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### Understanding Embedded - FPGAs (Field Programmable Gate Array)

Embedded - FPGAs, or Field Programmable Gate Arrays, are advanced integrated circuits that offer unparalleled flexibility and performance for digital systems. Unlike traditional fixed-function logic devices, FPGAs can be programmed and reprogrammed to execute a wide array of logical operations, enabling customized functionality tailored to specific applications. This reprogrammability allows developers to iterate designs quickly and implement complex functions without the need for custom hardware.

### Applications of Embedded - FPGAs

The versatility of Embedded - FPGAs makes them indispensable in numerous fields. In telecommunications.

#### Details

|                                |   |
|--------------------------------|---|
| Product Status                 | Obsolete  |
| Number of LABs/CLBs            | -   |
| Number of Logic Elements/Cells | 1600  |
| Total RAM Bits                 | -   |
| Number of I/O                  | 80  |
| Number of Gates                | 9000  |
| Voltage - Supply               | 4.5V ~ 5.5V   |
| Mounting Type                  | Surface Mount   |
| Operating Temperature          | -40°C ~ 85°C (TC)   |
| Package / Case                 | 100-TQFP  |
| Supplier Device Package        | 100-TQFP (14x14)  |
| Purchase URL                   | <a href="https://www.e-xfl.com/product-detail/microchip-technology/at6003-2ai">https://www.e-xfl.com/product-detail/microchip-technology/at6003-2ai</a> |

Each cell, in addition, provides the ability to route a signal on a 90° turn between the NS1 bus and EW1 bus and between the NS2 bus and EW2 bus.

Express buses are not connected directly to cells, and thus provide higher speeds. They are the fastest way to cover long, straight-line distances within the array.

Each express bus is paired with a local bus, so there are two express buses for every column and two express buses for every row of cells.

Connective units, called repeaters, spaced every eight cells, divide each bus, both local and express, into segments spanning eight cells. Repeaters are aligned in rows and columns thereby partitioning the array into 8 x 8 sectors of cells. Each repeater is associated with a local/express pair, and on each side of the repeater are connections to a local-bus segment and an express-bus segment. The repeater can be programmed to provide any one of twenty-one connecting functions. These functions are symmetric with respect to both the two repeater sides and the two types of buses.

Among the functions provided are the ability to:

- Isolate bus segments from one another
- Connect two local-bus segments
- Connect two express-bus segments
- Implement a local/express transfer

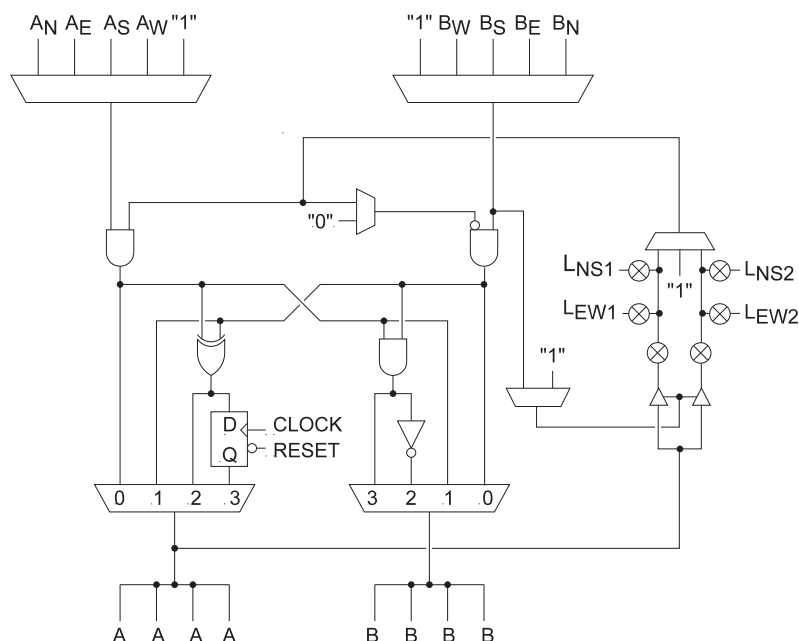
In all of these cases, each connection provides signal regeneration and is thus unidirectional. For bidirectional connections, the basic repeater function for the NS2 and EW2 repeaters is augmented with a special programmable connection allowing bidirectional communication between local-bus segments. This option is primarily used to implement long, tristate buses.

## The Cell Structure

The Atmel cell (Figure 4) is simple and small and yet can be programmed to perform all the logic and wiring functions needed to implement any digital circuit. Its four sides are functionally identical, so each cell is completely symmetrical.

Read/write access to the four local buses – NS1, EW1, NS2 and EW2 – is controlled, in part, by four bidirectional pass gates connected directly to the buses. To read a local bus, the pass gate for that bus is turned on and the three-input multiplexer is set accordingly. To write to a local bus, the pass gate for that bus and the pass gate for the associated tristate driver are both turned on. The two-input multiplexer supplying the control signal to the drivers permits either: (1) active drive, or (2) dynamic tristating controlled by the B input. Turning between  $L_{NS1}$  and  $L_{EW1}$  or between  $L_{NS2}$  and  $L_{EW2}$  is accomplished by turning on the two associated pass gates. The operations of reading, writing and turning are subject to the restriction that each bus can be involved in no more than a **single** operation.

**Figure 4.** Cell Structure



In addition to the four local-bus connections, a cell receives two inputs and provides two outputs to each of its North (N), South (S), East (E) and West (W) neighbors. These inputs and outputs are divided into two classes: “A” and “B”. There is an A input and a B input from each neighboring cell and an A output and a B output driving all four neighbors. Between cells, an A output is always connected to an A input and a B output to a B input.

Within the cell, the four A inputs and the four B inputs enter two separate, independently configurable multiplexers. Cell flexibility is enhanced by allowing each multiplexer to select also the logical constant “1”. The two multiplexer outputs enter the two upstream AND gates.

Downstream from these two AND gates are an Exclusive-OR (XOR) gate, a register, an AND gate, an inverter and two four-input multiplexers producing the A and B outputs. These multiplexers are controlled in tandem (unlike the A and B input multiplexers) and determine the function of the cell.

- In State 0 – corresponding to the “0” inputs of the multiplexers – the output of the left-hand upstream AND gate is connected to the cell’s A output, and the output of the right-hand upstream AND gate is connected to the cell’s B output.
- In State 1 – corresponding to the “1” inputs of the multiplexers – the output of the left-hand upstream AND gate is connected to the cell’s B output, the output of the right-hand upstream AND gate is connected to the cell’s A output.
- In State 2 – corresponding to the “2” inputs of the multiplexers – the XOR of the outputs from the two upstream AND gates is provided to the cell’s A output, while the NAND of these two outputs is provided to the cell’s B output.

- In State 3 – corresponding to the “3” inputs of the multiplexers – the XOR function of State 2 is provided to the D input of a D-type flip-flop, the Q output of which is connected to the cell’s A output. Clock and asynchronous reset signals are supplied externally as described later. The AND of the outputs from the two upstream AND gates is provided to the cell’s B output.

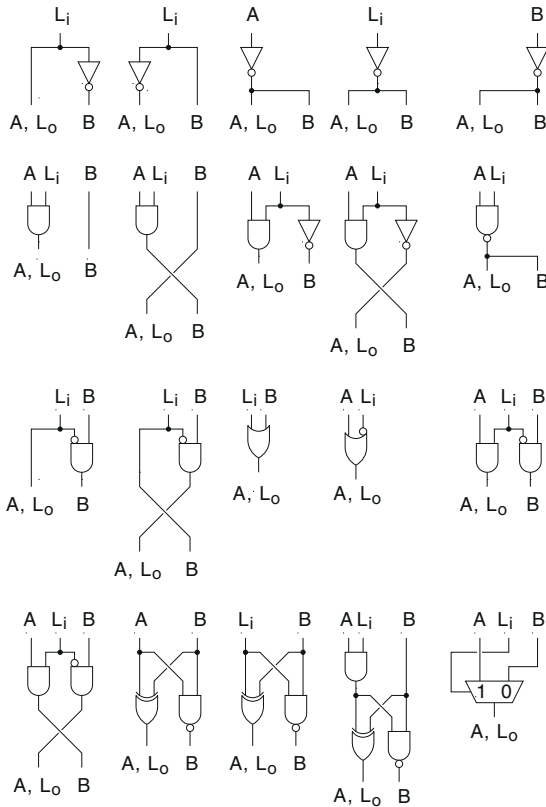
## Logic States

The Atmel cell implements a rich and powerful set of logic functions, stemming from 44 logical cell states which permute into 72 physical states. Some states use both A and B inputs. Other states are created by selecting the “1” input on either or both of the input multiplexers.

