

RadTolerant FPGAs

Features

General Characteristics

- Tested Total Ionizing Dose (TID) Survivability Level
- No Single Event Latch-up Below a Minimum LET Threshold of 80 MeV-cm²/mg for All RT Devices
- Packages: 84-Pin, 132-Pin, 172-Pin, 196-Pin, and 256-Pin Ceramic Quad Flat Pack
- Offered as Class B and E-Flow (Actel Space Level Flow)
- QML Certified Devices
- 100% Military Temperature Tested (–55°C to +125°C)

High Density and Performance

- 4,000 to 20,000 Logic Equivalent Gates
- 2,000 to 10,000 ASIC Equivalent Gates
- Up to 85 MHz Internal Performance
- Up to 60 MHz System Performance
- Up to 228 User I/Os
- Up to Four Fast, Low-Skew Clock Networks

Easy Logic Integration

- Non-Volatile, User Programmable
- Pin-Compatible Commercial Devices Available for Prototyping
- Highly Predictable Performance with 100% Automatic Place and Route

- 100% Resource Utilization with 100% Pin-Locking
- Secure Programming Technology Prevents Reverse Engineering and Design Theft
- Permanently Programmed for Operation on Power-Up
- Unique In-System Diagnostic and Verification Capability with Silicon Explorer

General Description

Actel builds the most reliable field programmable gate arrays (FPGAs) in the industry, with overall antifuse reliability ratings of less than 10 failures-in-time (FITs), corresponding to a useful life of more than 40 years. Actel FPGAs are production-proven, with more than five million devices shipped and more than one trillion antifuses manufactured. Actel devices are fully tested prior to shipment, with an out-going defect level of only 122 ppm (further reliability data is available in the *Actel Device Reliability Report* at <http://www.actel.com/hirel>).

Additionally, the programmable architecture of these devices offers high performance, design flexibility, and fast and inexpensive prototyping—all without the expense of test vectors, NRE charges, long lead times, and schedule and cost penalties for design refinements.

Product Family Profile

Device	RT1020	RT1280A	RT1425A	RT1460A	RT14100A
Capacity					
System Gates	6,000	24,000	7,500	18,000	30,000
Logic Gates	4,000	16,000	5,000	12,000	20,000
ASIC Equivalent Gates	2,000	8,000	2,500	6,000	10,000
PLD Equivalent Gates	5,000	20,000	6,250	15,000	25,000
TTL Equivalent Package	50	200	60	150	250
20-Pin PAL Equivalent Packages	20	80	25	60	100
Logic Modules	547	1,232	310	848	1,377
S-Modules	N/A	624	160	432	697
C-Modules	547	608	150	416	680
User I/Os (Maximum)	69	140	100	168	228
Performance					
System Speed (Maximum)	20 MHz	40 MHz	60 MHz	60 MHz	60 MHz
Packages (by Pin Count)					
CQFP	84	172	132	196	256

Device Description

The RT1020 device contains the same architecture as the A1020, A1020A, and A1020B devices. The architecture, a combinatorial logic module, is a logic structure that has 8 inputs and 1 output. The logic itself is comprised of a 4-input MUX, as described in [Figure 3 on page 6](#). In addition, since the RT1020 device contains the same number of gates and I/Os and has the same operating voltage as its commercial equivalent (A1020B), an inexpensive commercial grade A1020B-CQ84 device can be used during the prototype phase, and replaced by the RT1020 in the flight units.

The RT1280A device uses the A1280A die from the ACT 2 family of FPGAs. It utilizes a two-module architecture, consisting of combinatorial modules (C-modules) and sequential modules (S-modules) optimized for both combinatorial and sequential designs. Based on Actel's patented channeled array architecture, the RT1280A has 8,000 ASIC-equivalent gates and 140 user I/Os.

The RT1280A device is fully pin- and function-compatible with the commercially-equivalent A1280A-CQ172C device for easy and inexpensive prototyping.

The RT1425A, RT1460A and RT14100A devices use the A1425A, A1460A and A14100A die, respectively. These devices are derived from the ACT 3 family of FPGAs, which also utilize the two-module channeled array architecture, and offer faster performance than the RT1280A.

These devices also have fully pin- and function-compatible commercially-equivalent devices for easy and inexpensive prototyping. The A1425A-CQ132C is used for the RT1425A, the A1460A-CQ196C is used for the RT1460A, and the A14100A-CQ256C is used for the RT14100A.

Radiation Survivability

Total dose results are summarized in two ways. First by the maximum total dose level that is reached when the parts fail to meet a device specification but remain functional. For Actel FPGAs, the parameter that exceeds the specification first is I_{CC} , the standby supply current. Second by the maximum total dose that is reached prior to the functional failure of the device.

The RT devices have varying total dose radiation survivability. The ability of these devices to survive radiation effects is both device and lot dependent. The customer must evaluate and determine the applicability of these devices to their specific design and environmental requirements.

Typical results for the RT1020 device has shown ~100Krad (Si) for standby I_{CC} and >100Krad for functional failure. RT1280A device have shown results from 4 to 10Krad (Si) for standby I_{CC} , and 7 to 18Krad for functional failure. ACT 3 devices typical results have shown 10 to 28Krad for I_{CC} , and 20 to 77Krad for functional failure.

Actel will provide total dose radiation testing along with the test data on each pedigreed lot that is available for sale. These reports are available on our website or you can contact your local sales representative to receive a copy. A listing of available lots and devices is also provided. These results are only provided for reference and for customer information.

For a radiation performance summary, see *Radiation Performance of Actel Products* on the Actel Website at <http://www.actel.com/hirel>.

This summary will also show single event upset (SEU) and single event latch up (SEL) testing that has been performed on Actel FPGAs.

QML Certification

Actel has achieved full QML certification, demonstrating that quality management, procedures, processes, and controls are in place and comply with MIL-PRF-38535, the performance specification used by the Department of Defense for monolithic integrated circuits. QML certification is a good example of Actel's commitment to supplying the highest quality products for all types of high-reliability, military and space applications.

Many suppliers of microelectronics components have implemented QML as their primary worldwide business system. Appropriate use of this system not only helps in the implementation of advanced technologies, but also allows for a quality, reliable and cost-effective logistics support throughout QML products' life cycles.

Disclaimer

All radiation performance information is provided for information purposes only and is not guaranteed. The total dose effects are lot-dependent, and Actel does not guarantee that future devices will continue to exhibit similar radiation characteristics. In addition, actual performance can vary widely due to a variety of factors, including but not limited to, characteristics of the orbit, radiation environment, proximity to satellite exterior, amount of inherent shielding from other sources within the satellite, and actual bare die variations. For these reasons, Actel does not guarantee any level of radiation survivability, and it is solely the responsibility of the customer to determine whether the device will meet the requirements of the specific design.

Development Tool Support

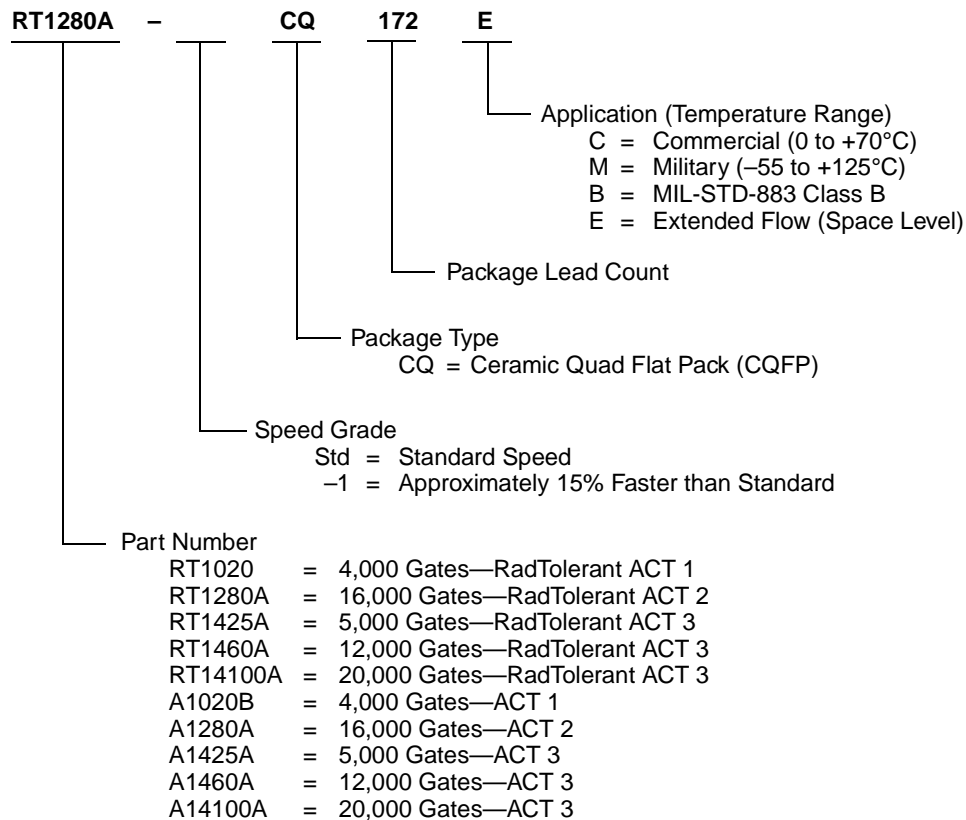
The RadTolerant devices are fully supported by Actel's line of FPGA development tools, including the Actel DeskTOP series and Designer Advantage tools. The Actel DeskTOP Series is an integrated design environment for PCs that includes design entry, simulation, synthesis, and place and route tools. Designer Advantage is Actel's suite of FPGA development

point tools for PCs and Workstations that includes the ACTgen Macro Builder, Designer with DirectTime timing driven place and route and analysis tools, and device programming software.

In addition, the RadTolerant devices contain ActionProbe circuitry that provides built-in access to every node in a design, enabling 100-percent real-time observation and analysis of a device's internal logic nodes without design iteration. The probe circuitry is accessed by Silicon Explorer,

an easy to use integrated verification and logic analysis tool that can sample data at 100 MHz (asynchronous) or 66 MHz (synchronous). Silicon Explorer attaches to a PC's standard COM port, turning the PC into a fully functional 18 channel logic analyzer. Silicon Explorer allows designers to complete the design verification process at their desks and reduces verification time from several hours per cycle to a few seconds.

