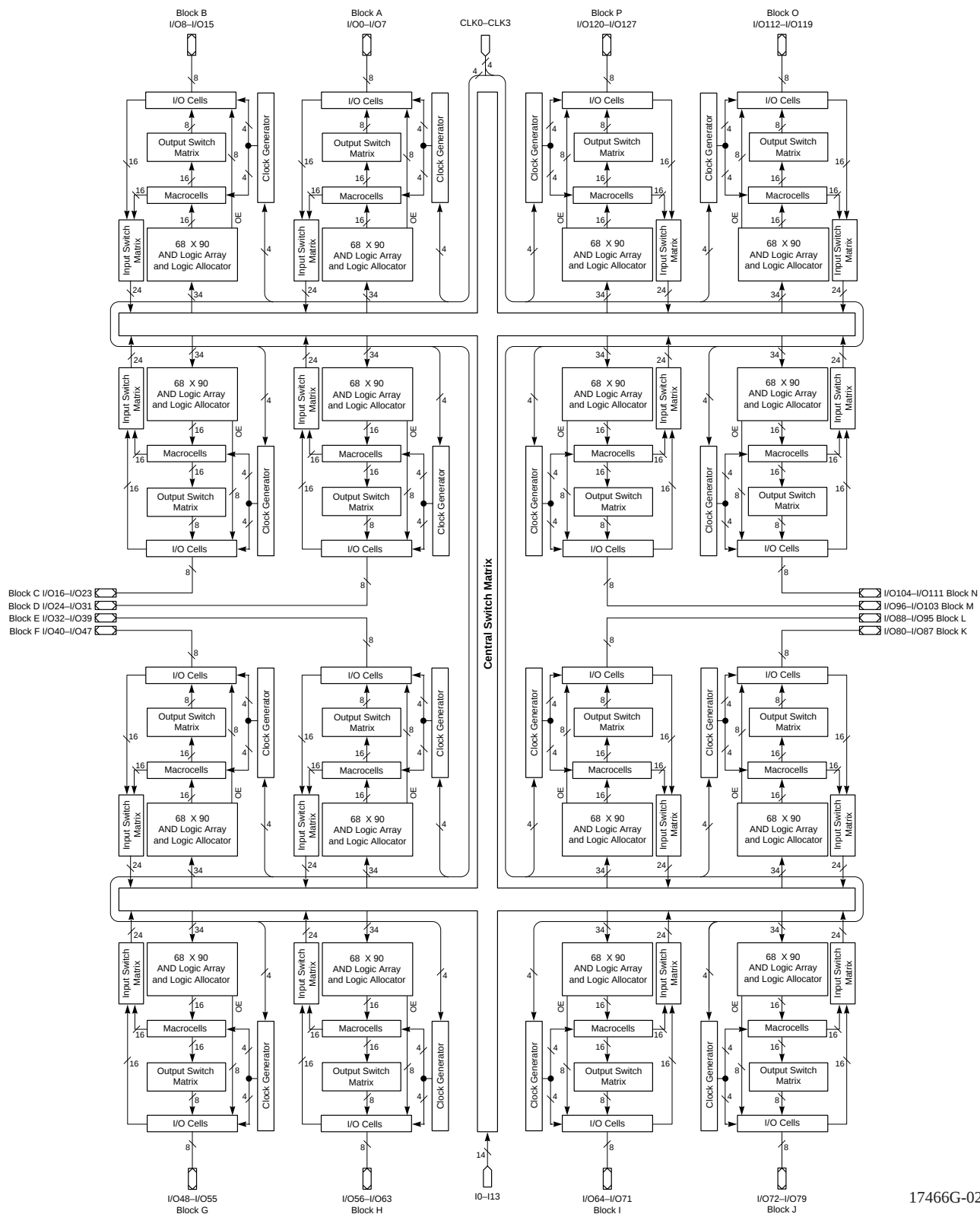
17466H-020

## BLOCK DIAGRAM – M4A(3,5)-128/64