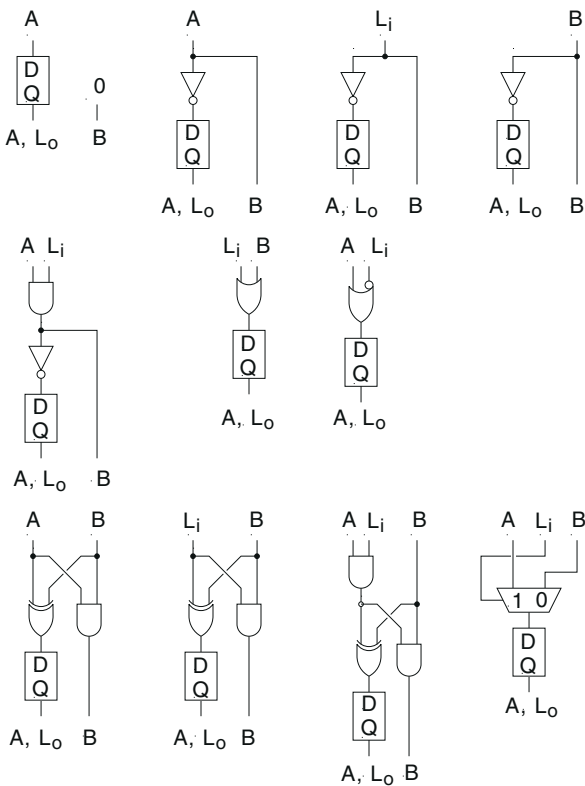
There are 28 combinatorial primitives created from the cell’s tristate capabilities and the 20 physical states represented in Figure 5. Five logical primitives are derived from the physical constants shown in Figure 7. More complex functions are created by using cells in combination.

A two-input AND feeding an XOR (Figure 8) is produced using a single cell (Figure 9). A two-to-one multiplexer selects the logical constant “0” and feeds it to the right-hand AND gate. The AND gate acts as a feed-through, letting the B input pass through to the XOR. The three-to-one multiplexer on the right side selects the local-bus input, LNS1, and passes it to the left-hand AND gate. The A and LNS1 signals are the inputs to the AND gate. The output of the AND gate feeds into the XOR, producing the logic state (A•L) XOR B.

**Figure 5. Combinatorial Physical States**



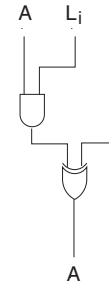
**Figure 6. Register States**



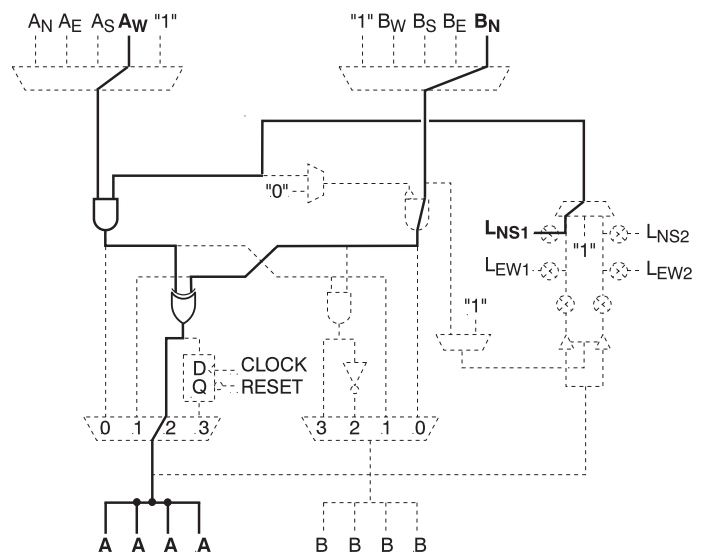
**Figure 7. Physical Constants**

|                   |   |                   |   |                   |   |                   |   |
|-------------------|---|-------------------|---|-------------------|---|-------------------|---|
| 0                 | 0 | 0                 | 1 | 1                 | 0 | 1                 | 1 |
| A, L <sub>0</sub> | B | A, L <sub>0</sub> | B | A, L <sub>0</sub> | B | A, L <sub>0</sub> | B |

**Figure 8. Two-input AND Feeding XOR**



**Figure 9. Cell Configuration (A•L) XOR B**



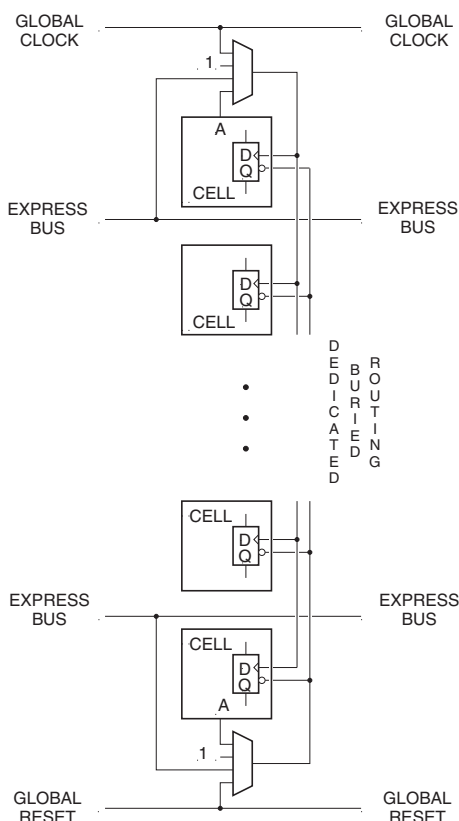
## Clock Distribution

Along the top edge of the array is logic for distributing clock signals to the D flip-flop in each logic cell (Figure 10). The distribution network is organized by column and permits columns of cells to be independently clocked. At the head of each column is a user-configurable multiplexer providing the clock signal for that column. It has four inputs:

- Global clock supplied through the CLOCK pin
- Express bus adjacent to the distribution logic
- “A” output of the cell at the head of the column
- Logical constant “1” to conserve power (no clock)

Through the global clock, the network provides low-skew distribution of an externally supplied clock to any or all of the columns of the array. The global clock pin is also connected directly to the array via the A input of the upper left and right corner cells (AW on the left, and AN on the right). The express bus is useful in distributing a secondary clock to multiple columns when the global clock line is used as a primary clock. The A output of a cell is useful in providing a clock signal to a single column. The constant “1” is used to reduce power dissipation in columns using no registers.

**Figure 10.** Column Clock and Column Reset



## Asynchronous Reset

Along the bottom edge of the array is logic for asynchronously resetting the D flip-flops in the logic cells (Figure 10). Like the clock network, the asynchronous reset network is organized by column and permits columns to be independently reset. At the bottom of each column is a user-configurable multiplexer providing the reset signal for that column. It has four inputs:

- Global asynchronous reset supplied through the  $\overline{\text{RESET}}$  pin
- Express bus adjacent to the distribution logic
- “A” output of the cell at the foot of the column
- Logical constant “1” to conserve power

The asynchronous reset logic uses these four inputs in the same way that the clock distribution logic does. Through the global asynchronous reset, any or all columns can be reset by an externally supplied signal. The global asynchronous reset pin is also connected directly to the array via the A input of the lower left and right corner cells (AS on the left, and AE on the right). The express bus can be used to distribute a secondary reset to multiple columns when the global reset line is used as a primary reset, the A output of a cell can also provide an asynchronous reset signal to a single column, and the constant “1” is used by columns with registers requiring no reset. All registers are reset during power-up.

## Input/Output

The Atmel architecture provides a flexible interface between the logic array, the configuration control logic and the I/O pins.

Two adjacent cells – an “exit” and an “entrance” cell – on the perimeter of the logic array are associated with each I/O pin.

There are two types of I/Os: A-type (Figure 11) and B-type (Figure 12). For A-type I/Os, the edge-facing A output of an exit cell is connected to an output driver, and the edge-facing A input of the adjacent entrance cell is connected to an input buffer. The output of the output driver and the input of the input buffer are connected to a common pin.

B-type I/Os are the same as A-type I/Os, but use the B inputs and outputs of their respective entrance and exit cells. A- and B-type I/Os alternate around the array. Control of the I/O logic is provided by user-configurable memory bits.

The devices can be partially reconfigured while in operation. Portions of the device not being modified remain operational during reconfiguration. Simultaneous configuration of more than one device is also possible. Full configuration takes as little as a millisecond, partial configuration is even faster.

Refer to the Pin Function Description section following for a brief summary of the pins used in configuration. For more information about configuration, refer to the AT6000 Series Configuration data sheet.

## Pin Function Description

This section provides abbreviated descriptions of the various AT6000 Series pins. For more complete descriptions, refer to the AT6000 Series Configuration data sheet.

Pinout tables for the AT6000 series of devices follow.

### Power Pins

#### $V_{CC}$ , $V_{DD}$ , GND, $V_{SS}$

$V_{CC}$  and GND are the I/O supply pins,  $V_{DD}$  and  $V_{SS}$  are the internal logic supply pins.  $V_{CC}$  and  $V_{DD}$  should be tied to the same trace on the printed circuit board. GND and  $V_{SS}$  should be tied to the same trace on the printed circuit board.

### Input/Output Pins

All I/O pins can be used in the same way (refer to the I/O section of the architecture description). Some I/O pins are dual-function pins used during configuration of the array. When not being used for configuration, dual-function I/Os are fully functional as normal I/O pins. On initial power-up, all I/Os are configured as TTL inputs with a pull-up.

### Dedicated Timing and Control Pins

#### $\overline{CON}$

Configuration-in-process pin. After power-up,  $\overline{CON}$  stays low until power-up initialization is complete, at which time  $\overline{CON}$  is then released.  $\overline{CON}$  is an open collector signal. After power-up initialization, forcing  $\overline{CON}$  low begins the configuration process.

#### $\overline{CS}$

Configuration enable pin. All configuration pins are ignored if  $\overline{CS}$  is high.  $\overline{CS}$  must be held low throughout the configuration process.  $\overline{CS}$  is a TTL input pin.

#### M0, M1, M2

Configuration mode pins are used to determine the configuration mode. All three are TTL input pins.