RadTolerant Device Ordering Information





Product Plan

	Speed Grade		Application			
	Std	-1*	C	M	B	E
ACT 1						
RT1020 Device						
84-Pin Ceramic Quad Flat Pack (CQFP)	✓	—	—	—	✓	✓
A1020B Device (Prototyping Use)						
84-Pin Ceramic Quad Flat Pack (CQFP)	✓	✓	✓	✓	✓	—
ACT 2						
RT1280A Device						
172-Pin Ceramic Quad Flat Pack (CQFP)	✓	✓	—	—	✓	✓
A1280A Device (Prototyping Use)						
172-Pin Ceramic Quad Flat Pack (CQFP)	✓	✓	✓	✓	✓	—
ACT 3						
RT1425A Device						
132-Pin Ceramic Quad Flat Pack (CQFP)	✓	✓	—	—	✓	✓
A1425A Device (Prototyping Use)						
132-Pin Ceramic Quad Flat Pack (CQFP)	✓	✓	✓	✓	✓	—
RT1460A Device						
196-Pin Ceramic Quad Flat Pack (CQFP)	✓	✓	—	—	✓	✓
A1460A Device (Prototyping Use)						
196-Pin Ceramic Quad Flat Pack (CQFP)	✓	✓	✓	✓	✓	—
RT14100A Device						
256-Pin Ceramic Quad Flat Pack (CQFP)	✓	✓	—	—	✓	✓
A14100A Device (Prototyping Use)						
256-Pin Ceramic Quad Flat Pack (CQFP)	✓	✓	✓	✓	✓	—

Contact your Actel sales representative for product availability.

Applications: C = Commercial Availability: ✓ = Available *Speed Grade: -1 = Approx. 15% faster than Standard
 M = Military — = Not Planned
 B = MIL-STD-883
 E = Extended Flow

Device Resources

FPGA Device Type	Logic Modules	Gate Array Equivalent Gates	User I/Os				
			CQFP 84-Pin	CQFP 132-Pin	CQFP 172-Pin	CQFP 196-Pin	CQFP 256-Pin
RT1020/A1020B	547	2,000	69	—	—	—	—
RT1280A/A1280A	1,232	8,000	—	—	140	—	—
RT1425A/A1425A	310	2,500	—	100	—	—	—
RT1460A/A1460A	848	6,000	—	—	—	168	—
RT14100A/A14100A	1,377	10,000	—	—	—	—	228

Package Definitions: CQFP = Ceramic Quad Flat Pack
 (Contact your Actel sales representative for product availability.)

RadTolerant Architecture

The Actel architecture is composed of fine-grained logic modules that produce fast, efficient logic designs. All devices are composed of logic modules, routing resources, clock networks, and I/O modules which are the building blocks for fast logic designs.

Logic Modules

These RadTolerant devices contain two types of logic modules, combinatorial (C-modules) and sequential (S-modules). RT1020 and A1020B devices contain only C-modules.

The C-module, shown in Figure 1, implements the following function:

$$Y = !S1 * !S0 * D00 + !S1 * S0 * D01 + S1 * !S0 * D10 + S1 * S0 * D11$$

where:

$$S0 = A0 * B0$$

$$S1 = A1 + B1$$

The S-module, shown in Figure 2, is designed to implement high-speed sequential functions within a single logic module. The S-module implements the same combinatorial logic function as the C-module while adding a sequential element. The sequential element can be configured as either a D-type

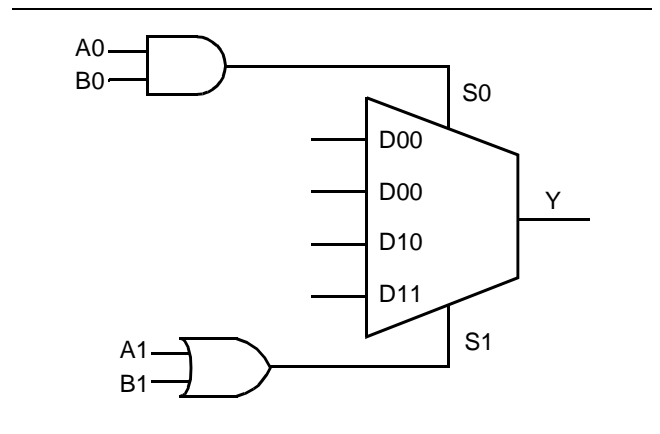


Figure 1 • C-Module Implementation

flip-flop or a transparent latch. To increase flexibility, the S-module register can be by-passed so it implements purely combinatorial logic.

Flip-flops can also be created using two C-modules. The SEU characteristics differ between an S-module flip-flop and a flip-flop created using two C-modules. For details see the *Design Techniques for RadHard Field Programmable Gate Arrays* application note at <http://www.actel.com/hirel>.

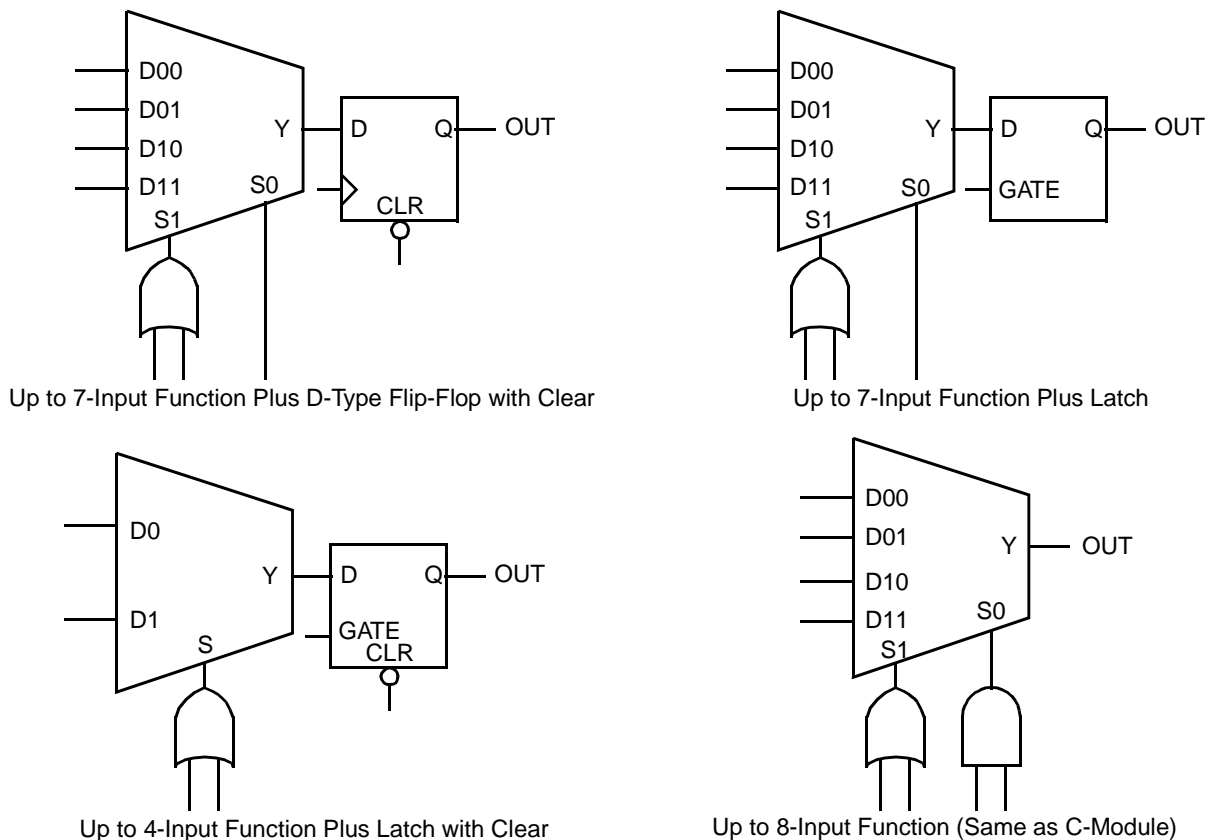


Figure 2 • S-Module Implementation

The RT1020 Logic Module

The RT1020 logic module is an 8-input, one-output logic circuit chosen for the wide range of functions it implements and for its efficient use of interconnect routing resources (Figure 3).

The logic module can implement the four basic logic functions (NAND, AND, OR, and NOR) in gates of two, three, or four inputs. Each function may have many versions, with different combinations of active-low inputs. The logic module can also implement a variety of D-latches, exclusivity functions, AND-ORs, and OR-ANDs. No dedicated hardwired latches or flip-flops are required in the array, since latches and flip-flops may be constructed from logic modules wherever needed in the application.

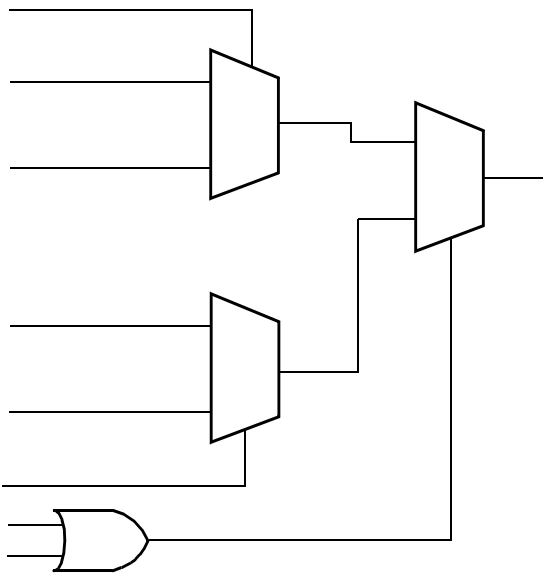
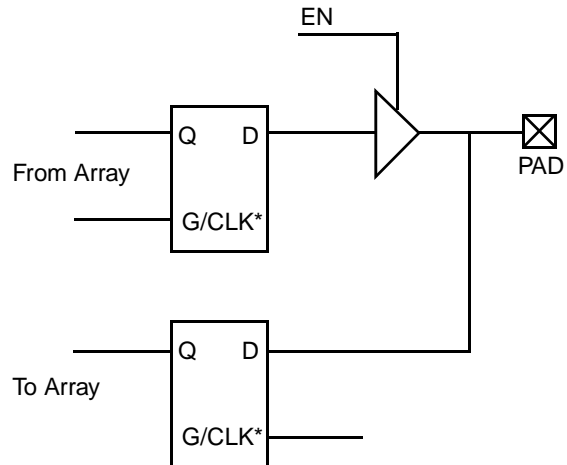


Figure 3 • RT1020 Logic Module

I/O Modules

I/O modules provide the interface between the device pins and the logic array. A variety of user functions, determined by a library macro selection, can be implemented in the module (refer to the *Macro Library Guide* for more information). I/O modules contain a tri-state buffer, and input and output latches that can be configured for input, output, or bi-directional pins (Figure 4).