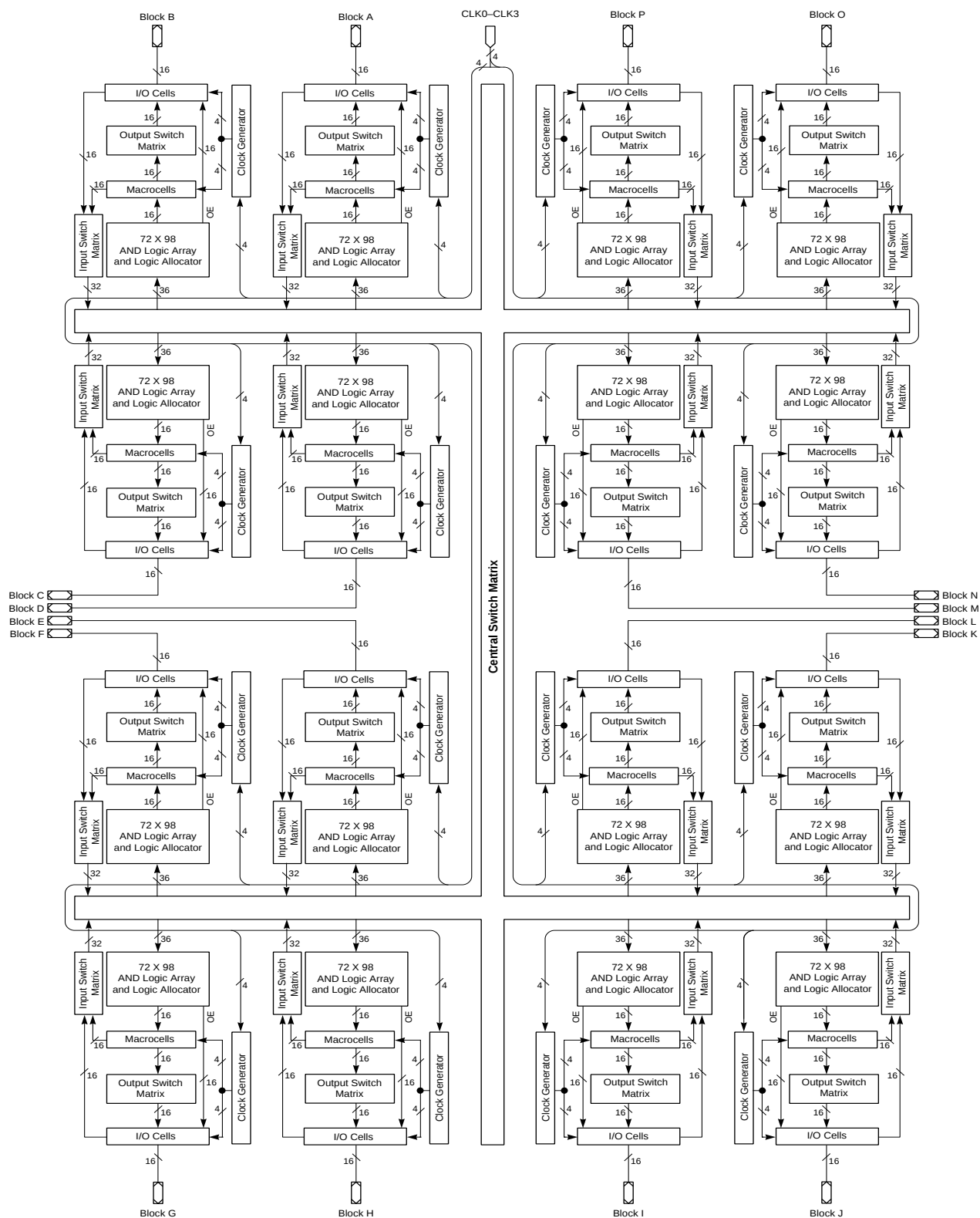
17466H-022

## BLOCK DIAGRAM – M4A(3,5)-256/128



17466G-024