#### CCLK

Configuration clock pin. CCLK is a TTL input or a CMOS output depending on the mode of operation. In modes 1, 2, 3, and 6 it is an input. In modes 4 and 5 it is an output with a typical frequency of 1 MHz. In all modes, the rising edge of the CCLK signal is used to sample inputs and change outputs.

#### CLOCK

External logic source used to drive the internal global clock line. Registers toggle on the rising edge of CLOCK. The CLOCK signal is neither used nor affected by the configuration modes. It is always a TTL input.

#### $\overline{RESET}$

Array register asynchronous reset.  $\overline{RESET}$  drives the internal global reset. The  $\overline{RESET}$  signal is neither used nor affected by the configuration modes. It is always a TTL input.

#### Dual-function Pins

When  $\overline{CON}$  is high, dual-function I/O pins act as device I/Os; when  $\overline{CON}$  is low, dual-function pins are used as configuration control or data signals as determined by the configuration modes. Care must be taken when using these pins to ensure that configuration activity does not interfere with other circuitry connected to these pins in the application.

#### D0 or I/O

Serial configuration modes use D0 as the serial data input pin. Parallel configuration modes use D0 as the least-significant bit. Input data must meet setup and hold requirements with respect to the rising edge of CCLK. D0 is a TTL input during configuration.

#### D1 to D7 or I/O

Parallel configuration modes use these pins as inputs. Serial configuration modes do not use them. Data must meet setup and hold requirements with respect to the rising edge of CCLK. D1 - D7 are TTL inputs during configuration.

#### A0 to A16 or I/O

During configuration in modes 1, 2 and 5, these pins are CMOS outputs and act as the address pins for a parallel EPROM. A0 - A16 eliminates the need for an external address counter when using an external parallel nonvolatile

memory to configure the FPGA. Addresses change after the rising edge of the CCLK signal.

#### **$\overline{\text{CSOUT}}$ or I/O**

When cascading devices,  $\overline{\text{CSOUT}}$  is an output used to enable other devices.  $\overline{\text{CSOUT}}$  should be connected to the  $\overline{\text{CS}}$  input of the downstream device. The  $\overline{\text{CSOUT}}$  function is optional and can be disabled during initial programming when cascading is not used. When cascading devices,  $\overline{\text{CSOUT}}$  should be dedicated to configuration and not used as a configurable I/O.

#### **$\overline{\text{CHECK}}$ or I/O**

During configuration,  $\overline{\text{CHECK}}$  is a TTL input that can be used to enable the data check function at the beginning of a configuration cycle. No data is written to the device while  $\overline{\text{CHECK}}$  is low. Instead, the configuration file being applied to D0 (or D0 - D7, in parallel mode) is compared with the

current contents of the internal configuration RAM. If a mismatch is detected between the data being loaded and the data already in the RAM, the  $\overline{\text{ERR}}$  pin goes low. The  $\overline{\text{CHECK}}$  function is optional and can be disabled during initial programming.

#### **$\overline{\text{ERR}}$ or I/O**


During configuration,  $\overline{\text{ERR}}$  is an output. When the  $\overline{\text{CHECK}}$  function is activated and a mismatch is detected between the current configuration data stream and the data already loaded in the configuration RAM,  $\overline{\text{ERR}}$  goes low. The  $\overline{\text{ERR}}$  output is a registered signal. Once a mismatch is found, the signal is set and is only reset after the configuration cycle is restarted.  $\overline{\text{ERR}}$  is also asserted for configuration file errors. The  $\overline{\text{ERR}}$  function is optional and can be disabled during initial programming.

### **Device Pinout Selection (Max. Number of User I/O)**

|                         | AT6002 <sup>(1)</sup> | AT6003 <sup>(1)</sup> | AT6005  | AT6010  |
|-------------------------|-----------------------|-----------------------|---------|---------|
| 84 PLCC <sup>(1)</sup>  | 64 I/O                | 64 I/O                | 64 I/O  | -       |
| 100 VQFP                | 80 I/O                | 80 I/O                | 80 I/O  | -       |
| 132 PQFP <sup>(1)</sup> | 96 I/O                | 108 I/O               | -       | -       |
| 144 TQFP                | 95 I/O                | 120 I/O               | 108 I/O | 120 I/O |
| 208 PQFP <sup>(1)</sup> | -                     | -                     | -       | -       |
| 240 PQFP                | -                     | -                     | -       | 204 I/O |

### **Bit-stream Sizes**

| Mode(s) | Type     | Beginning Sequence | AT6002 <sup>(1)</sup> | AT6003 <sup>(1)</sup> | AT6005 | AT6010 |
|---------|----------|--------------------|-----------------------|-----------------------|--------|--------|
| 1       | Parallel | Preamble           | 2677                  | 4153                  | 8077   | 16393  |
| 2       | Parallel | Preamble           | 2677                  | 4153                  | 8077   | 16393  |
| 3       | Serial   | Null Byte/Preamble | 2678                  | 4154                  | 8078   | 16394  |
| 4       | Serial   | Null Byte/Preamble | 2678                  | 4154                  | 8078   | 16394  |
| 5       | Parallel | Preamble           | 2677                  | 4153                  | 8077   | 16393  |
| 6       | Parallel | Preamble/Preamble  | 2678                  | 4154                  | 8078   | 16394  |

Note: 1.  Obsolete. Not recommended for new design.



## Pinout Assignment

| Left Side (Top to Bottom) |                       |                |                |                           |             |                            |             |                            |                            |                            |
|---------------------------|-----------------------|----------------|----------------|---------------------------|-------------|----------------------------|-------------|----------------------------|----------------------------|----------------------------|
| AT6002 <sup>(3)</sup>     | AT6003 <sup>(3)</sup> | AT6005         | AT6010         | 84 <sup>(3)</sup><br>PLCC | 100<br>VQFP | 132 <sup>(3)</sup><br>PQFP | 144<br>TQFP | 180 <sup>(3)</sup><br>CPGA | 208 <sup>(3)</sup><br>PQFP | 240 <sup>(3)</sup><br>PQFP |
| -                         | -                     | -              | I/O51(A)       | -                         | -           | -                          | -           | B1                         | 1                          | 1                          |
| I/O24(A) or A7            | I/O30(A) or A7        | I/O27(A) or A7 | I/O50(A) or A7 | 12                        | 1           | 18                         | 1           | C1                         | 2                          | 2                          |
| -                         | I/O29(B)              | -              | I/O49(A)       | -                         | -           | -                          | 2           | D1                         | 3                          | 3                          |
| -                         | -                     | -              | I/O48(B)       | -                         | -           | -                          | -           | -                          | -                          | 4                          |
| -                         | -                     | -              | VCC            | -                         | -           | -                          | -           | PWR <sup>(1)</sup>         | 4                          | 5                          |
| -                         | -                     | -              | I/O47(A)       | -                         | -           | -                          | -           | E1                         | 5                          | 6                          |
| -                         | -                     | -              | GND            | -                         | -           | -                          | -           | GND <sup>(2)</sup>         | 6                          | 7                          |
| -                         | I/O28(A)              | I/O26(A)       | I/O46(A)       | -                         | -           | 19                         | 3           | G1                         | 7                          | 8                          |
| I/O23(A) or A6            | I/O27(A) or A6        | I/O25(A) or A6 | I/O45(A) or A6 | 13                        | 2           | 20                         | 4           | H1                         | 8                          | 9                          |
| -                         | -                     | -              | I/O44(B)       | -                         | -           | -                          | -           | -                          | -                          | 10                         |
| -                         | -                     | -              | I/O43(A)       | -                         | -           | -                          | -           | C2                         | 9                          | 11                         |
| I/O22(B)                  | I/O26(A)              | I/O24(A)       | I/O42(A)       | -                         | -           | 21                         | 5           | D2                         | 10                         | 12                         |
| I/O21(A) or A5            | I/O25(A) or A5        | I/O23(A) or A5 | I/O41(A) or A5 | 14                        | 3           | 22                         | 6           | E2                         | 11                         | 13                         |
| -                         | -                     | -              | I/O40(B)       | -                         | -           | -                          | -           | -                          | -                          | 14                         |
| -                         | -                     | -              | I/O39(A)       | -                         | -           | -                          | -           | F2                         | 12                         | 15                         |
| I/O20(B)                  | I/O24(B)              | I/O22(A)       | I/O38(A)       | -                         | 4           | 23                         | 7           | G2                         | 13                         | 16                         |
| I/O19(A) or A4            | I/O23(A) or A4        | I/O21(A) or A4 | I/O37(A) or A4 | 15                        | 5           | 24                         | 8           | H2                         | 14                         | 17                         |
| -                         | -                     | -              | I/O36(B)       | -                         | -           | -                          | -           | -                          | -                          | 18                         |
| I/O18(B)                  | I/O22(B)              | I/O20(A)       | I/O35(A)       | -                         | -           | 25                         | 9           | D3                         | 15                         | 19                         |
| I/O17(A) or A3            | I/O21(A) or A3        | I/O19(A) or A3 | I/O34(A) or A3 | 16                        | 6           | 26                         | 10          | E3                         | 16                         | 20                         |
| I/O16(B)                  | I/O20(B)              | I/O18(A)       | I/O33(A)       | -                         | 7           | 27                         | 11          | F3                         | 17                         | 21                         |
| -                         | -                     | -              | I/O32(B)       | -                         | -           | -                          | -           | -                          | 18                         | 22                         |
| I/O15(A) or A2            | I/O19(A) or A2        | I/O17(A) or A2 | I/O31(A) or A2 | 17                        | 8           | 28                         | 12          | G3                         | 19                         | 23                         |
| -                         | I/O18(B)              | I/O16(A)       | I/O30(A)       | -                         | -           | 29                         | 13          | H3                         | 20                         | 24                         |
| GND                       | GND                   | GND            | GND            | 18                        | 9           | 30                         | 14          | GND <sup>(2)</sup>         | 21                         | 25                         |
| VSS                       | VSS                   | VSS            | VSS            | 19                        | 10          | 31                         | 15          | GND <sup>(2)</sup>         | 22                         | 26                         |
| I/O14(A) or A1            | I/O17(A) or A1        | I/O15(A) or A1 | I/O29(A) or A1 | 20                        | 11          | 32                         | 16          | F4                         | 23                         | 27                         |
| -                         | -                     | -              | I/O28(B)       | -                         | -           | -                          | -           | -                          | 24                         | 28                         |
| -                         | I/O16(B)              | -              | I/O27(A)       | -                         | -           | -                          | 17          | G4                         | 25                         | 29                         |
| I/O13(A) or A0            | I/O15(A) or A0        | I/O14(A) or A0 | I/O26(A) or A0 | 21                        | 12          | 33                         | 18          | H4                         | 26                         | 30                         |
| I/O12(B) or D7            | I/O14(A) or D7        | I/O13(A) or D7 | I/O25(B) or D7 | 22                        | 13          | 34                         | 19          | H5                         | 27                         | 31                         |
| -                         | -                     | -              | I/O24(B)       | -                         | -           | -                          | -           | -                          | 28                         | 32                         |
| I/O11(A) or D6            | I/O13(A) or D6        | I/O12(A) or D6 | I/O23(A) or D6 | 23                        | 14          | 35                         | 20          | J4                         | 29                         | 33                         |