The RadTolerant devices contain flexible I/O structures in that each output pin has a dedicated output enable control. The I/O module can be used to latch input and/or output data, providing a fast set-up time. In addition, the Actel Designer Series software tools can build a D flip-flop, using a C-module, to register input and/or output signals.



* Can be configured as a Latch or D Flip-Flop (Using C-Module)

Figure 4 • I/O Module

Actel's Designer Series development tools provide a design library of I/O macros. The I/O macro library provides macro functions that can implement all I/O configurations supported by the RadTolerant FPGAs.

Routing Structure

The RadTolerant device architecture uses vertical and horizontal routing tracks to interconnect the various logic and I/O modules. These routing tracks are metal interconnects that may either be of continuous length or broken into segments. Varying segment lengths allow over 90% of the circuit interconnects to be made with only two antifuse connections. Segments can be joined together at the ends, using antifuses to increase their length up to the full length of the track. All interconnects can be accomplished with a maximum of four antifuses.

Horizontal Routing

Horizontal channels are located between the rows of modules, and are composed of several routing tracks. The horizontal routing tracks within the channel are divided into one or more segments. The minimum horizontal segment length is the width of a module-pair, and the maximum horizontal segment length is the full length of the channel. Any segment that spans more than one-third the row length is considered a long horizontal segment. A typical channel is shown in Figure 5 on page 7. Non-dedicated horizontal routing tracks are used to route signal nets. Dedicated routing tracks are used for the global clock networks, and for power and ground tie-off tracks.

Vertical Routing

Another set of routing tracks run vertically through the module. There are three types of vertical tracks, input, output, and long, that can be divided into one or more segments. Each segment in an input track is dedicated to the input of a particular module. Each segment in an output track is dedicated to the output of a particular module. Long segments are uncommitted and can be assigned during routing. Each output segment spans four channels (two above and two below), except near the top and bottom of the array where edge effects occur. Long vertical tracks contain either one or two segments. An example of vertical routing tracks and segments is shown in Figure 5.

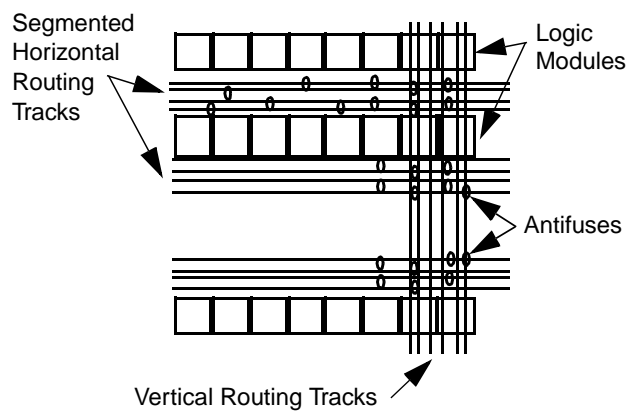


Figure 5 • Routing Structure

Antifuse Structures

An antifuse is a “normally open” structure as opposed to the normally closed fuse structure used in PROMs or PALs. The use of antifuses to implement a programmable logic device results in highly testable structures, as well as efficient programming algorithms. The structure is highly testable because there are no pre-existing connections, enabling temporary connections to be made using pass transistors. These temporary connections can isolate individual antifuses to be programmed, as well as isolate individual circuit structures to be tested. This can be done both before and after programming. For example, all metal tracks can be tested for continuity and shorts between adjacent tracks, and the functionality of all logic modules can be verified.

Actel MIL-STD-883 Product Flow

Step	Screen	883 Method	883—Class B Requirement
1.	Internal Visual	2010, Test Condition B	100%
2.	Temperature Cycling	1010, Test Condition C	100%
3.	Constant Acceleration	2001, Test Condition D or E, Y ₁ , Orientation Only	100%
4.	Seal a. Fine b. Gross	1014	100% 100%
5.	Visual Inspection	2009	100%
6.	Pre-Burn-In Electrical Parameters	In accordance with applicable Actel device specification	100%
7.	Burn-in Test	1015, Condition D, 160 hours @ 125°C or 80 hours @ 150°C	100%
8.	Interim (Post-Burn-In) Electrical Parameters	In accordance with applicable Actel device specification	100%
9.	Percent Defective Allowable	5%	All Lots
10.	Final Electrical Test	In accordance with applicable Actel device specification, which includes a, b, and c:	
	a. Static Tests		100%
	(1) 25°C (Subgroup 1, Table I)	5005	
	(2) -55°C and +125°C (Subgroups 2, 3, Table I)	5005	
	b. Functional Tests		100%
	(1) 25°C (Subgroup 7, Table I)	5005	
	(2) -55°C and +125°C (Subgroups 8A and 8B, Table I)	5005	
	c. Switching Tests at 25°C (Subgroup 9, Table I)	5005	100%
11.	External Visual	2009	100%

Note: When Destructive Physical Analysis (DPA) is performed on Class B devices, the step coverage requirement as specified in Method 2018 must be waived.

Actel Extended Flow¹

Step	Screen	Method	Requirement
1.	Wafer Lot Acceptance ²	5007 with Step Coverage Waiver	All Lots
2.	Destructive In-Line Bond Pull ³	2011, Condition D	Sample
3.	Internal Visual	2010, Condition A	100%
4.	Serialization		100%
5.	Temperature Cycling	1010, Condition C	100%
6.	Constant Acceleration	2001, Condition D or E, Y ₁ Orientation Only	100%
7.	Particle Impact Noise Detection	2020, Condition A	100%
8.	Radiographic	2012	100%
9.	Pre-Burn-In Test	In accordance with applicable Actel device specification	100%
10.	Burn-in Test	1015, Condition D, 240 hours @ 125°C minimum	100%
11.	Interim (Post-Burn-In) Electrical Parameters	In accordance with applicable Actel device specification	100%
12.	Reverse Bias Burn-In	1015, Condition C, 72 hours @ 150°C minimum	100%
13.	Interim (Post-Burn-In) Electrical Parameters	In accordance with applicable Actel device specification	100%
14.	Percent Defective Allowable (PDA) Calculation	5%, 3% Functional Parameters @ 25°C	All Lots
15.	Final Electrical Test	In accordance with Actel applicable device specification, which includes a, b, and c:	100%
	a. Static Tests		100%
	(1) 25°C (Subgroup 1, Table 1)	5005	
	(2) -55°C and +125°C (Subgroups 2, 3, Table 1)	5005	
	b. Functional Tests		100%
	(1) 25°C (Subgroup 7, Table 15)	5005	
	(2) -55°C and +125°C (Subgroups 8A and B, Table 1)	5005	
	c. Switching Tests at 25°C (Subgroup 9, Table 1)	5005	100%
16.	Seal	1014	100%
	a. Fine		
	b. Gross		
17.	External Visual	2009	100%

Notes:

- Actel offers the extended flow for customers that require additional screening beyond the requirements of MIL-STD-883, Class B. Actel is compliant to the requirements of MIL-STD-883, Paragraph 1.2.1, and MIL-I-38535, Appendix A. Actel is offering this extended flow incorporating the majority of the screening procedures as outlined in Method 5004 of MIL-STD-883 Class S. The exceptions to Method 5004 are shown in notes 2 and 3 below.
- Wafer lot acceptance is performed to Method 5007; however, the step coverage requirement as specified in Method 2018 must be waived.
- Method 5004 requires a 100 percent, non-destructive bond pull (Method 2023). Actel substitutes a destructive bond pull (Method 2011), Condition D on a sample basis only.

Absolute Maximum Ratings¹

Free Air Temperature Range

Symbol	Parameter	Limits	Units
V _{CC}	DC Supply Voltage ^{2, 3, 4}	-0.5 to +7.0	V
V _I	Input Voltage	-0.5 to V _{CC} +0.5	V
V _O	Output Voltage	-0.5 to V _{CC} +0.5	V
I _{IO}	I/O Source Sink Current ⁵	±20	mA
T _{STG}	Storage Temperature	-65 to +150	°C

Notes:

- Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. Exposure to absolute maximum rated conditions for extended periods may affect device reliability. Devices should not be operated outside the recommended operating conditions.
- V_{PP} = V_{CC}, except during device programming.
- V_{SV} = V_{CC}, except during device programming.
- V_{KS} = GND, except during device programming.
- Device inputs are normally high impedance and draw extremely low current. However, when input voltage is greater than V_{CC} + 0.5V or less than GND - 0.5V, the internal protection diode will be forward-biased and can draw excessive current.

Recommended Operating Conditions

Parameter	Commercial	Military	Units
Temperature Range ¹	0 to +70	-55 to +125	°C
Power Supply Tolerance ²	±5	±10	%V _{CC}

Notes:

- Ambient temperature (T_A) is used for commercial and industrial; case temperature (T_C) is used for military.
- All power supplies must be in the recommended operating range. For more information, refer to the Power-Up Design Considerations application note at <http://www.actel.com/appnotes>.

Electrical Specifications

Symbol	Parameter	Test Condition	Commercial		Military		Units
			Min.	Max.	Min.	Max.	
V _{OH} ^{1, 2}	HIGH Level Output	I _{OH} = -4 mA (CMOS)			3.7		V
		I _{OH} = -6 mA (CMOS)	3.84				V
V _{OL} ^{1, 2}	LOW Level Output	I _{OL} = +6 mA (CMOS)		0.33		0.4	V
V _{IH}	HIGH Level Input	TTL Inputs	2.0	V _{CC} + 0.3	2.0	V _{CC} + 0.3	V
V _{IL}	LOW Level Input	TTL Inputs	-0.3	0.8	-0.3	0.8	V
I _{IN}	Input Leakage	V _I = V _{CC} or GND	-10	+10	-10	+10	µA
I _{OZ}	3-State Output Leakage	V _O = V _{CC} or GND	-10	+10	-10	+10	µA
C _{IO}	I/O Capacitance ^{3, 4}			10		10	pF
I _{CC(S)}	Standby V _{CC} Supply Current	V _I = V _{CC} or GND, I _O = 0 mA		2		20	mA
I _{CC(D)}	Dynamic V _{CC} Supply Current	See the “Power Dissipation” Section on page 11.					