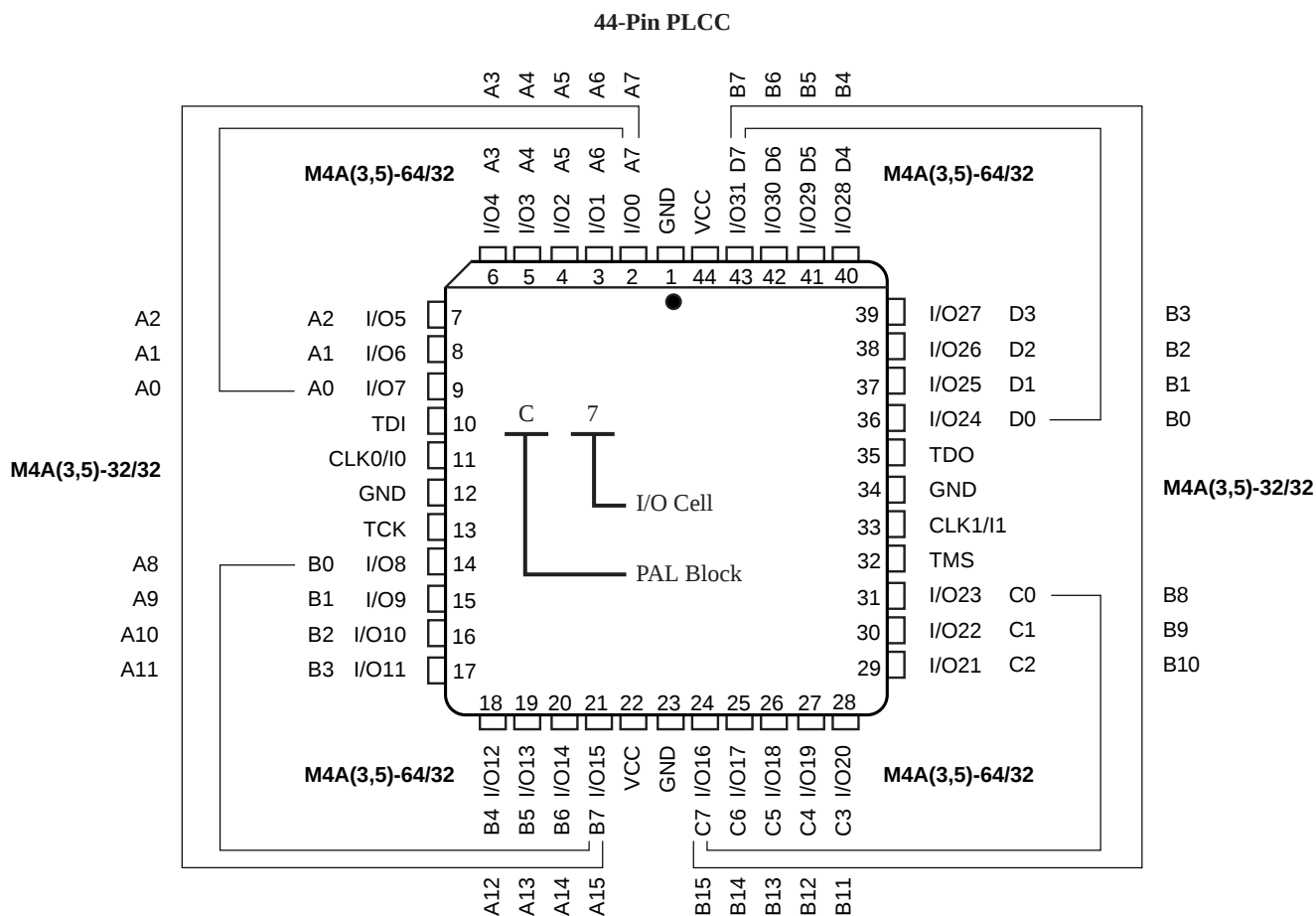
## BLOCK DIAGRAM – M4A3-256/160, M4A3-256/192