- Notes:
1. PWR = Pins connected to power plane = F1, E4/E5, L2, R4, K15, L12, E14, A12.
  2. GND = Pins connected to ground plane = L4, M4, N9, N10, E12, D12, C7, C6.
  3.  Obsolete. Not recommended for new design.




## Pinout Assignment

| Bottom Side (Left to Right) |                       |                       |                       |                           |             |                            |             |                            |                            |                            |
|-----------------------------|-----------------------|-----------------------|-----------------------|---------------------------|-------------|----------------------------|-------------|----------------------------|----------------------------|----------------------------|
| AT6002 <sup>(3)</sup>       | AT6003 <sup>(3)</sup> | AT6005                | AT6010                | 84 <sup>(3)</sup><br>PLCC | 100<br>VQFP | 132 <sup>(3)</sup><br>PQFP | 144<br>TQFP | 180 <sup>(3)</sup><br>CPGA | 208 <sup>(3)</sup><br>PQFP | 240 <sup>(3)</sup><br>PQFP |
| CON                         | CON                   | CON                   | CON                   | 33                        | 26          | 51                         | 37          | M5                         | 53                         | 61                         |
| -                           | -                     | -                     | I/O204(A)             | -                         | -           | -                          | -           | M6                         | 54                         | 62                         |
| I/O96(A)                    | I/O120(A)             | I/O108(A)             | I/O203(A)             | 34                        | 27          | 52                         | 38          | M7                         | 55                         | 63                         |
| -                           | I/O119(B)             | -                     | I/O202(A)             | -                         | -           | -                          | 39          | R2                         | 56                         | 64                         |
| -                           | -                     | -                     | I/O201(B)             | -                         | -           | -                          | -           | -                          | -                          | 65                         |
| -                           | -                     | -                     | VCC                   | -                         | -           | -                          | -           | PWR <sup>(1)</sup>         | 57                         | 66                         |
| -                           | -                     | -                     | I/O200(A)             | -                         | -           | -                          | -           | R3                         | 58                         | 67                         |
| -                           | -                     | -                     | GND                   | -                         | -           | -                          | -           | GND <sup>(2)</sup>         | 59                         | 68                         |
| -                           | I/O118(A)             | I/O107(A)             | I/O199(A)             | -                         | -           | 53                         | 40          | R5                         | 60                         | 69                         |
| I/O95(A) or<br>CSOUT        | I/O117(A) or<br>CSOUT | I/O106(A) or<br>CSOUT | I/O198(A) or<br>CSOUT | 35                        | 28          | 54                         | 41          | R6                         | 61                         | 70                         |
| -                           | -                     | -                     | I/O197(B)             | -                         | -           | -                          | -           | -                          | -                          | 71                         |
| -                           | -                     | -                     | I/O196(A)             | -                         | -           | -                          | -           | R7                         | 62                         | 72                         |
| I/O94(B)                    | I/O116(A)             | I/O105(A)             | I/O195(A)             | -                         | -           | 55                         | 42          | P3                         | 63                         | 73                         |
| I/O93(A)                    | I/O115(A)             | I/O104(A)             | I/O194(A)             | 36                        | 29          | 56                         | 43          | P4                         | 64                         | 74                         |
| -                           | -                     | -                     | I/O193(B)             | -                         | -           | -                          | -           | -                          | -                          | 75                         |
| -                           | -                     | -                     | I/O192(A)             | -                         | -           | -                          | -           | P5                         | 65                         | 76                         |
| I/O92(B)                    | I/O114(B)             | I/O103(A)             | I/O191(A)             | -                         | 30          | 57                         | 44          | P6                         | 66                         | 77                         |
| I/O91(A) or<br>CHECK        | I/O113(A) or<br>CHECK | I/O102(A) or<br>CHECK | I/O190(A) or<br>CHECK | 37                        | 31          | 58                         | 45          | P7                         | 67                         | 78                         |
| -                           | -                     | -                     | I/O189(B)             | -                         | -           | -                          | -           | -                          | -                          | 79                         |
| I/O90(B)                    | I/O112(B)             | I/O101(A)             | I/O188(A)             | -                         | -           | 59                         | 46          | N4                         | 68                         | 80                         |
| I/O89(A) or<br>ERR          | I/O111(A) or<br>ERR   | I/O100(A) or<br>ERR   | I/O187(A) or<br>ERR   | 38                        | 32          | 60                         | 47          | N5                         | 69                         | 81                         |
| I/O88(B)                    | I/O110(B)             | I/O99(A)              | I/O186(A)             | -                         | 33          | 61                         | 48          | N6                         | 70                         | 82                         |
| -                           | -                     | -                     | I/O185(B)             | -                         | -           | -                          | -           | -                          | 71                         | 83                         |
| I/O87(A)                    | I/O109(A)             | I/O98(A)              | I/O184(A)             | 39                        | 34          | 62                         | 49          | N7                         | 72                         | 84                         |
| -                           | I/O108(B)             | I/O97(A)              | I/O183(A)             | -                         | -           | 63                         | 50          | M8                         | 73                         | 85                         |
| GND                         | GND                   | GND                   | GND                   | 40                        | 35          | 64                         | 51          | GND <sup>(2)</sup>         | 74                         | 86                         |
| I/O86(A)                    | I/O107(A)             | I/O96(A)              | I/O182(A)             | 41                        | 36          | 65                         | 52          | M9                         | 75                         | 87                         |
| -                           | -                     | -                     | I/O181(B)             | -                         | -           | -                          | -           | -                          | 76                         | 88                         |
| -                           | I/O106(B)             | -                     | I/O180(A)             | -                         | -           | -                          | 53          | M10                        | 77                         | 89                         |
| I/O85(A)                    | I/O105(A)             | I/O95(A)              | I/O179(A)             | 42                        | 37          | 66                         | 54          | M11                        | 78                         | 90                         |
| CS                          | CS                    | CS                    | CS                    | 43                        | 38          | 67                         | 55          | L8                         | 79                         | 91                         |
| I/O84(B)                    | I/O104(A)             | I/O94(A)              | I/O178(A)             | 44                        | 39          | 68                         | 56          | M12                        | 80                         | 92                         |


Notes: 1. PWR = Pins connected to power plane = F1, E4/E5, L2, R4, K15, L12, E14, A12.