Notes:

- Actel devices can drive and receive either CMOS or TTL signal levels. No assignment of I/Os as TTL or CMOS is required.
- Tested one output at a time, V_{CC} = min.
- Not tested; for information only.
- V_{OUT} = 0V, f = 1 MHz

Package Thermal Characteristics

The device junction to case thermal characteristic is θ_{jc} , and the junction to ambient air characteristic is θ_{ja} . The thermal characteristics for θ_{ja} are shown with two different air flow rates.

Maximum junction temperature is 150°C.

A sample calculation of the absolute maximum power dissipation allowed for a CQFP 172-pin package at military temperature is as follows:

$$\frac{\text{Max. junction temp. (°C)} - \text{Max. military temp.}}{\theta_{ja} (\text{°C/W})} = \frac{150\text{°C} - 125\text{°C}}{25\text{°C/W}} = 1.0\text{W}$$

Package Type	Pin Count	θ_{jc}	θ_{ja} Still Air	θ_{ja} 300 ft/min	Units
Ceramic Quad Flat Pack	84	7.8	40	30	°C/W
	132	7.2	35	25	°C/W
	172	6.8	25	20	°C/W
	196	6.4	23	15	°C/W
	256	6.2	20	10	°C/W

Power Dissipation

General Power Equation

$$P = [I_{CC\text{standby}} + I_{CC\text{active}}] * V_{CC} + I_{OL} * V_{OL} * N + I_{OH} * (V_{CC} - V_{OH}) * M$$

where:

$I_{CC\text{standby}}$ is the current flowing when no inputs or outputs are changing.

$I_{CC\text{active}}$ is the current flowing due to CMOS switching.

I_{OL} , I_{OH} are TTL sink/source currents.

V_{OL} , V_{OH} are TTL level output voltages.

N equals the number of outputs driving TTL loads to V_{OL} .

M equals the number of outputs driving TTL loads to V_{OH} .

Accurate values for N and M are difficult to determine because they depend on the family type, on design details, and on the system I/O. The power can be divided into two components: static and active.

Static Power Component

Actel FPGAs have small static power components that result in power dissipation lower than that of PALs or PLDs. By integrating multiple PALs or PLDs into one FPGA, an even greater reduction in board-level power dissipation can be achieved.

The power due to standby current is typically a small component of the overall power. Standby power is calculated below for commercial, worst-case conditions.

I_{CC}	V_{CC}	Power
2 mA	5.25V	10.5 mW

The static power dissipated by TTL loads depends on the number of outputs driving HIGH or LOW and on the DC load current. Again, this value is typically small. For instance, a 32-bit bus sinking 4 mA at 0.33V will generate 42 mW with all outputs driving LOW, and 140 mW with all outputs driving HIGH.

Active Power Component

Power dissipation in CMOS devices is usually dominated by the active (dynamic) power dissipation. This component is frequency-dependent, a function of the logic and the external I/O. Active power dissipation results from charging internal chip capacitances of the interconnect, unprogrammed antifuses, module inputs, and module outputs, plus external capacitance due to PC board traces and load device inputs. An additional component of the active power dissipation is the totempole current in CMOS transistor pairs. The net effect can be associated with an equivalent capacitance that can be combined with frequency and voltage to represent active power dissipation.

Equivalent Capacitance

The power dissipated by a CMOS circuit can be expressed by Equation 1:

$$\text{Power (uW)} = C_{EQ} * V_{CC}^2 * F \quad (1)$$

where:

C_{EQ}	=	Equivalent capacitance in pF
V_{CC}	=	Power supply in volts (V)
F	=	Switching frequency in MHz

Equivalent capacitance is calculated by measuring I_{CC} active at a specified frequency and voltage for each circuit component of interest. Measurements are made over a range of frequencies at a fixed value of V_{CC} . Equivalent capacitance is frequency-independent, so the results can be used over a wide range of operating conditions. Equivalent capacitance values are shown below.

CEQ Values for Actel FPGAs

	RT1425A A1425A RT1460A A1460A		
	RT1020 A1020B	RT1280A A1280A	RT14100A A14100A
Modules (C_{EQM})	3.7	5.8	6.7
Input Buffers (C_{EQI})	22.1	12.9	7.2
Output Buffers (C_{EQO})	32.1	23.8	10.4
Routed Array Clock Buffer Loads (C_{EQCR})	4.6	3.9	1.6
Dedicated Clock Buffer Loads (C_{EQCD})	n/a	n/a	0.7
I/O Clock Buffer Loads (C_{EQCI})	n/a	n/a	0.9

To calculate the active power dissipated from the complete design, the switching frequency of each part of the logic must be known. Equation 2 shows a piece-wise linear summation over all components. Since the RT1280A and A1280A have two routed array clocks, the dedicated_Clk and IO_Clk terms do not apply. For all other devices all terms apply.

$$\text{Power} = V_{CC}^2 * [(m * C_{EQM} * f_m)_{\text{modules}} + (n * C_{EQI} * f_n)_{\text{inputs}} + (p * (C_{EQO} + C_L) * f_p)_{\text{outputs}} + 0.5 * (q_1 * C_{EQCR} * f_{q1})_{\text{routed_Clk1}} + (r_1 * f_{q1})_{\text{routed_Clk1}} + 0.5 * (q_2 * C_{EQCR} * f_{q2})_{\text{routed_Clk2}} + (r_2 * f_{q2})_{\text{routed_Clk2}} + 0.5 * (s_1 * C_{EQCD} * f_{s1})_{\text{dedicated_Clk}} + (s_2 * C_{EQCI} * f_{s2})_{\text{IO_Clk}}] \quad (2)$$

where:

- m = Number of logic modules switching at f_m
- n = Number of input buffers switching at f_n
- p = Number of output buffers switching at f_p
- q_1 = Number of clock loads on the first routed array clock
- q_2 = Number of clock loads on the second routed array clock (Not applicable for RT1020 or A1020B.)
- r_1 = Fixed capacitance due to first routed array clock
- r_2 = Fixed capacitance due to second routed array clock (Not applicable for RT1020 or A1020B.)
- s_1 = Fixed number of clock loads on the dedicated array clock (Not applicable for RT1020, A1020B, RT1280A, or A1280A.)
- s_2 = Fixed number of clock loads on the dedicated I/O clock (Not applicable for RT1020, A1020B, RT1280A, or A1280A.)
- C_{EQM} = Equivalent capacitance of logic modules in pF
- C_{EQI} = Equivalent capacitance of input buffers in pF
- C_{EQO} = Equivalent capacitance of output buffers in pF
- C_{EQCR} = Equivalent capacitance of routed array clock in pF
- C_{EQCD} = Equivalent capacitance of dedicated array clock in pF
- C_{EQCI} = Equivalent capacitance of dedicated I/O clock in pF
- C_L = Output lead capacitance in pF
- f_m = Average logic module switching rate in MHz
- f_n = Average input buffer switching rate in MHz
- f_p = Average output buffer switching rate in MHz
- f_{q1} = Average first routed array clock rate in MHz
- f_{q2} = Average second routed array clock rate in MHz (Not applicable for RT1020 or A1020B.)
- f_{s1} = Average dedicated array clock rate in MHz (Not applicable for RT1020, A1020B, RT1280A, or A1280A.)
- f_{s2} = Average dedicated I/O clock rate in MHz (Not applicable for RT1020, A1020B, RT1280A, or A1280A.)

Fixed Capacitance Values for Actel FPGAs (pF)

Device Type	r_1 routed_Clk1	r_2 routed_Clk2
RT1020, A1020B	69	n/a
RT1280A, A1280A	168	168
RT1425A, A1425A	75	75
RT1460A, A1460A	165	165
RT14100A, A14100A	195	195

Fixed Clock Loads (s_1/s_2 —ACT 3 Only)

Device Type	s_1 Clock Loads on Dedicated Array Clock	s_2 Clock Loads on Dedicated I/O Clock
RT1425A, A1425A	160	100
RT1460A, A1460A	432	168
RT14100A, A14100A	697	228

Determining Average Switching Frequency

To determine the switching frequency for a design, you must have a detailed understanding of the data input values to the circuit. The guidelines in the table below are meant to represent worst-case scenarios; they can be generally used to predict the upper limits of power dissipation.

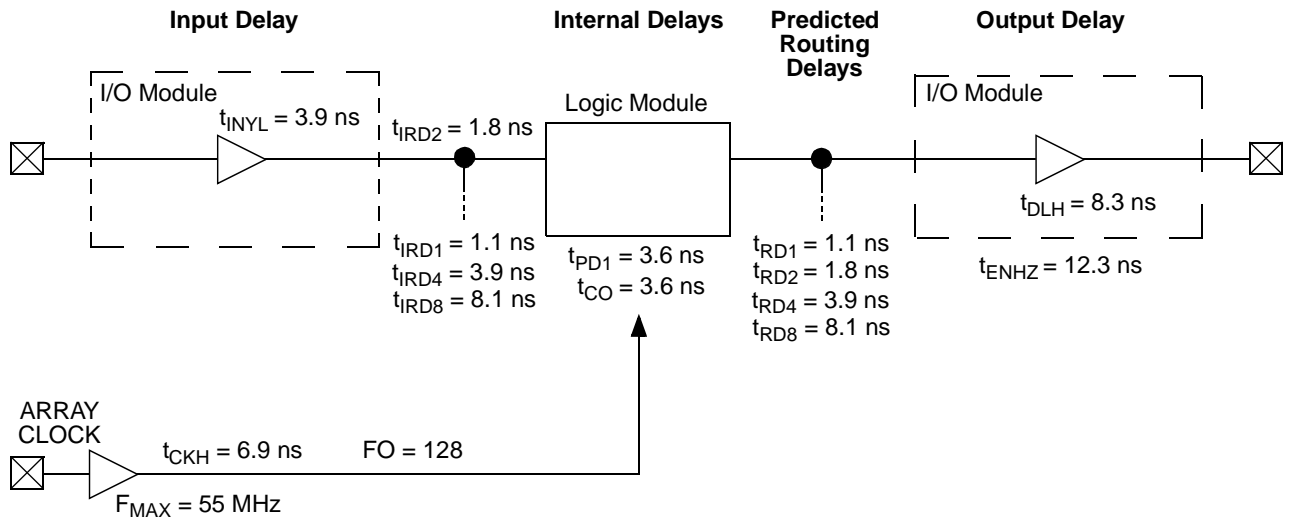
RT1020, A1020B, RT1280A, A1280A

Logic Modules (m)	= 80% of Combinatorial Modules
Input Switching (n)	= # Inputs/4
Outputs Switching (p)	= # Outputs/4
First Routed Array Clock Loads (q_1)	= 40% of Sequential Modules
Second Routed Array Clock Loads (q_2)	= 40% of Sequential Modules
Load Capacitance (C_L)	= 35 pF
Average Logic Module Switching Rate (f_m)	= F/10
Average Input Switching Rate (f_n)	= F/5
Average Output Switching Rate (f_p)	= F/10
Average First Routed Array Clock Rate (f_{q1})	= F
Average Second Routed Array Clock Rate (f_{q2})	= F/2
Average Dedicated Array Clock Rate (f_{s1})	= n/a
Average Dedicated I/O Clock Rate (f_{s2})	= n/a