17466G-050

## 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

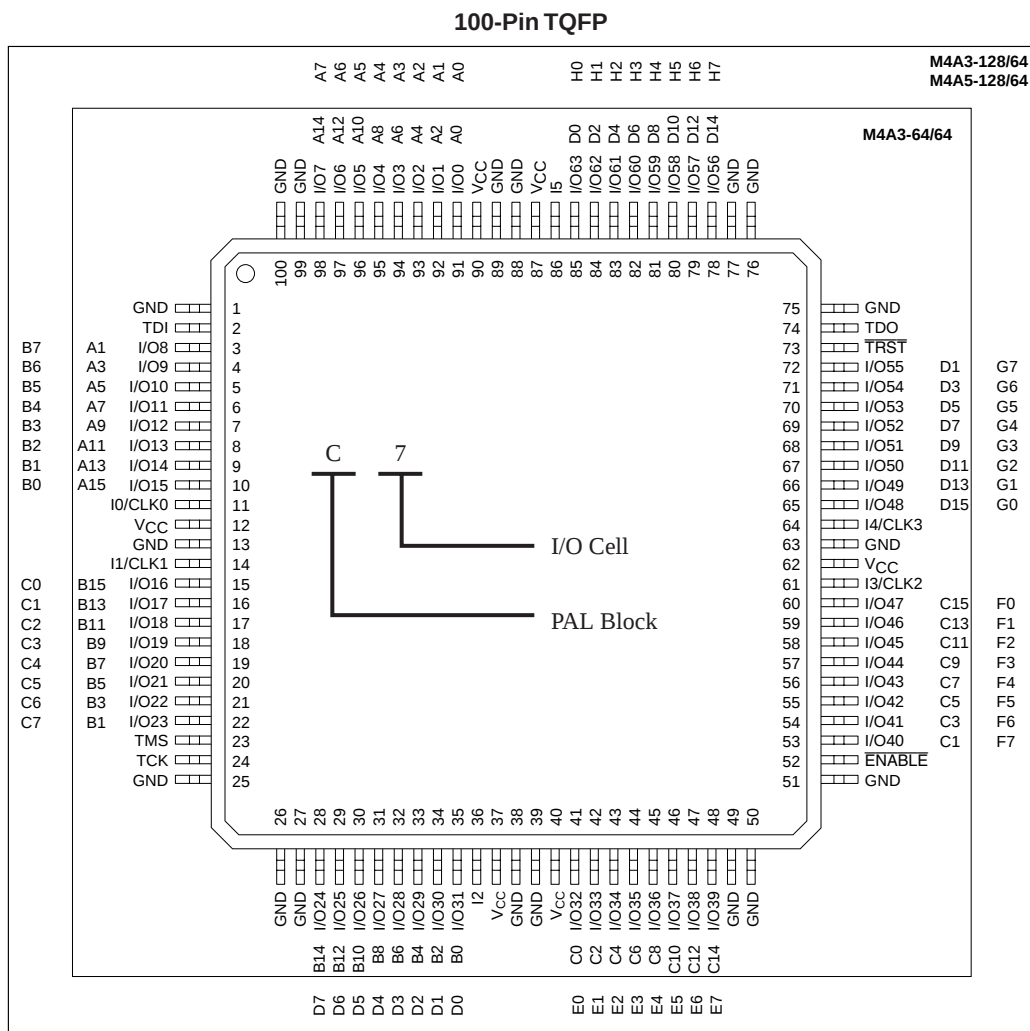
TCK = Test Clock

TMS = Test Mode Select

TDO = Test Data Out

## 100-PIN TQFP CONNECTION DIAGRAM (M4A3-64/64 AND M4A(3,5)-128/64)

### Top View



### PIN DESIGNATIONS

CLK/I = Clock or Input

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

TRST = Test Reset

ENABLE = Program

## 100-BALL caBGA CONNECTION DIAGRAM (M4A3-128/64)

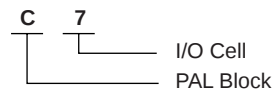
### Bottom View

100-Ball caBGA

|   | 10          | 9           | 8           | 7           | 6           | 5           | 4           | 3           | 2           | 1           |   |
|---|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---|
| A | GND         | I/O63<br>H7 | I/O60<br>H4 | I/O57<br>H1 | GND         | GND         | I/O1<br>A1  | I/O4<br>A4  | I/O7<br>A7  | GND         | A |
| B | TRST        | GND         | I/O61<br>H5 | I5          | VCC         | I/O0<br>A0  | I/O6<br>A6  | GND         | TDI         | I/O15<br>B7 | B |
| C | I/O53<br>G5 | TDO         | I/O62<br>H6 | I/O58<br>H2 | I/O56<br>H0 | I/O2<br>A2  | GND         | I/O14<br>B6 | I/O13<br>B5 | I/O12<br>B4 | C |
| D | I/O50<br>G2 | I/O55<br>G7 | GND         | I/O59<br>H3 | I/O3<br>A3  | I/O5<br>A5  | I/O11<br>B3 | I/O10<br>B2 | CLK0/I0     | I/O9<br>B1  | D |
| E | CLK3/I4     | I/O49<br>G1 | I/O51<br>G3 | I/O54<br>G6 | VCC         | I/O16<br>C0 | I/O20<br>C4 | I/O8<br>B0  | VCC         | GND         | E |
| F | GND         | VCC         | I/O40<br>F0 | I/O52<br>G4 | I/O48<br>G0 | VCC         | I/O22<br>C6 | I/O19<br>C3 | I/O17<br>C1 | CLK1/I1     | F |
| G | I/O41<br>F1 | CLK2/I3     | I/O42<br>F2 | I/O43<br>F3 | I/O37<br>E5 | I/O35<br>E3 | I/O27<br>D3 | GND         | I/O23<br>C7 | I/O18<br>C2 | G |
| H | I/O44<br>F4 | I/O45<br>F5 | I/O46<br>F6 | GND         | I/O34<br>E2 | I/O24<br>D0 | I/O26<br>D2 | I/O30<br>D6 | TCK         | I/O21<br>C5 | H |
| J | I/O47<br>F7 | ENABLE      | GND         | I/O38<br>E6 | I/O32<br>E0 | VCC         | I2          | I/O29<br>D5 | GND         | TMS         | J |
| K | GND         | I/O39<br>E7 | I/O36<br>E4 | I/O33<br>E1 | GND         | GND         | I/O25<br>D1 | I/O28<br>D4 | I/O31<br>D7 | GND         | K |
|   | 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  
 TRST = Test Reset  
 ENABLE = Program