2. GND = Pins connected to ground plane = L4, M4, N9, N10, E12, D12, C7, C6.

3.  Obsolete. Not recommended for new design.

## Pinout Assignment (Continued)

| Top Side (Right to Left) |                       |                 |                 |                           |             |                            |             |                            |                            |                            |
|--------------------------|-----------------------|-----------------|-----------------|---------------------------|-------------|----------------------------|-------------|----------------------------|----------------------------|----------------------------|
| AT6002 <sup>(3)</sup>    | AT6003 <sup>(3)</sup> | AT6005          | AT6010          | 84 <sup>(3)</sup><br>PLCC | 100<br>VQFP | 132 <sup>(3)</sup><br>PQFP | 144<br>TQFP | 180 <sup>(3)</sup><br>CPGA | 208 <sup>(3)</sup><br>PQFP | 240 <sup>(3)</sup><br>PQFP |
| -                        | -                     | -               | I/O75(B)        | -                         | -           | -                          | -           | -                          | 185                        | 213                        |
| I/O35(A) or A14          | I/O43(A) or A14       | I/O39(A) or A14 | I/O74(A) or A14 | 3                         | 90          | 3                          | 129         | C8                         | 186                        | 214                        |
| -                        | -                     | -               | VDD             | -                         | -           | -                          | -           | PWR <sup>(1)</sup>         | 187                        | 215                        |
| VCC                      | VCC                   | VCC             | VCC             | 4                         | 91          | 4                          | 130         | PWR <sup>(1)</sup>         | 188                        | 216                        |
| I/O34(A) or A13          | I/O42(A) or A13       | I/O38(A) or A13 | I/O73(A) or A13 | 5                         | 92          | 5                          | 131         | C5                         | 189                        | 217                        |
| I/O33(B)                 | I/O41(B)              | I/O37(A)        | I/O72(A)        | -                         | -           | 6                          | 132         | C4                         | 190                        | 218                        |
| -                        | -                     | -               | I/O71(B)        | -                         | -           | -                          | -           | -                          | 191                        | 219                        |
| I/O32(A) or A12          | I/O40(A) or A12       | I/O36(A) or A12 | I/O70(A) or A12 | 6                         | 93          | 7                          | 133         | C3                         | 192                        | 220                        |
| I/O31(B)                 | I/O39(B)              | I/O35(A)        | I/O69(A)        | -                         | 94          | 8                          | 134         | B8                         | 193                        | 221                        |
| -                        | -                     | -               | I/O68(A)        | -                         | -           | -                          | -           | B7                         | 194                        | 222                        |
| -                        | -                     | -               | I/O67(B)        | -                         | -           | -                          | -           | -                          | -                          | 223                        |
| I/O30(A) or A11          | I/O38(A) or A11       | I/O34(A) or A11 | I/O66(A) or A11 | 7                         | 95          | 9                          | 135         | B6                         | 195                        | 224                        |
| -                        | I/O37(B)              | I/O33(A)        | I/O65(A)        | -                         | -           | 10                         | 136         | B5                         | 196                        | 225                        |
| -                        | -                     | -               | I/O64(A)        | -                         | -           | -                          | -           | B4                         | 197                        | 226                        |
| GND                      | GND                   | GND             | GND             | -                         | -           | 11                         | 137         | GND <sup>(2)</sup>         | 198                        | 227                        |
| -                        | -                     | -               | I/O63(B)        | -                         | -           | -                          | -           | -                          | -                          | 228                        |
| I/O29(A) or A10          | I/O36(A) or A10       | I/O32(A) or A10 | I/O62(A) or A10 | 8                         | 96          | 12                         | 138         | B3                         | 199                        | 229                        |
| I/O28(B)                 | I/O35(B)              | I/O31(A)        | I/O61(A)        | -                         | 97          | 13                         | 139         | B2                         | 200                        | 230                        |
| -                        | -                     | -               | I/O60(A)        | -                         | -           | -                          | -           | A8                         | 201                        | 231                        |
| -                        | -                     | -               | I/O59(B)        | -                         | -           | -                          | -           | -                          | -                          | 232                        |
| I/O27(A) or A9           | I/O34(A) or A9        | I/O30(A) or A9  | I/O58(A) or A9  | 9                         | 98          | 14                         | 140         | A7                         | 202                        | 233                        |
| I/O26(B)                 | I/O33(A)              | I/O29(A)        | I/O57(A)        | -                         | -           | 15                         | 141         | A6                         | 203                        | 234                        |
| -                        | -                     | -               | I/O56(A)        | -                         | -           | -                          | -           | A5                         | 204                        | 235                        |
| -                        | -                     | -               | I/O55(B)        | -                         | -           | -                          | -           | -                          | -                          | 236                        |
| -                        | I/O32(B)              | -               | I/O54(A)        | -                         | -           | -                          | 142         | A4                         | 205                        | 237                        |
| I/O25(A) or A8           | I/O31(A) or A8        | I/O28(A) or A8  | I/O53(A) or A8  | 10                        | 99          | 16                         | 143         | A3                         | 206                        | 238                        |
| -                        | -                     | -               | I/O52(A)        | -                         | -           | -                          | -           | A2                         | -207                       | 239                        |
| M0                       | M0                    | M0              | M0              | 11                        | 100         | 17                         | 144         | A1                         | 208                        | 240                        |

- Notes:
1. PWR = Pins connected to power plane = F1, E4/E5, L2, R4, K15, L12, E14, A12.
  2. GND = Pins connected to ground plane = L4, M4, N9, N10, E12, D12, C7, C6.
  3.  Obsolete. Not recommended for new design.

## AC Timing Characteristics – 5V Operation

Delays are based on fixed load. Loads for each type of device are described in the notes. Delays are in nanoseconds. Worst case:  $V_{CC} = 4.75V$  to  $5.25V$ . Temperature =  $0^{\circ}C$  to  $70^{\circ}C$ .

| Cell Function                 | Parameter            | From        | To      | Load Definition <sup>(7)</sup> | -1  | -2  | -4   | Units |
|-------------------------------|----------------------|-------------|---------|--------------------------------|-----|-----|------|-------|
| Wire <sup>(4)</sup>           | $t_{PD} (max)^{(4)}$ | A, B, L     | A, B    | 1                              | 0.8 | 1.2 | 1.8  | ns    |
| NAND                          | $t_{PD} (max)$       | A, B, L     | B       | 1                              | 1.6 | 2.2 | 3.2  | ns    |
| XOR                           | $t_{PD} (max)$       | A, B, L     | A       | 1                              | 1.8 | 2.4 | 4.0  | ns    |
| AND                           | $t_{PD} (max)$       | A, B, L     | B       | 1                              | 1.7 | 2.2 | 3.2  | ns    |
| MUX                           | $t_{PD} (max)$       | A, B        | A       | 1                              | 1.7 | 2.3 | 4.0  | ns    |
|                               |                      | L           | A       | 1                              | 2.1 | 3.0 | 4.9  | ns    |
| D-Flip-flop <sup>(5)</sup>    | $t_{setup} (min)$    | A, B, L     | CLK     | -                              | 1.5 | 2.0 | 3.0  | ns    |
| D-Flip-flop <sup>(5)</sup>    | $t_{hold} (min)$     | CLK         | A, B, L | -                              | 0   | 0   | 0    | ns    |
| D-Flip-flop                   | $t_{PD} (max)$       | CLK         | A       | 1                              | 1.5 | 2.0 | 3.0  | ns    |
| Bus Driver                    | $t_{PD} (max)$       | A           | L       | 2                              | 2.0 | 2.6 | 4.0  | ns    |
| Repeater                      | $t_{PD} (max)$       | L, E        | E       | 3                              | 1.3 | 1.6 | 2.3  | ns    |
|                               |                      | L, E        | L       | 2                              | 1.7 | 2.1 | 3.0  | ns    |
| Column Clock                  | $t_{PD} (max)$       | GCLK, A, ES | CLK     | 3                              | 1.8 | 2.4 | 3.0  | ns    |
| Column Reset                  | $t_{PD} (max)$       | GRES, A, EN | RES     | 3                              | 1.8 | 2.4 | 3.0  | ns    |
| Clock Buffer <sup>(5)</sup>   | $t_{PD} (max)$       | CLOCK PIN   | GCLK    | -                              | 1.6 | 2.0 | 2.9  | ns    |
| Reset Buffer <sup>(5)</sup>   | $t_{PD} (max)$       | RESET PIN   | GRES    | -                              | 1.5 | 1.9 | 2.8  | ns    |
| TTL Input <sup>(1)</sup>      | $t_{PD} (max)$       | I/O         | A       | 3                              | 1.0 | 1.2 | 1.5  | ns    |
| CMOS Input <sup>(2)</sup>     | $t_{PD} (max)$       | I/O         | A       | 3                              | 1.3 | 1.4 | 2.3  | ns    |
| Fast Output <sup>(3)</sup>    | $t_{PD} (max)$       | A           | I/O PIN | 4                              | 3.3 | 3.5 | 6.0  | ns    |
| Slow Output <sup>(3)</sup>    | $t_{PD} (max)$       | A           | I/O PIN | 4                              | 7.5 | 8.0 | 12.0 | ns    |
| Output Disable <sup>(5)</sup> | $t_{PXZ} (max)$      | L           | I/O PIN | 4                              | 3.1 | 3.3 | 5.5  | ns    |
| Fast Enable <sup>(3)(5)</sup> | $t_{PXZ} (max)$      | L           | I/O PIN | 4                              | 3.8 | 4.0 | 6.5  | ns    |
| Slow Enable <sup>(3)(5)</sup> | $t_{PXZ} (max)$      | L           | I/O PIN | 4                              | 8.2 | 8.5 | 12.5 | ns    |

| Device                      | Cell Types                                   | Outputs | $I_{CC} (max)$  |
|-----------------------------|--|---------|-----------------|
| Cell <sup>(6)</sup>         | Wire, XWire, Half-adder, Flip-flop           | A, B    | 4.5 $\mu A/MHz$ |
| Bus <sup>(6)</sup>          | Wire, XWire, Half-adder, Flip-flop, Repeater | L       | 2.5 $\mu A/MHz$ |
| Column Clock <sup>(6)</sup> | Column Clock Driver                          | CLK     | 40 $\mu A/MHz$  |

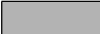
- Notes:
1. TTL buffer delays are measured from a  $V_{IH}$  of 1.5V at the pad to the internal  $V_{IH}$  at A. The input buffer load is constant.
  2. CMOS buffer delays are measured from a  $V_{IH}$  of 1/2  $V_{CC}$  at the pad to the internal  $V_{IH}$  at A. The input buffer load is constant.
  3. Buffer delay is to a pad voltage of 1.5V with one output switching.
  4. Max specifications are the average of  $t_{PDLH}$  and  $t_{PDHL}$ .
  5. Parameter based on characterization and simulation; not tested in production
  6. Exact power calculation is available in an Atmel application note.
  7. Load Definition: 1 = Load of one A or B input; 2 = Load of one L input; 3 = Constant Load; 4 = Tester Load of 50 pF.