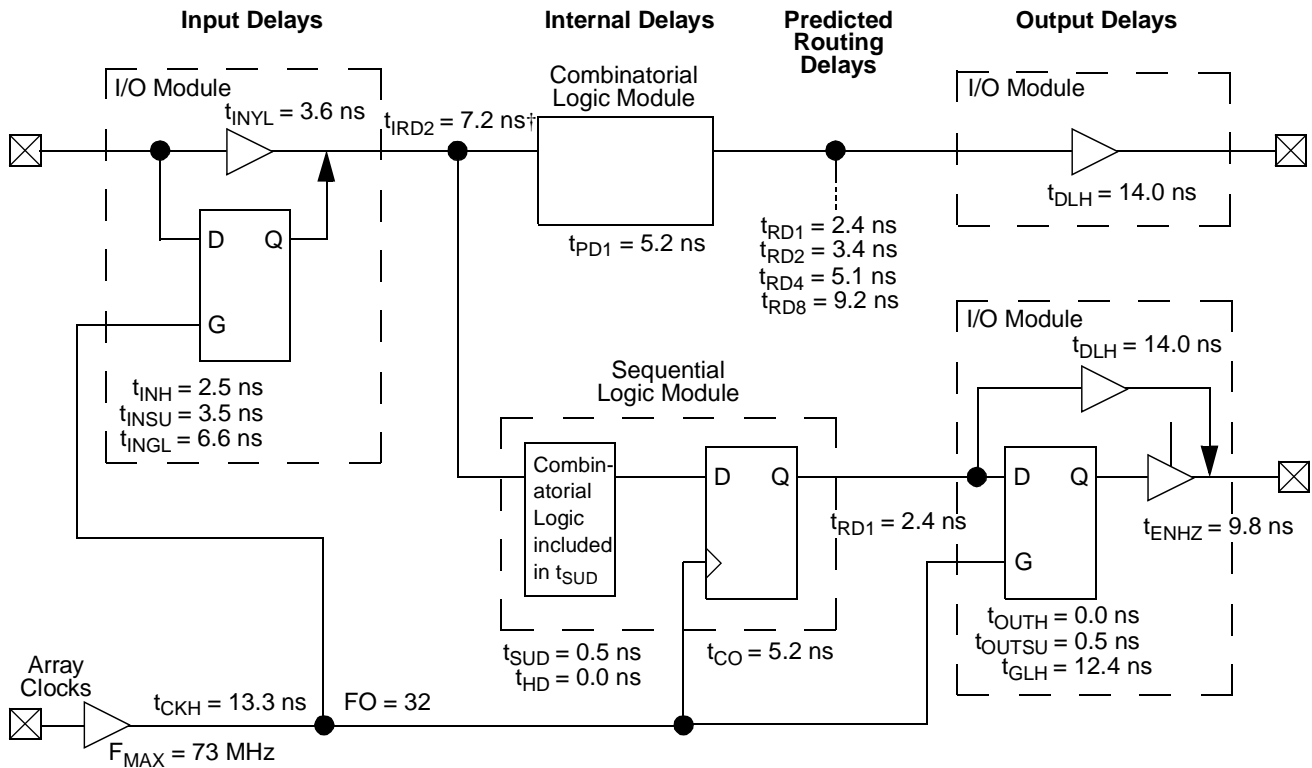
RT1425A, A1425A, RT1460A, A1460A, RT14100A, A14100A

Logic Modules (m)	= 80% of Combinatorial Modules
Input Switching (n)	= # Inputs/4
Outputs Switching (p)	= # Outputs/4
First Routed Array Clock Loads (q_1)	= 40% of Sequential Modules
Second Routed Array Clock Loads (q_2)	= 40% of Sequential Modules
Load Capacitance (C_L)	= 35 pF
Average Logic Module Switching Rate (f_m)	= F/10
Average Input Switching Rate (f_n)	= F/5
Average Output Switching Rate (f_p)	= F/10
Average First Routed Array Clock Rate (f_{q1})	= F/2
Average Second Routed Array Clock Rate (f_{q2})	= F/2
Average Dedicated Array Clock Rate (f_{s1})	= F
Average Dedicated I/O Clock Rate (f_{s2})	= F

RT1020, A1020B Timing Model



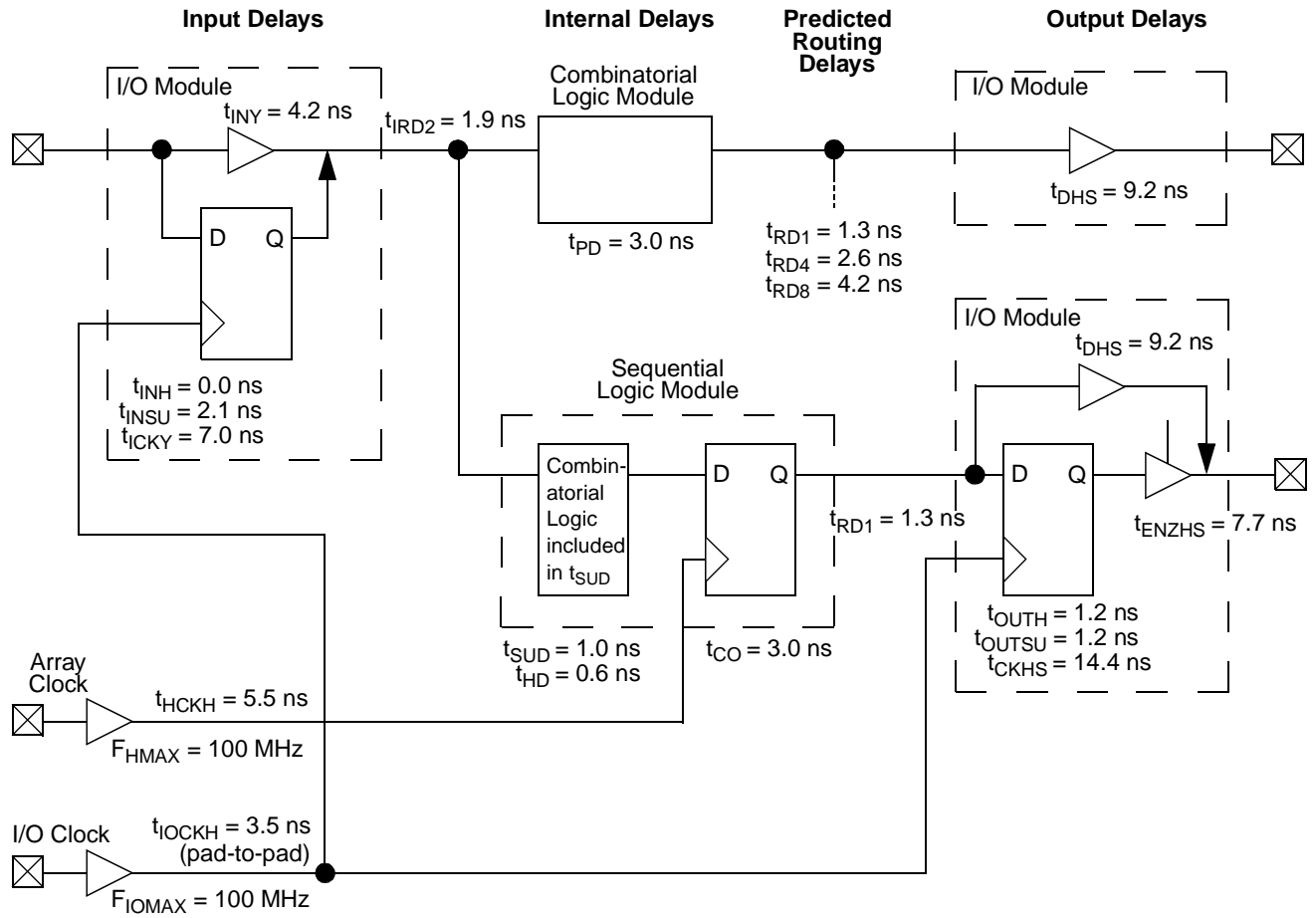
RT1280A, A1280A Timing Model*



*Values shown for RT1280A-1 at worst-case military conditions.

† Input module predicted routing delay.

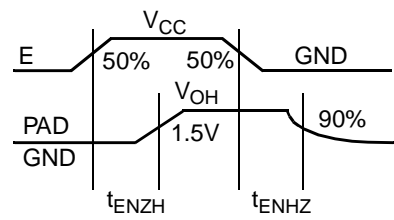
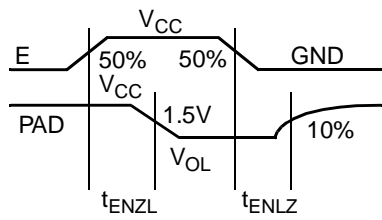
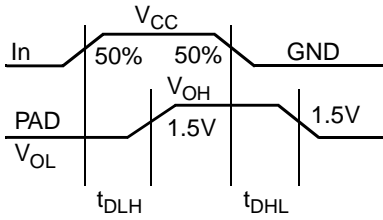
RT1425A, A1425A, RT1460A, A1460A, RT14100A, A14100A Timing Model*



*Values shown for RT14100A -1 at worst-case military conditions.