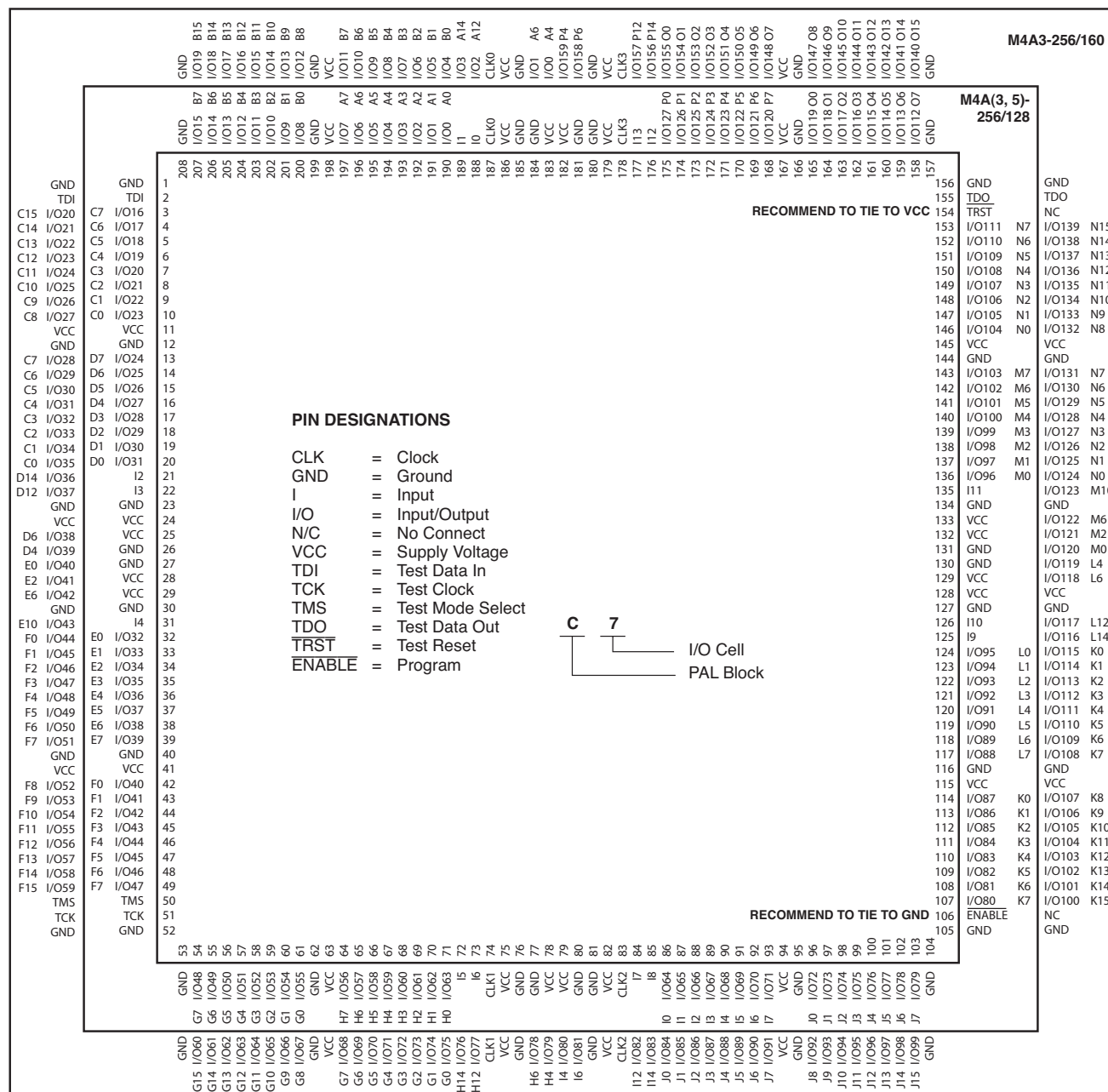


17466G-100cabga

# 208-PIN PQFP CONNECTION DIAGRAM (M4A(3,5)-256/128 AND M4A3-256/160)

## Top View

### 208-Pin PQFP

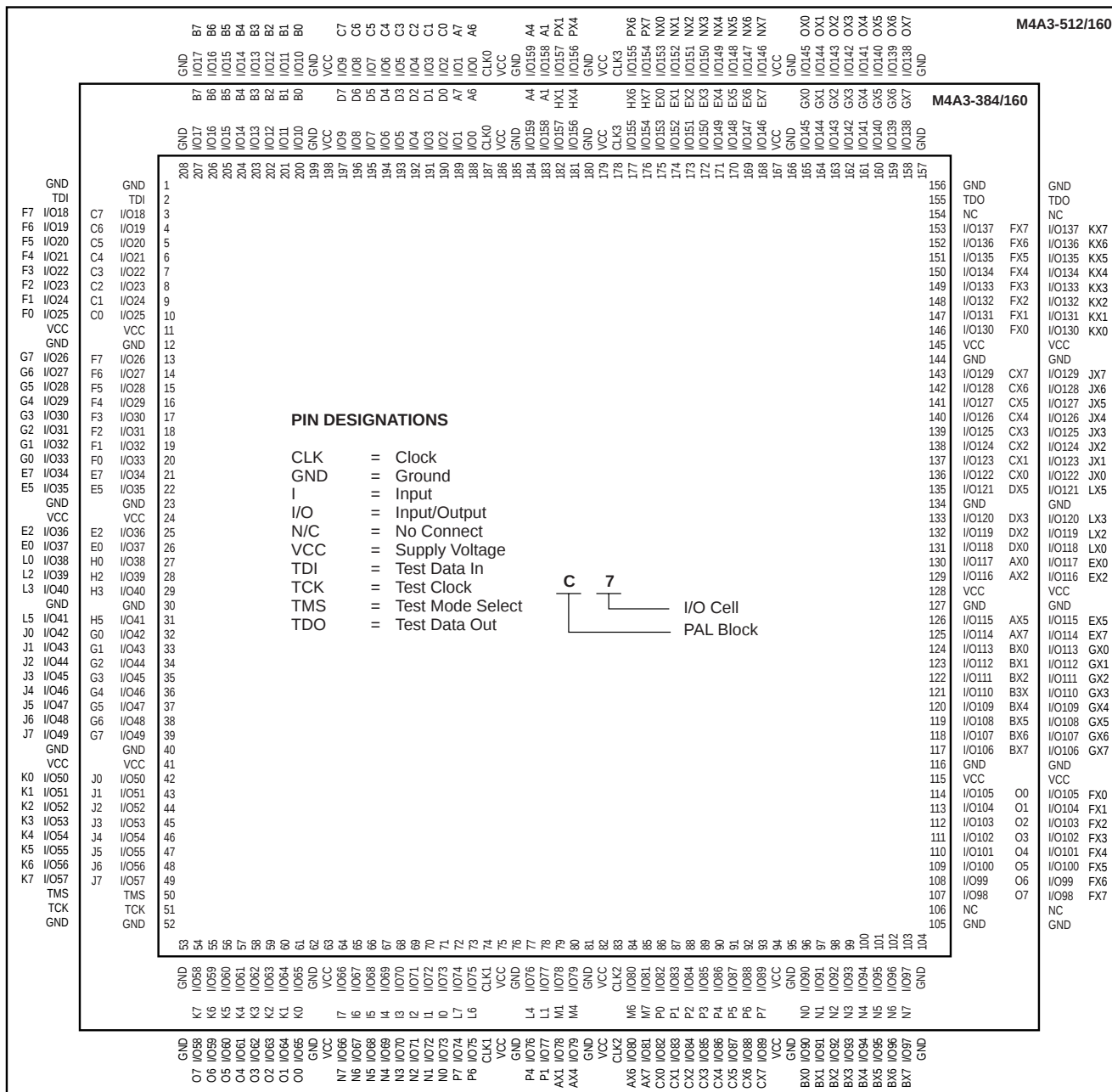


17466G-044

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

## Top View

### 208-Pin PQFP



17466Ga-044

# 256-BALL BGA CONNECTION DIAGRAM (M4A3-256/128)

## 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          | N/C          | GND          | I/O108<br>N4 | I/O105<br>N1                                                                                                                                                                                                                                                                                                                                                                                                                                           | GND          | I/O100<br>M4 | I/O96<br>M0  | GND         | GND | GND | GND         | I/O95<br>L0 | I/O91<br>L4 | GND         | I/O87<br>K0 | N/C         | GND         | GND         | GND         | A |
| B | GND          | I/O113<br>O6 | N/C          | I/O109<br>N5 | I/O106<br>N2                                                                                                                                                                                                                                                                                                                                                                                                                                           | I/O103<br>M7 | I/O102<br>M6 | I/O98<br>M2  | N/C         | I11 | N/C | N/C         | I/O93<br>L2 | I/O89<br>L6 | I/O88<br>L7 | I/O85<br>K2 | I/O83<br>K4 | I/O82<br>K5 | N/C         | GND         | B |
| C | I/O116<br>O3 | N/C          | VCC          | TRST         | I/O111<br>N7                                                                                                                                                                                                                                                                                                                                                                                                                                           | I/O107<br>N3 | I/O104<br>N0 | I/O101<br>M5 | I/O97<br>M1 | N/C | I10 | I/O94<br>L1 | I/O90<br>L5 | I/O86<br>K1 | I/O84<br>K3 | I/O80<br>K7 | ENABLE      | VCC         | I/O78<br>J6 | I/O74<br>J2 | C |
| D | I/O120<br>P7 | I/O117<br>O2 | I/O112<br>O7 | VCC          | VCC                                                                                                                                                                                                                                                                                                                                                                                                                                                    | I/O110<br>N6 | VCC          | N/C          | I/O99<br>M3 | N/C | I9  | I/O92<br>L3 | N/C         | VCC         | I/O81<br>K6 | VCC         | VCC         | I/O79<br>J7 | I/O75<br>J3 | I/O71<br>I7 | D |
| E | I/O123<br>P4 | I/O119<br>O0 | I/O114<br>O5 | 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>TRST = Test Reset</div><div>ENABLE = Program</div></div><div><div>C7</div><div>I/O Cell</div><div>PAL Block</div></div></div> |              |              |              |             |     |     |             |             |             |             |             | TDO         | I/O77<br>J5 | I/O72<br>J0 | I/O68<br>I4 | E |