## AC Timing Characteristics – 3.3V Operation <sup>(8)</sup>

Delays are based on fixed load. Loads for each type of device are described in the notes. Delays are in nanoseconds. Worst case:  $V_{CC} = 3.0V$  to  $3.6V$ . Temperature =  $0^{\circ}C$  to  $70^{\circ}C$ .

| Cell Function                 | Parameter            | From        | To      | Load Definition <sup>(7)</sup> | -4   | Units |
|-------------------------------|----------------------|-------------|---------|--------------------------------|------|-------|
| Wire <sup>(4)</sup>           | $t_{PD} (max)^{(4)}$ | A, B, L     | A, B    | 1                              | 1.8  | ns    |
| NAND                          | $t_{PD} (max)$       | A, B, L     | B       | 1                              | 3.2  | ns    |
| XOR                           | $t_{PD} (max)$       | A, B, L     | A       | 1                              | 4.0  | ns    |
| AND                           | $t_{PD} (max)$       | A, B, L     | B       | 1                              | 3.2  | ns    |
| MUX                           | $t_{PD} (max)$       | A, B        | A       | 1                              | 4.0  | ns    |
|                               |                      | L           | A       | 1                              | 4.9  | ns    |
| D-Flip-flop <sup>(5)</sup>    | $t_{setup} (min)$    | A, B, L     | CLK     | -                              | 3.0  | ns    |
| D-Flip-flop <sup>(5)</sup>    | $t_{hold} (min)$     | CLK         | A, B, L | -                              | 0    | ns    |
| D-Flip-flop                   | $t_{PD} (max)$       | CLK         | A       | 1                              | 3.0  | ns    |
| Bus Driver                    | $t_{PD} (max)$       | A           | L       | 2                              | 4.0  | ns    |
| Repeater                      | $t_{PD} (max)$       | L, E        | E       | 3                              | 2.3  | ns    |
|                               |                      | L, E        | L       | 2                              | 3.0  | ns    |
| Column Clock                  | $t_{PD} (max)$       | GCLK, A, ES | CLK     | 3                              | 3.0  | ns    |
| Column Reset                  | $t_{PD} (max)$       | GRES, A, EN | RES     | 3                              | 3.0  | ns    |
| Clock Buffer <sup>(5)</sup>   | $t_{PD} (max)$       | CLOCK PIN   | GCLK    | 4                              | 2.9  | ns    |
| Reset Buffer <sup>(5)</sup>   | $t_{PD} (max)$       | RESET PIN   | GRES    | 5                              | 2.8  | ns    |
| TTL Input <sup>(1)</sup>      | $t_{PD} (max)$       | I/O         | A       | 3                              | 1.5  | ns    |
| CMOS Input <sup>(2)</sup>     | $t_{PD} (max)$       | I/O         | A       | 3                              | 2.3  | ns    |
| Fast Output <sup>(3)</sup>    | $t_{PD} (max)$       | A           | I/O PIN | 6                              | 6.0  | ns    |
| Slow Output <sup>(3)</sup>    | $t_{PD} (max)$       | A           | I/O PIN | 6                              | 12.0 | ns    |
| Output Disable <sup>(5)</sup> | $t_{PXZ} (max)$      | L           | I/O PIN | 6                              | 5.5  | ns    |
| Fast Enable <sup>(3)(5)</sup> | $t_{PXZ} (max)$      | L           | I/O PIN | 6                              | 6.5  | ns    |
| Slow Enable <sup>(3)(5)</sup> | $t_{PXZ} (max)$      | L           | I/O PIN | 6                              | 12.5 | ns    |

| Device                      | Cell Types                                   | Outputs | $I_{CC} (max)$  |
|-----------------------------|--|---------|-----------------|
| Cell <sup>(6)</sup>         | Wire, XWire, Half-adder, Flip-flop           | A, B    | 2.3 $\mu A/MHz$ |
| Bus <sup>(6)</sup>          | Wire, XWire, Half-adder, Flip-flop, Repeater | L       | 1.3 $\mu A/MHz$ |
| Column Clock <sup>(6)</sup> | Column Clock Driver                          | CLK     | 20 $\mu A/MHz$  |

- Notes:
1. TTL buffer delays are measured from a  $V_{IH}$  of 1.5V at the pad to the internal  $V_{IH}$  at A. The input buffer load is constant.
  2. CMOS buffer delays are measured from a  $V_{IH}$  of 1/2  $V_{CC}$  at the pad to the internal  $V_{IH}$  at A. The input buffer load is constant.
  3. Buffer delay is to a pad voltage of 1.5V with one output switching.
  4. Max specifications are the average of  $t_{PDLH}$  and  $t_{PDHL}$ .
  5. Parameter based on characterization and simulation; not tested in production
  6. Exact power calculation is available in an Atmel application note.
  7. Load Definition: 1 = Load of one A or B input; 2 = Load of one L input; 3 = Constant Load; 4 = Load of 28 Clock Columns; 5 = Load of 28 Reset Columns; 6 = Tester Load of 50 pF.
  8.  Obsolete. Not recommended for new design.

## Absolute Maximum Ratings\*

|  |                          |
|--|--------------------------|
| Supply Voltage ( $V_{CC}$ )                        | -0.5V to + 7.0V          |
| DC Input Voltage ( $V_{IN}$ )                      | -0.5V to $V_{CC} + 0.5V$ |
| DC Output Voltage ( $V_{ON}$ )                     | -0.5V to $V_{CC} + 0.5V$ |
| Storage Temperature Range (TSTG)                   | -65°C to +150°C          |
| Power Dissipation (PD)                             | 1500 mW                  |
| Lead Temperature ( $T_L$ )<br>(Soldering, 10 sec.) | 260°C                    |
| ESD ( $R_{ZAP} = 1.5K$ , $C_{ZAP} = 100$ pF)       | 2000V                    |

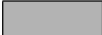
\*NOTICE: Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress rating only and functional operation of the device at these or any other conditions beyond those listed under operating conditions is not implied. Exposure to Absolute Maximum Rating conditions for extended periods of time may affect device reliability.

## DC and AC Operating Range – 5V Operation

|   |                    | AT6002-2/4 <sup>(1)</sup><br>AT6003-2/4 <sup>(1)</sup><br>AT6005-2/4 <sup>(1)</sup><br>AT6010-2/4 <sup>(1)</sup><br>Commercial <sup>(1)</sup> | AT6002-2/4 <sup>(1)</sup><br>AT6003-2/4 <sup>(1)</sup><br>AT6005-2/4 <sup>(1)</sup><br>AT6010-2/4 <sup>(1)</sup><br>Industrial | AT6002-2/4 <sup>(1)</sup><br>AT6003-2/4 <sup>(1)</sup><br>AT6005-2/4 <sup>(1)</sup><br>AT6010-2/4 <sup>(1)</sup><br>Military <sup>(1)</sup> |
|---|--------------------|---|--|---|
| Operating Temperature (Case)              |                    | 0°C - 70°C  | -40°C - 85°C   | -55°C - 125°C   |
| $V_{CC}$ Power Supply                     |                    | 5V ± 5%   | 5V ± 10%   | 5V ± 10%  |
| Input Voltage Level (TTL)                 | High ( $V_{IHT}$ ) | 2.0V - $V_{CC}$   | 2.0V - $V_{CC}$  | 2.0V - $V_{CC}$   |
|   | Low ( $V_{ILT}$ )  | 0V - 0.8V   | 0V - 0.8V  | 0V - 0.8V   |
| Input Voltage Level (CMOS)                | High ( $V_{IHC}$ ) | 70% - 100% $V_{CC}$   | 70% - 100% $V_{CC}$  | 70% - 100% $V_{CC}$   |
|   | Low ( $V_{ILC}$ )  | 0 - 30% $V_{CC}$  | 0 - 30% $V_{CC}$   | 0 - 30% $V_{CC}$  |
| Input Signal Transition Time ( $T_{IN}$ ) |                    | 50 ns (max)   | 50 ns (max)  | 50 ns (max)   |


## DC and AC Operating Range – 3.3V Operation<sup>(1)</sup>

|   |                    | AT6002-2/4 <sup>(1)</sup> , AT6003-2/4 <sup>(1)</sup><br>AT6005-2/4 <sup>(1)</sup> , AT6010-2/4 <sup>(1)</sup><br>Commercial |
|---|--------------------|--|
| Operating Temperature (Case)              |                    | 0°C - 70°C   |
| $V_{CC}$ Power Supply                     |                    | 3.3V ± 5%  |
| Input Voltage Level (TTL)                 | High ( $V_{IHT}$ ) | 2.0V - $V_{CC}$  |
|   | Low ( $V_{ILT}$ )  | 0V - 0.8V  |
| Input Voltage Level (CMOS)                | High ( $V_{IHC}$ ) | 70% - 100% $V_{CC}$  |
|   | Low ( $V_{ILC}$ )  | 0 - 30% $V_{CC}$   |
| Input Signal Transition Time ( $T_{IN}$ ) |                    | 50 ns (max)  |

Note: 1.  Obsolete. Not recommended for new design.