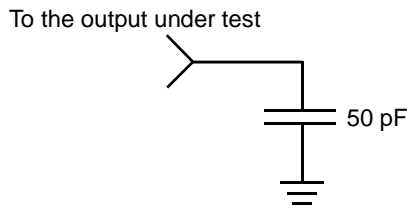
Parameter Measurement

Output Buffer Delays

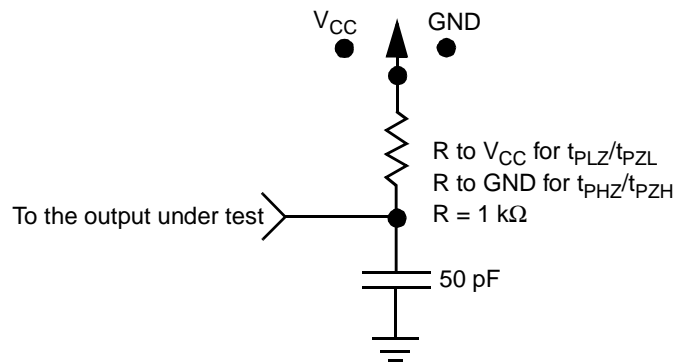


AC Test Load

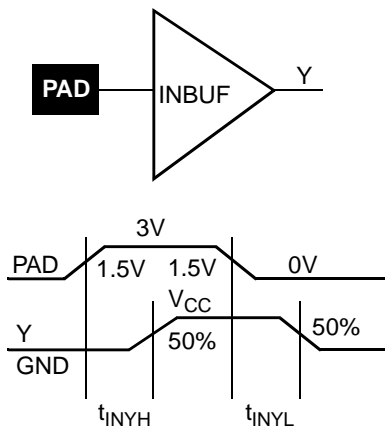
Load 1
(Used to measure propagation delay)



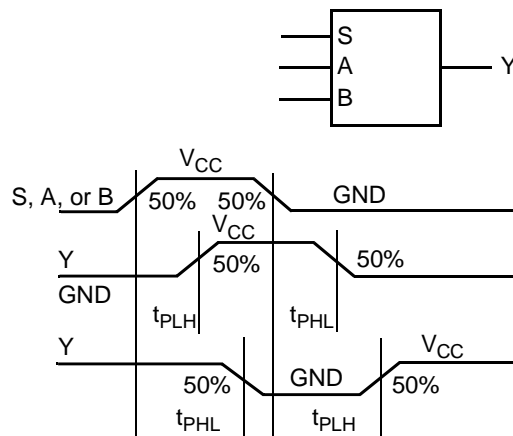
Load 2
(Used to measure rising/falling edges)



Input Buffer Delays

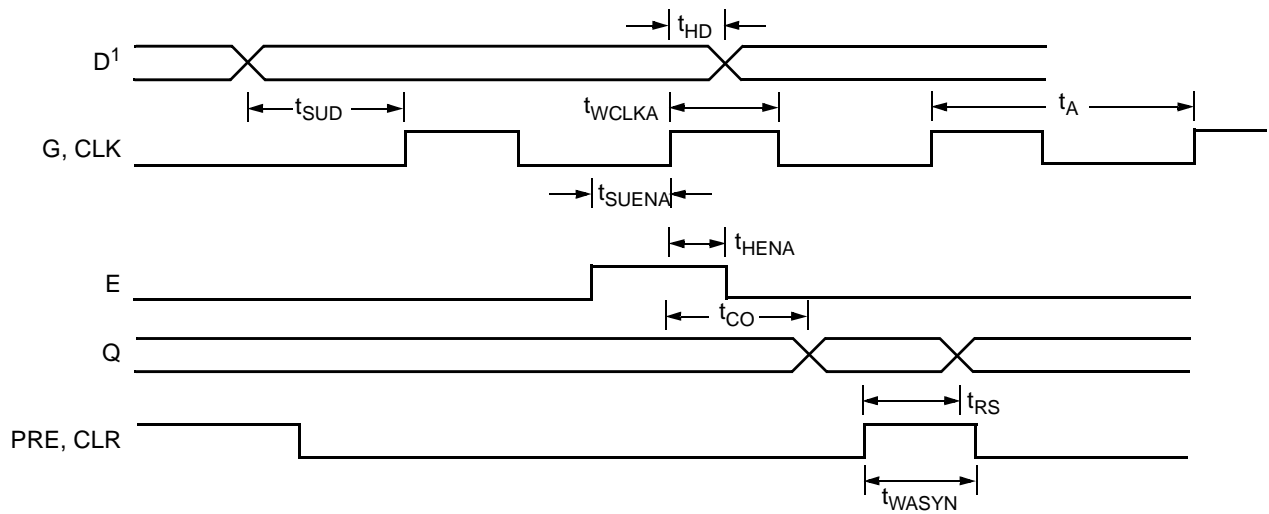
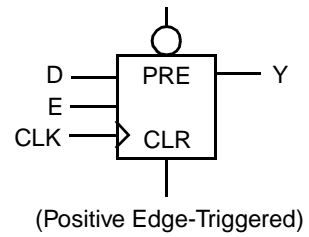


Combinatorial Macro Delays



Sequential Timing Characteristics

Flip-Flops and Latches (RT1280A, A1280A)

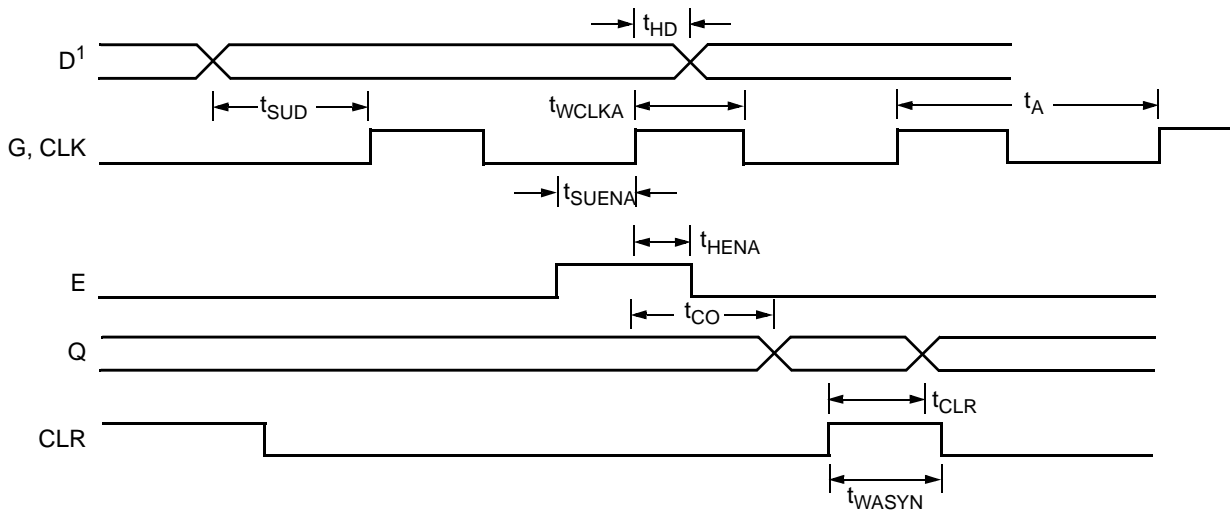
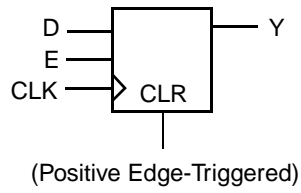


Note:

1. D represents all data functions involving A, B, and S for multiplexed flip-flops.

Sequential Timing Characteristics (continued)

Flip-Flops and Latches (RT1425A, A1425A, RT1460A, A1460A, RT14100A, A14100A)

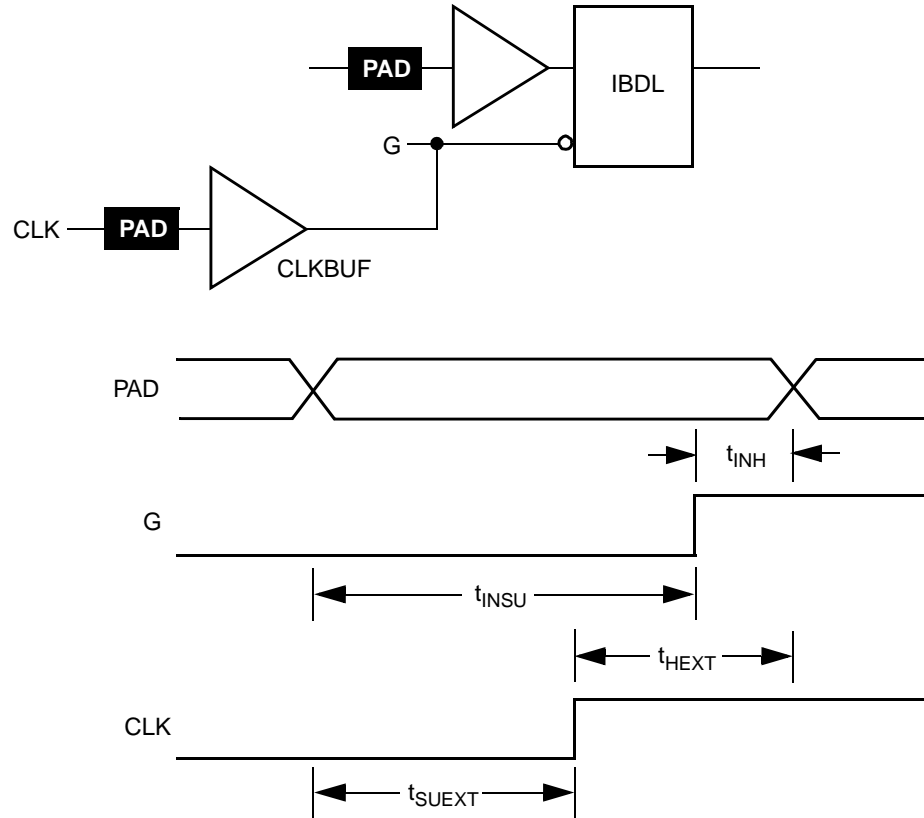


Note:

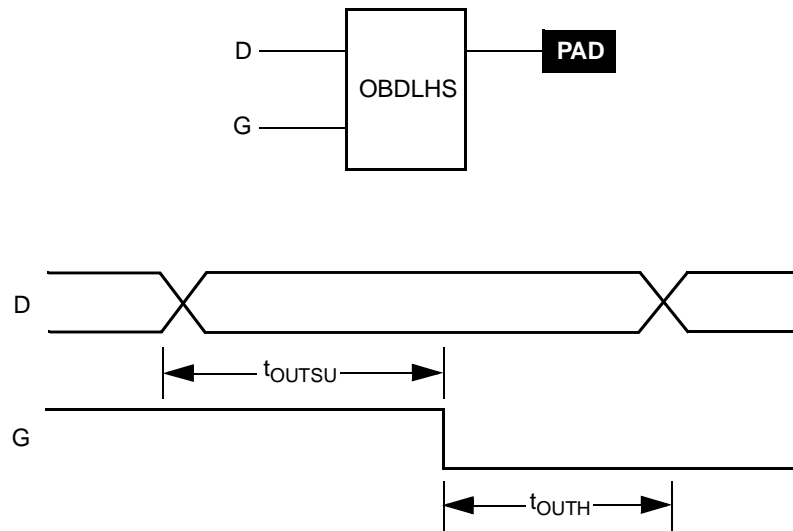
1. D represents all data functions involving A , B , and S for multiplexed flip-flops.