| F | GND          | I/O122<br>P5 | I/O118<br>O1 | I/O115<br>O4 |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |              |              |             |     |     |             |             |             |             |             | I/O76<br>J4 | I/O73<br>J1 | I/O69<br>I5 | GND         | F |
| G | I12          | I/O125<br>P2 | I/O121<br>P6 | VCC          |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |              |              |             |     |     |             |             |             |             |             | VCC         | I/O70<br>I6 | I/O65<br>I1 | I8          | G |
| H | GND          | I/O127<br>P0 | I/O126<br>P1 | I/O124<br>P3 |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |              |              |             |     |     |             |             |             |             |             | I/O67<br>I3 | I/O66<br>I2 | I/O64<br>I0 | GND         | H |
| J | N/C          | N/C          | N/C          | I13          |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |              |              |             |     |     |             |             |             |             |             | I7          | N/C         | N/C         | N/C         | J |
| K | GND          | CLK3         | N/C          | N/C          |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |              |              |             |     |     |             |             |             |             |             | N/C         | N/C         | CLK2        | N/C         | K |
| L | N/C          | CLK0         | N/C          | N/C          |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |              |              |             |     |     |             |             |             |             |             | N/C         | N/C         | CLK1        | GND         | L |
| M | N/C          | N/C          | N/C          | I0           |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |              |              |             |     |     |             |             |             |             |             | I6          | N/C         | I/O63<br>H0 | I/O62<br>H1 | M |
| N | GND          | I/O0<br>A0   | I/O2<br>A2   | I/O3<br>A3   |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |              |              |             |     |     |             |             |             |             |             | I/O60<br>H3 | I/O61<br>H2 | I/O59<br>H4 | GND         | N |
| P | I1           | I/O1<br>A1   | I/O6<br>A6   | VCC          | VCC                                                                                                                                                                                                                                                                                                                                                                                                                                                    | I/O57<br>H6  | I/O58<br>H5  | I5           | P           |     |     |             |             |             |             |             |             |             |             |             |   |
| R | GND          | I/O5<br>A5   | I/O9<br>B1   | N/C          | I/O51<br>G4                                                                                                                                                                                                                                                                                                                                                                                                                                            | I/O54<br>G1  | I/O56<br>H7  | GND          | R           |     |     |             |             |             |             |             |             |             |             |             |   |