## DC Characteristics – 5V Operation

| Symbol           | Parameter                 | Conditions   |   | Min                 | Max                 | Units |
|------------------|---------------------------|--|---|---------------------|---------------------|-------|
| V <sub>IH</sub>  | High-level Input Voltage  | Commercial   | CMOS  | 70% V <sub>CC</sub> | V <sub>CC</sub>     | V     |
|                  |                           |  | TTL   | 2.0                 | V <sub>CC</sub>     | V     |
| V <sub>IL</sub>  | Low-level Input Voltage   | Commercial   | CMOS  | 0                   | 30% V <sub>CC</sub> | V     |
|                  |                           |  | TTL   | 0                   | 0.8                 | V     |
| V <sub>OH</sub>  | High-level Output Voltage | Commercial   | I <sub>OH</sub> = -4 mA, V <sub>CC</sub> min  | 3.9                 |                     | V     |
|                  |                           |  | I <sub>OH</sub> = -16 mA, V <sub>CC</sub> min | 3.0                 |                     | V     |
| V <sub>OL</sub>  | Low-level Output Voltage  | Commercial   | I <sub>OL</sub> = 4 mA, V <sub>CC</sub> min   |                     | 0.4                 | V     |
|                  |                           |  | I <sub>OL</sub> = 16 mA, V <sub>CC</sub> min  |                     | 0.5                 | V     |
| I <sub>OZH</sub> | High-level Tristate       | V <sub>O</sub> = V <sub>CC</sub> (max)             |   |                     | 10                  | μA    |
|                  | Output Leakage Current    |  |   |                     |                     |       |
| I <sub>OZL</sub> | High-level Tristate       | Without Pull-up, V <sub>O</sub> = V <sub>SS</sub>  |   | -10                 |                     | μA    |
|                  | Output Leakage Current    | With Pull-up, V <sub>O</sub> = V <sub>SS</sub>     |   | -500                |                     | μA    |
| I <sub>IH</sub>  | High-level Input Current  | V <sub>IN</sub> = V <sub>CC</sub> (max)            |   |                     | 10                  | μA    |
| I <sub>IL</sub>  | Low-level Input Current   | Without Pull-up, V <sub>IN</sub> = V <sub>SS</sub> |   | -10                 |                     | μA    |
|                  |                           | With Pull-up, V <sub>IN</sub> = V <sub>SS</sub>    |   | -500                |                     | μA    |
| I <sub>CC</sub>  | Power Consumption         | Without Internal Oscillator (Standby)              |   |                     | 500                 | μA    |
| C <sub>IN</sub>  | Input Capacitance         | All Pins   |   |                     | 10                  | pF    |

Note: 1.  Obsolete. Not recommended for new design.

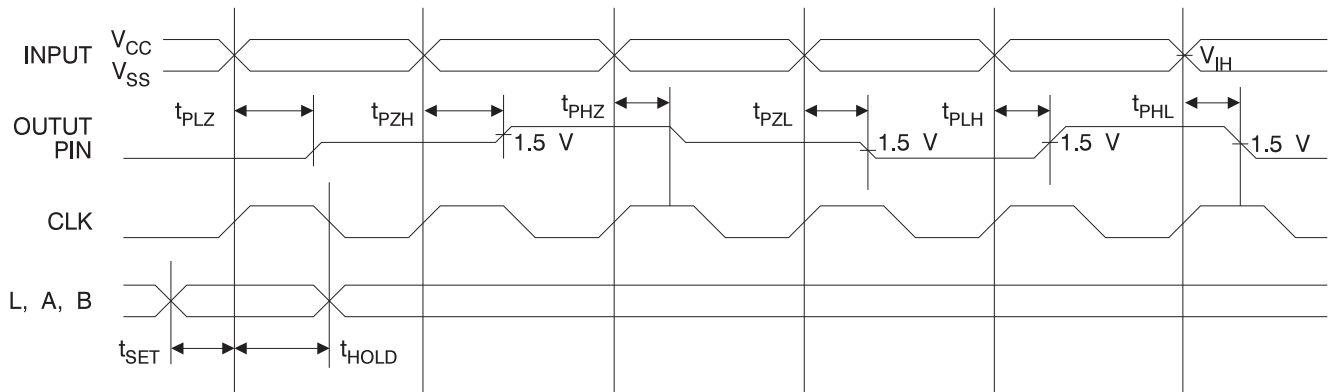
## DC Characteristics – 3.3V Operation<sup>(2)</sup>

| Symbol         | Parameter                 | Conditions                            | Min  | Max          | Units         |
|----------------|---------------------------|---------------------------------------|--|--------------|---------------|
| $V_{IH}$       | High-level Input Voltage  | Commercial                            | CMOS   | 70% $V_{CC}$ | V             |
|                |                           |                                       | TTL  | 2.0          | V             |
| $V_{IL}$       | Low-level Input Voltage   | Commercial                            | CMOS   | 0            | 30% $V_{CC}$  |
|                |                           |                                       | TTL  | 0            | 0.8           |
| $V_{OH}$       | High-level Output Voltage | Commercial                            | $I_{OH} = -2 \text{ mA}, V_{CC} \text{ min}$ | 2.4          | V             |
|                |                           |                                       | $I_{OH} = -6 \text{ mA}, V_{CC} \text{ min}$ | 2.0          | V             |
| $V_{OL}$       | Low-level Output Voltage  | Commercial                            | $I_{OL} = +2 \text{ mA}, V_{CC} \text{ min}$ | 0.4          | V             |
|                |                           |                                       | $I_{OL} = +6 \text{ mA}, V_{CC} \text{ min}$ | 0.5          | V             |
| $I_{OZH}$      | High-level Tristate       | $V_O = V_{CC} \text{ (max)}$          |  | 10           | $\mu\text{A}$ |
|                | Output Leakage Current    |                                       |  |              |               |
| $I_{OZL}$      | High-level Tristate       | Without Pull-up, $V_O = V_{SS}$       | -10  |              | $\mu\text{A}$ |
|                | Output Leakage Current    | With Pull-up, $V_O = V_{SS}$          | -500   |              | $\mu\text{A}$ |
| $I_{IH}$       | High-level Input Current  | $V_{IN} = V_{CC} \text{ (max)}$       |  | 10           | $\mu\text{A}$ |
| $I_{IL}$       | Low-level Input Current   | Without Pull-up, $V_{IN} = V_{SS}$    | -10  |              | $\mu\text{A}$ |
|                |                           | With Pull-up, $V_{IN} = V_{SS}$       | -500   |              | $\mu\text{A}$ |
| $I_{CC}$       | Power Consumption         | Without Internal Oscillator (Standby) |  | 200          | $\mu\text{A}$ |
| $C_{IN}^{(1)}$ | Input Capacitance         | All Pins                              |  | 10           | pF            |

Notes: 1. Parameter based on characterization and simulation; it is not tested in production.

2.   Obsolete. Not recommended for new design.


## Device Timing: During Operation





Ordering Information – AT6002<sup>(1)</sup>

| Usable Gates | Speed Grade (ns) | Ordering Code | Package | Operation Range                  |
|--------------|------------------|---------------|---------|----------------------------------|
| 6,000        | 2                | AT6002-2AC    | 100A    | 5V Commercial<br>(0°C to 70°C)   |
|              |                  | AT6002A-2AC   | 144A    |                                  |
|              |                  | AT6002-2JC    | 84J     |                                  |
|              |                  | AT6002-2QC    | 132Q    |                                  |
|              |                  | AT6002-2AI    | 100A    | 5V Industrial<br>(-40°C to 85°C) |
|              |                  | AT6002A-2AI   | 144A    |                                  |
|              |                  | AT6002-2JI    | 84J     |                                  |
|              |                  | AT6002-2QI    | 132Q    |                                  |
| 6,000        | 4                | AT6002-4AC    | 100A    | 5V Commercial<br>(0°C to 70°C)   |
|              |                  | AT6002A-4AC   | 144A    |                                  |
|              |                  | AT6002-4JC    | 84J     |                                  |
|              |                  | AT6002-4QC    | 132Q    |                                  |
|              |                  | AT6002LV-4AC  | 100A    | 3.3V Commercial<br>(0°C to 70°C) |
|              |                  | AT6002ALV-4AC | 144A    |                                  |
|              |                  | AT6002LV-4JC  | 84J     |                                  |
|              |                  | AT6002LV-4QC  | 132Q    |                                  |
|              |                  | AT6002-4AI    | 100A    | 5V Industrial<br>(-40°C to 85°C) |
|              |                  | AT6002A-4AI   | 144A    |                                  |
|              |                  | AT6002-4JI    | 84J     |                                  |
|              |                  | AT6002-4QI    | 132Q    |                                  |

Note: 1.  Obsolete. Not recommended for new design.

| Package Type |   |
|--------------|---|
| <b>84J</b>   | 84-lead, Plastic J-leaded Chip Carrier (PLCC)                           |
| <b>100A</b>  | 100-lead, Very Thin (1.0 mm) Plastic Gull-Wing Quad Flat Package (VQFP) |
| <b>132Q</b>  | 132-lead, Bumped Plastic Gull-Wing Quad Flat Package (BQFP)             |
| <b>144A</b>  | 144-lead, Thin (1.4 mm) Plastic Gull-Wing Quad Flat Package (TQFP)      |
| <b>208Q</b>  | 208-lead, Plastic Gull-Wing Quad Flat Package (PQFP)                    |
| <b>240Q</b>  | 240-lead, Plastic Gull-Wing Quad Flat Package (PQFP)                    |