Sequential Timing Characteristics (continued)

Input Buffer Latches (R1280A, A1280A)



Output Buffer Latches (RT1280A, A1280A)



RT1020, A1020B Timing Characteristics

(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)

		'Std' Speed		
Parameter	Description	Min.	Max.	Units
Logic Module Propagation Delays				
t_{PD1}	Single Module		3.6	ns
t_{PD2}	Dual Module Macros		8.4	ns
t_{CO}	Sequential Clock to Q		3.6	ns
t_{GO}	Latch G to Q		3.6	ns
t_{RS}	Flip-Flop (Latch) Reset to Q		3.6	ns
Logic Module Predicted Routing Delays¹				
t_{RD1}	FO=1 Routing Delay		1.1	ns
t_{RD2}	FO=2 Routing Delay		1.8	ns
t_{RD3}	FO=3 Routing Delay		2.6	ns
t_{RD4}	FO=4 Routing Delay		3.9	ns
t_{RD8}	FO=8 Routing Delay		8.1	ns
Logic Module Sequential Timing²				
t_{SUD}	Flip-Flop (Latch) Data Input Set-Up	6.9		ns
t_{HD}^3	Flip-Flop (Latch) Data Input Hold	0.0		ns
t_{SUENA}	Flip-Flop (Latch) Enable Set-Up	6.9		ns
t_{HENA}	Flip-Flop (Latch) Enable Hold	0.0		ns
t_{WCLKA}	Flip-Flop (Latch) Clock Active Pulse Width	8.4		ns
t_{WASYN}	Flip-Flop (Latch) Asynchronous Pulse Width	8.4		ns
t_A	Flip-Flop Clock Input Period	17.5		ns
f_{MAX}	Flip-Flop (Latch) Clock Frequency (FO = 128)		55	MHz
Input Module Propagation Delays				
t_{INYH}	Pad to Y High		3.9	ns
t_{INYL}	Pad to Y Low		3.9	ns
Input Module Predicted Routing Delays^{1, 3}				
t_{IRD1}	FO=1 Routing Delay		1.1	ns
t_{IRD2}	FO=2 Routing Delay		1.8	ns
t_{IRD3}	FO=3 Routing Delay		2.6	ns
t_{IRD4}	FO=4 Routing Delay		3.9	ns
t_{IRD8}	FO=8 Routing Delay		8.1	ns

Notes:

1. Routing delays are for typical designs across worst-case operating conditions. These parameters should be used for estimating device performance. Post-route timing analysis or simulation is required to determine actual worst-case performance. Post-route timing is based on actual routing delay measurements performed on the device prior to shipment.
2. Set-up times assume fanout of 3. Further testing information can be obtained from the DirectTime Analyzer utility.
3. Optimization techniques may further reduce delays by 0 to 4 ns.
4. The hold time for the DFME1A macro may be greater than 0 ns. Use the Designer Series 3.0 (or later) Timer to check the hold time for this macro.

RT1020, A1020B Timing Characteristics (continued)**(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^\circ C$)**

		'Std' Speed		
Parameter	Description	Min.	Max.	Units
Global Clock Network				
t_{CKH}	Input Low to High		6.0	ns
			6.9	
t_{CKL}	Input High to Low		7.9	ns
			8.7	
t_{PWH}	Minimum Pulse Width High			ns
		8.0		
		8.4		
t_{PWL}	Minimum Pulse Width Low			ns
		1.5		
		2.2		
t_{CKSW}	Maximum Skew		1.5	ns
			2.3	
t_P	Minimum Period		16.3	ns
			17.5	
f_{MAX}	Maximum Frequency		60	MHz
			50	
TTL Output Module Timing¹				
t_{DLH}	Data to Pad High		8.3	ns
t_{DHL}	Data to Pad Low		9.3	ns
t_{ENZH}	Enable Pad Z to High		8.1	ns
t_{ENZL}	Enable Pad Z to Low		9.8	ns
t_{ENHZ}	Enable Pad High to Z		12.3	ns
t_{ENLZ}	Enable Pad Low to Z		11.1	ns
d_{TLH}	Delta Low to High		0.07	ns/pF
d_{THL}	Delta High to Low		0.10	ns/pF
CMOS Output Module Timing¹				
t_{DLH}	Data to Pad High		9.8	ns
t_{DHL}	Data to Pad Low		7.9	ns
t_{ENZH}	Enable Pad Z to High		7.4	ns
t_{ENZL}	Enable Pad Z to Low		10.2	ns
t_{ENHZ}	Enable Pad High to Z		12.3	ns
t_{ENLZ}	Enable Pad Low to Z		11.1	ns
d_{TLH}	Delta Low to High		0.13	ns/pF
d_{THL}	Delta High to Low		0.07	ns/pF

Notes:

1. Delays based on 35 pF loading.
2. SSO information can be found in the Simultaneously Switching Output Limits for Actel FPGAs application note at <http://www.actel.com/appnotes>.

RT1280A, A1280A Timing Characteristics

(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^\circ C$)

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
Logic Module Propagation Delays¹						
t_{PD1}	Single Module		5.2		6.1	ns
t_{CO}	Sequential Clock-to-Q		5.2		6.1	ns
t_{GO}	Latch G-to-Q		5.2		6.1	ns
t_{RS}	Flip-Flop (Latch) Reset-to-Q		5.2		6.1	ns
Logic Module Predicted Routing Delays²						
t_{RD1}	FO=1 Routing Delay		2.4		2.8	ns
t_{RD2}	FO=2 Routing Delay		3.4		4.0	ns
t_{RD3}	FO=3 Routing Delay		4.2		4.9	ns
t_{RD4}	FO=4 Routing Delay		5.1		6.0	ns
t_{RD8}	FO=8 Routing Delay		9.2		10.8	ns
Logic Module Sequential Timing^{3, 4}						
t_{SUD}	Flip-Flop (Latch) Data Input Set-Up	0.5		0.5		ns
t_{HD}	Flip-Flop (Latch) Data Input Hold	0.0		0.0		ns
t_{SUENA}	Flip-Flop (Latch) Enable Set-Up	1.3		1.3		ns
t_{HENA}	Flip-Flop (Latch) Enable Hold	0.0		0.0		ns
t_{WCLKA}	Flip-Flop (Latch) Clock Active Pulse Width	7.4		8.6		ns
t_{WASYN}	Flip-Flop (Latch) Asynchronous Pulse Width	7.4		8.6		ns
t_A	Flip-Flop Clock Input Period	16.4		22.1		ns
t_{INH}	Input Buffer Latch Hold	2.5		2.5		ns
t_{INSU}	Input Buffer Latch Set-Up	3.5		3.5		ns
t_{OUTH}	Output Buffer Latch Hold	0.0		0.0		ns
t_{OUTSU}	Output Buffer Latch Set-Up	0.5		0.5		ns
f_{MAX}	Flip-Flop (Latch) Clock Frequency		60		41	MHz

Notes:

1. For dual-module macros, use $t_{PD1} + t_{RD1} + t_{PDn}$, $t_{CO} + t_{RD1} + t_{PDn}$, or $t_{PD1} + t_{RD1} + t_{SUD}$, whichever is appropriate.
2. Routing delays are for typical designs across worst-case operating conditions. These parameters should be used for estimating device performance. Post-route timing analysis or simulation is required to determine actual worst-case performance. Post-route timing is based on actual routing delay measurements performed on the device prior to shipment.
3. Data applies to macros based on the S-module. Timing parameters for sequential macros constructed from C-modules can be obtained from the DirectTime Analyzer utility.
4. Set-Up and hold timing parameters for the input buffer latch are defined with respect to the PAD and the D input. External set-up/hold timing parameters must account for delay from an external PAD signal to the G inputs. Delay from an external PAD signal to the G input subtracts (adds) to the internal set-up (hold) time.