| T | I/O4<br>A4   | I/O8<br>B0   | I/O12<br>B4  | TCK          | TMS                                                                                                                                                                                                                                                                                                                                                                                                                                                    | I/O50<br>G5  | I/O55<br>G0  | N/C          | T           |     |     |             |             |             |             |             |             |             |             |             |   |
| U | I/O7<br>A7   | I/O11<br>B3  | I/O15<br>B7  | VCC          | VCC                                                                                                                                                                                                                                                                                                                                                                                                                                                    | I/O18<br>C5  | VCC          | I/O24<br>D7  | I/O29<br>D2 | I2  | N/C | I/O35<br>E3 | N/C         | VCC         | N/C         | VCC         | VCC         | I/O48<br>G7 | I/O53<br>G2 | N/C         | U |
| V | I/O10<br>B2  | I/O13<br>B5  | VCC          | I/O16<br>C7  | I/O17<br>C6                                                                                                                                                                                                                                                                                                                                                                                                                                            | I/O21<br>C2  | I/O23<br>C0  | I/O27<br>D4  | I/O31<br>D0 | I3  | N/C | I/O33<br>E1 | I/O37<br>E5 | I/O41<br>F1 | I/O43<br>F3 | I/O46<br>F6 | I/O47<br>F7 | VCC         | I/O52<br>G3 | N/C         | V |
| W | GND          | I/O14<br>B6  | N/C          | N/C          | I/O19<br>C4                                                                                                                                                                                                                                                                                                                                                                                                                                            | I/O22<br>C1  | I/O25<br>D6  | I/O28<br>D3  | N/C         | N/C | I4  | N/C         | I/O34<br>E2 | I/O38<br>E6 | I/O39<br>E7 | I/O42<br>F2 | I/O45<br>F5 | N/C         | I/O49<br>G6 | GND         | W |
| Y | GND          | GND          | GND          | N/C          | I/O20<br>C3                                                                                                                                                                                                                                                                                                                                                                                                                                            | GND          | I/O26<br>D5  | I/O30<br>D1  | GND         | GND | GND | GND         | I/O32<br>E0 | I/O36<br>E4 | GND         | I/O40<br>F0 | I/O44<br>F4 | GND         | N/C         | GND         | Y |
|   | 20           | 19           | 18           | 17           | 16                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 15           | 14           | 13           | 12          | 11  | 10  | 9           | 8           | 7           | 6           | 5           | 4           | 3           | 2           | 1           |   |