## Ordering Information – AT6003<sup>(1)</sup>


| Usable Gates | Speed Grade (ns) | Ordering Code | Package | Operation Range                  |
|--------------|------------------|---------------|---------|----------------------------------|
| 9,000        | 2                | AT6003-2AC    | 100A    | 5V Commercial<br>(0°C to 70°C)   |
|              |                  | AT6003A-2AC   | 144A    |                                  |
|              |                  | AT6003-2JC    | 84J     |                                  |
|              |                  | AT6003-2QC    | 132Q    |                                  |
|              |                  | AT6003-2AI    | 100A    | Industrial<br>(-40°C to 85°C)    |
|              |                  | AT6003A-2AI   | 144A    |                                  |
|              |                  | AT6003-2JI    | 84J     |                                  |
|              |                  | AT6003-2QI    | 132Q    |                                  |
| 9,000        | 4                | AT6003-4AC    | 100A    | 5V Commercial<br>(0°C to 70°C)   |
|              |                  | AT6003A-4AC   | 144A    |                                  |
|              |                  | AT6003-4JC    | 84J     |                                  |
|              |                  | AT6003-4QC    | 132Q    |                                  |
|              |                  | AT6003LV-4AC  | 100A    | 3.3V Commercial<br>(0°C to 70°C) |
|              |                  | AT6003ALV-4AC | 144A    |                                  |
|              |                  | AT6003LV-4JC  | 84J     |                                  |
|              |                  | AT6003LV-4QC  | 132Q    |                                  |
|              |                  | AT6003-4AI    | 100A    | 5V Industrial<br>(-40°C to 85°C) |
|              |                  | AT6003A-4AI   | 144A    |                                  |
|              |                  | AT6003-4JI    | 84J     |                                  |
|              |                  | AT6003-4QI    | 132Q    |                                  |

Note: 1.  Obsolete. Not recommended for new design.

| Package Type |   |
|--------------|---|
| <b>84J</b>   | 84-lead, Plastic J-leaded Chip Carrier (PLCC)                           |
| <b>100A</b>  | 100-lead, Very Thin (1.0 mm) Plastic Gull-Wing Quad Flat Package (VQFP) |
| <b>132Q</b>  | 132-lead, Bumped Plastic Gull-Wing Quad Flat Package (BQFP)             |
| <b>144A</b>  | 144-lead, Thin (1.4 mm) Plastic Gull-Wing Quad Flat Package (TQFP)      |
| <b>208Q</b>  | 208-lead, Plastic Gull-Wing Quad Flat Package (PQFP)                    |
| <b>240Q</b>  | 240-lead, Plastic Gull-Wing Quad Flat Package (PQFP)                    |

## Ordering Information – AT6005


| Usable Gates | Speed Grade (ns) | Ordering Code | Package | Operation Range                              |
|--------------|------------------|---------------|---------|--|
| 15,000       | 2                | AT6005-2AU    | 100A    | 5V Industrial Temperature<br>(-40°C to 85°C) |
| 15,000       | 2                | AT6005-2AC    | 100A    | 5V Commercial<br>(0°C to 70°C)               |
|              |                  | AT6005A-2AC   | 144A    |  |
|              |                  | AT6005-2JC    | 84J     |  |
|              |                  | AT6005-2QC    | 132Q    |  |
|              |                  | AT6005A-2QC   | 208Q    |  |
|              |                  | AT6005-2AI    | 100A    | Industrial<br>(-40°C to 85°C)                |
|              |                  | AT6005A-2AI   | 144A    |  |
|              |                  | AT6005-2JI    | 84J     |  |
|              |                  | AT6005-2QI    | 132Q    |  |
|              |                  | AT6005A-2QI   | 208Q    |  |
| 15,000       | 4                | AT6005-4AC    | 100A    | 5V Commercial<br>(0°C to 70°C)               |
|              |                  | AT6005A-4AC   | 144A    |  |
|              |                  | AT6005-4JC    | 84J     |  |
|              |                  | AT6005-4QC    | 132Q    |  |
|              |                  | AT6005A-4QC   | 208Q    |  |
|              |                  | AT6005LV-4AC  | 100A    | 3.3V Commercial<br>(0°C to 70°C)             |
|              |                  | AT6005ALV-4AC | 144A    |  |
|              |                  | AT6005LV-4JC  | 84J     |  |
|              |                  | AT6005LV-4QC  | 132Q    |  |
|              |                  | AT6005ALV-4QC | 208Q    |  |
|              |                  | AT6005-4AI    | 100A    | 5V Commercial<br>(-40°C to 85°C)             |
|              |                  | AT6005A-4AI   | 144A    |  |
|              |                  | AT6005-4JI    | 84J     |  |
|              |                  | AT6005-4QI    | 132Q    |  |
|              |                  | AT6005A-4QI   | 208Q    |  |

Note: 1  Obsolete. Package options are not recommended for new design.

| Package Type |   |
|--------------|---|
| <b>84J</b>   | 84-lead, Plastic J-leaded Chip Carrier (PLCC)                           |
| <b>100A</b>  | 100-lead, Very Thin (1.0 mm) Plastic Gull-Wing Quad Flat Package (VQFP) |
| <b>132Q</b>  | 132-lead, Bumped Plastic Gull-Wing Quad Flat Package (BQFP)             |
| <b>144A</b>  | 144-lead, Thin (1.4 mm) Plastic Gull-Wing Quad Flat Package (TQFP)      |
| <b>208Q</b>  | 208-lead, Plastic Gull-Wing Quad Flat Package (PQFP)                    |
| <b>240Q</b>  | 240-lead, Plastic Gull-Wing Quad Flat Package (PQFP)                    |

## Ordering Information – AT6010

| Usable Gates | Speed Grade (ns) | Ordering Code | Package | Operation Range                              |
|--------------|------------------|---------------|---------|--|
| 30,000       | 2                | AT6010A-2AU   | 144A    | 5V Industrial Temperature<br>(-40°C to 85°C) |
| 30,000       | 2                | AT6010-2JC    | 84J     | 5V Commercial<br>(0°C to 70°C)               |
|              |                  | AT6010A-2AC   | 144A    |  |
|              |                  | AT6010-2QC    | 132Q    |  |
|              |                  | AT6010A-2QC   | 208Q    |  |
|              |                  | AT6010H-2QC   | 240Q    |  |
|              |                  | AT6010-2JI    | 84J     | Industrial<br>(-40°C to 85°C)                |
|              |                  | AT6010A-2AI   | 144A    |  |
|              |                  | AT6010-2QI    | 132Q    |  |
|              |                  | AT6010A-2QI   | 208Q    |  |
|              |                  | AT6010H-2QI   | 240Q    |  |
| 30,000       | 4                | AT6010A-4AC   | 144A    | 5V Commercial<br>(0°C to 70°C)               |
|              |                  | AT6010-4QC    | 132Q    |  |
|              |                  | AT6010-4JC    | 84J     |  |
|              |                  | AT6010A-4QC   | 208Q    |  |
|              |                  | AT6010H-4QC   | 240Q    |  |
|              |                  | AT6010ALV-4AC | 144A    | 3.3V Commercial<br>(0°C to 70°C)             |
|              |                  | AT6010LV-4QC  | 132Q    |  |
|              |                  | AT6010LV-4JC  | 84J     |  |
|              |                  | AT6010ALV-4QC | 208Q    |  |
|              |                  | AT6010HLV-4QC | 240Q    |  |
|              |                  | AT6010A-4AI   | 144A    | 5V Industrial<br>(-40°C to 85°C)             |
|              |                  | AT6010-4QI    | 132Q    |  |
|              |                  | AT6010-4JI    | 84J     |  |
|              |                  | AT6010A-4QI   | 208Q    |  |
|              |                  | AT6010H-4QI   | 240Q    |  |

Note: 1  Obsolete. Package options are not recommended for new design.

| Package Type |   |
|--------------|---|
| <b>84J</b>   | 84-lead, Plastic J-leaded Chip Carrier (PLCC)                           |
| <b>100A</b>  | 100-lead, Very Thin (1.0 mm) Plastic Gull-Wing Quad Flat Package (VQFP) |
| <b>132Q</b>  | 132-lead, Bumped Plastic Gull-Wing Quad Flat Package (BQFP)             |
| <b>144A</b>  | 144-lead, Thin (1.4 mm) Plastic Gull-Wing Quad Flat Package (TQFP)      |
| <b>208Q</b>  | 208-lead, Plastic Gull-Wing Quad Flat Package (PQFP)                    |
| <b>240Q</b>  | 240-lead, Plastic Gull-Wing Quad Flat Package (PQFP)                    |

## Revision History

| Doc. No. | Date    | Description   |
|----------|---------|---|
| 0264G    | 04/2015 | Obsoleted AT6002, AT6003, and all AT6K low voltage (LV) devices and the AT6005 and AT6010A lead based packages.<br>Added lead free packages options for AT6005 and AT6010A devices. |
| 0264F    | 10/2009 |   |



**Atmel Corporation** 1600 Technology Drive, San Jose, CA 95110 USA T: (+1)(408) 441.0311 F: (+1)(408) 436.4200 | **www.atmel.com**

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