17466G-045

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

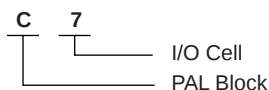
### Bottom View

#### 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

## 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 |                                                                              |
|---------------------------------------------------------------------------------|------------------------------------------------------------|-------|------------------|----|-----|----|---|---|------------------------------------------------------------------------------|
|                                                                                 |                                                            |       |                  |    |     |    |   |   | 48 = 48-pin TQFP for<br>M4A3-32/32 or M4A3-64/32<br>M4A5-32/32 or M4A5-64/32 |
| <b>FAMILY TYPE</b>                                                              |                                                            |       |                  |    |     |    |   |   |                                                                              |
| M4A3- = ispMACH 4A Family Low Voltage Advanced Feature (3.3-V V <sub>CC</sub> ) |                                                            |       |                  |    |     |    |   |   |                                                                              |
| M4A5- = ispMACH 4A Family Advanced Feature (5-V V <sub>CC</sub> )               |                                                            |       |                  |    |     |    |   |   |                                                                              |
| <b>MACROCELL DENSITY</b>                                                        |                                                            |       |                  |    |     |    |   |   |                                                                              |
| 32                                                                              | = 32 Macrocells                                            | 192   | = 192 Macrocells |    |     |    |   |   |                                                                              |
| 64                                                                              | = 64 Macrocells                                            | 256   | = 256 Macrocells |    |     |    |   |   |                                                                              |
| 96                                                                              | = 96 Macrocells                                            | 384   | = 384 Macrocells |    |     |    |   |   |                                                                              |
| 128                                                                             | = 128 Macrocells                                           | 512   | = 512 Macrocells |    |     |    |   |   |                                                                              |
| <b>I/Os</b>                                                                     |                                                            |       |                  |    |     |    |   |   |                                                                              |
| /32                                                                             | = 32 I/Os in 44-pin PLCC, 44-pin TQFP or 48-pin TQFP       |       |                  |    |     |    |   |   |                                                                              |
| /48                                                                             | = 48 I/Os in 100-pin TQFP                                  |       |                  |    |     |    |   |   |                                                                              |
| /64                                                                             | = 64 I/Os in 100-pin TQFP, 100-pin PQFP, or 100-ball caBGA |       |                  |    |     |    |   |   |                                                                              |
| /96                                                                             | = 96 I/Os in 144-pin TQFP or 144-ball fpBGA                |       |                  |    |     |    |   |   |                                                                              |
| /128                                                                            | = 128 I/Os in 208-pin PQFP, 256-ball BGA or 256-ball fpBGA |       |                  |    |     |    |   |   |                                                                              |
| /160                                                                            | = 160 I/Os in 208-pin PQFP                                 |       |                  |    |     |    |   |   |                                                                              |
| /192                                                                            | = 192 I/Os in 256-ball BGA or 256-ball fpBGA               |       |                  |    |     |    |   |   |                                                                              |
| /256                                                                            | = 256 I/Os in 388-ball fpBGA                               |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
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|                                                                                 |                                                            |       |                  |    |     |    |   |   |                                                                              |
|                                                                                 |                                                            |       |                  | </ |     |    |   |   |                                                                              |

\*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                 |               | FAI          |
| M4A3-384/160                 | -65, -10, -12                   | YC           | M4A3-384/160                 | -10, -12, -14 | 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.