RT1280A, A1280A Timing Characteristics (continued)**(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^\circ C$)**

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
Input Module Propagation Delays						
t_{INYH}	Pad-to-Y HIGH		4.0		4.7	ns
t_{INYL}	Pad-to-Y LOW		3.6		4.3	ns
t_{INGH}	G-to-Y HIGH		6.9		8.1	ns
t_{INGL}	G-to-Y LOW		6.6		7.7	ns
Input Module Predicted Routing Delays¹						
t_{IRD1}	FO=1 Routing Delay		6.2		7.3	ns
t_{IRD2}	FO=2 Routing Delay		7.2		8.4	ns
t_{IRD3}	FO=3 Routing Delay		7.7		9.1	ns
t_{IRD4}	FO=4 Routing Delay		8.9		10.5	ns
t_{IRD8}	FO=8 Routing Delay		12.9		15.2	ns
Global Clock Network						
t_{CKH}	Input LOW to HIGH	FO = 32	13.3		15.7	ns
		FO = 384	17.9		21.1	
t_{CKL}	Input HIGH to LOW	FO = 32	13.3		15.7	ns
		FO = 384	18.2		21.4	
t_{PWH}	Minimum Pulse Width HIGH	FO = 32	6.9	8.1		ns
		FO = 384	7.9	9.3		
t_{PWL}	Minimum Pulse Width LOW	FO = 32	6.9	8.1		ns
		FO = 384	7.9	9.3		
t_{CKSW}	Maximum Skew	FO = 32	0.6		0.6	ns
		FO = 384	3.1		3.1	
t_{SUEXT}	Input Latch External Set-Up	FO = 32	0.0	0.0		ns
		FO = 384	0.0	0.0		
t_{HEXT}	Input Latch External Hold	FO = 32	8.6	8.6		ns
		FO = 384	13.8	13.8		
t_P	Minimum Period	FO = 32	13.7	16.2		ns
		FO = 384	16.0	18.9		
f_{MAX}	Maximum Frequency	FO = 32	73	62		MHz
		FO = 384	63	53		

Note:

1. Routing delays are for typical designs across worst-case operating conditions. These parameters should be used for estimating device performance. Post-route timing analysis or simulation is required to determine actual worst-case performance. Post-route timing is based on actual routing delay measurements performed on the device prior to shipment. Optimization techniques may further reduce delays by 0 to 4 ns.

RT1280A, A1280A Timing Characteristics (continued)

(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
TTL Output Module Timing¹						
t _{DLH}	Data-to-Pad HIGH		11.0		13.0	ns
t _{DHL}	Data-to-Pad LOW		13.9		16.4	ns
t _{ENZH}	Enable-to-Pad Z to HIGH		12.3		14.4	ns
t _{ENZL}	Enable-to-Pad Z to LOW		16.1		19.0	ns
t _{ENHZ}	Enable-to-Pad HIGH to Z		9.8		11.5	ns
t _{ENLZ}	Enable-to-Pad LOW to Z		11.5		13.6	ns
t _{GLH}	G-to-Pad HIGH		12.4		14.6	ns
t _{GHL}	G-to-Pad LOW		15.5		18.2	ns
d _{TLH}	Delta LOW to HIGH		0.09		0.11	ns/pF
d _{THL}	Delta HIGH to LOW		0.17		0.20	ns/pF
CMOS Output Module Timing¹						
t _{DLH}	Data-to-Pad HIGH		14.0		16.5	ns
t _{DHL}	Data-to-Pad LOW		11.7		13.7	ns
t _{ENZH}	Enable-to-Pad Z to HIGH		12.3		14.4	ns
t _{ENZL}	Enable-to-Pad Z to LOW		16.1		19.0	ns
t _{ENHZ}	Enable-to-Pad HIGH to Z		9.8		11.5	ns
t _{ENLZ}	Enable-to-Pad LOW to Z		11.5		13.6	ns
t _{GLH}	G-to-Pad HIGH		12.4		14.6	ns
t _{GHL}	G-to-Pad LOW		15.5		18.2	ns
d _{TLH}	Delta LOW to HIGH		0.17		0.20	ns/pF
d _{THL}	Delta HIGH to LOW		0.12		0.15	ns/pF

Notes:

1. Delays based on 50 pF loading.
2. SSO information can be found in the Simultaneously Switching Output Limits for Actel FPGAs application note at <http://www.actel.com/appnotes>.

RT1425A, A1425A Timing Characteristics**(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^\circ C$)**

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
Logic Module Propagation Delays¹						
t_{PD}	Internal Array Module		3.0		3.5	ns
t_{CO}	Sequential Clock to Q		3.0		3.5	ns
t_{CLR}	Asynchronous Clear to Q		3.0		3.5	ns
Logic Module Predicted Routing Delays²						
t_{RD1}	FO=1 Routing Delay		1.3		1.5	ns
t_{RD2}	FO=2 Routing Delay		1.9		2.1	ns
t_{RD3}	FO=3 Routing Delay		2.1		2.5	ns
t_{RD4}	FO=4 Routing Delay		2.6		2.9	ns
t_{RD8}	FO=8 Routing Delay		4.2		4.9	ns
Logic Module Sequential Timing						
t_{SUD}	Flip-Flop (Latch) Data Input Setup	0.9		1.0		ns
t_{HD}	Flip-Flop (Latch) Data Input Hold	0.0		0.0		ns
t_{SUENA}	Flip-Flop (Latch) Enable Setup	0.9		1.0		ns
t_{HENA}	Flip-Flop (Latch) Enable Hold	0.0		0.0		ns
t_{WASYN}	Asynchronous Pulse Width	3.8		4.4		ns
t_{WCLKA}	Flip-Flop Clock Pulse Width	3.8		4.4		ns
t_A	Flip-Flop Clock Input Period	7.9		9.3		ns
f_{MAX}	Flip-Flop Clock Frequency		125		100	MHz
Input Module Propagation Delays						
t_{INY}	Input Data Pad to Y		4.2		4.9	ns
t_{ICKY}	Input Reg IOCLK Pad to Y		7.0		8.2	ns
t_{OCKY}	Output Reg IOCLK Pad to Y		7.0		8.2	ns
t_{ICLRY}	Input Asynchronous Clear to Y		7.0		8.2	ns
t_{OCLRY}	Output Asynchronous Clear to Y		7.0		8.2	ns
Input Module Predicted Routing Delays^{2, 3}						
t_{IRD1}	FO=1 Routing Delay		1.3		1.5	ns
t_{IRD2}	FO=2 Routing Delay		1.9		2.1	ns
t_{IRD3}	FO=3 Routing Delay		2.1		2.5	ns
t_{IRD4}	FO=4 Routing Delay		2.6		2.9	ns
t_{IRD8}	FO=8 Routing Delay		4.2		4.9	ns

Notes:

1. For dual-module macros, use $t_{PD} + t_{RD1} + t_{PDn}$, $t_{CO} + t_{RD1} + t_{PDn}$, or $t_{PD1} + t_{RD1} + t_{SUD}$, whichever is appropriate.
2. Routing delays are for typical designs across worst-case operating conditions. These parameters should be used for estimating device performance. Post-route timing analysis or simulation is required to determine actual worst-case performance. Post-route timing is based on actual routing delay measurements performed on the device prior to shipment.
3. Optimization techniques may further reduce delays by 0 to 4 ns.

RT1425A, A1425A Timing Characteristics (continued)

(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^\circ C$)

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
I/O Module Sequential Timing						
t_{INH}	Input F-F Data Hold (w.r.t. IOCLK Pad)	0.0		0.0		ns
t_{INSU}	Input F-F Data Setup (w.r.t. IOCLK Pad)	2.1		2.4		ns
t_{IDEH}	Input Data Enable Hold (w.r.t. IOCLK Pad)	0.0		0.0		ns
t_{IDESU}	Input Data Enable Setup (w.r.t. IOCLK Pad)	8.7		10.0		ns
t_{OUTH}	Output F-F Data Hold (w.r.t. IOCLK Pad)	1.1		1.2		ns
t_{OUTSU}	Output F-F Data Setup (w.r.t. IOCLK Pad)	1.1		1.2		ns
t_{ODEH}	Output Data Enable Hold (w.r.t. IOCLK Pad)	0.5		0.6		ns
t_{ODESU}	Output Data Enable Setup (w.r.t. IOCLK Pad)	2.0		2.4		ns
TTL Output Module Timing¹						
t_{DHS}	Data to Pad, High Slew		7.5		8.9	ns
t_{DLS}	Data to Pad, Low Slew		11.9		14.0	ns
t_{ENZHS}	Enable to Pad, Z to H/L, High Slew		6.0		7.0	ns
t_{ENZLS}	Enable to Pad, Z to H/L, Low Slew		10.9		12.8	ns
t_{ENHSZ}	Enable to Pad, H/L to Z, High Slew		9.9		11.6	ns
t_{ENLSZ}	Enable to Pad, H/L to Z, Low Slew		9.9		11.6	ns
t_{CKHS}	IOCLK Pad to Pad H/L, High Slew		10.5		11.6	ns
t_{CKLS}	IOCLK Pad to Pad H/L, Low Slew		15.7		17.4	ns
d_{TLHHS}	Delta Low to High, High Slew		0.04		0.04	ns/pF
d_{TLHLS}	Delta Low to High, Low Slew		0.07		0.08	ns/pF
d_{THLHS}	Delta High to Low, High Slew		0.05		0.06	ns/pF
d_{THLLS}	Delta High to Low, Low Slew		0.07		0.08	ns/pF

Note:

1. Delays based on 35 pF loading.

RT1425A, A1425A Timing Characteristics (continued)**(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)**

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
CMOS Output Module Timing¹						
t_{DHS}	Data to Pad, High Slew		9.2		10.8	ns
t_{DLS}	Data to Pad, Low Slew		17.3		20.3	ns
t_{ENZHS}	Enable to Pad, Z to H/L, High Slew		7.7		9.1	ns
t_{ENZLS}	Enable to Pad, Z to H/L, Low Slew		13.1		15.5	ns
t_{ENHSZ}	Enable to Pad, H/L to Z, High Slew		9.9		11.6	ns
t_{ENLSZ}	Enable to Pad, H/L to Z, Low Slew		10.5		11.6	ns
t_{CKHS}	IOCLK Pad to Pad H/L, High Slew		12.5		13.7	ns
t_{CKLS}	IOCLK Pad to Pad H/L, Low Slew		18.1		20.1	ns
d_{TLHHS}	Delta Low to High, High Slew		0.06		0.07	ns/pF
d_{TLHLS}	Delta Low to High, Low Slew		0.11		0.13	ns/pF
d_{THLHS}	Delta High to Low, High Slew		0.04		0.05	ns/pF
d_{THLLS}	Delta High to Low, Low Slew		0.05		0.06	ns/pF
Dedicated (Hard-Wired) I/O Clock Network						
t_{IOCKH}	Input Low to High (Pad to I/O Module Input)		3.0		3.5	ns
t_{IOPWH}	Minimum Pulse Width High	3.9		4.4		ns
t_{IOPWL}	Minimum Pulse Width Low	3.9		4.4		ns
t_{IOSAPW}	Minimum Asynchronous Pulse Width	3.9		4.4		ns
t_{IOCKSW}	Maximum Skew		0.5		0.5	ns
t_{IOP}	Minimum Period	7.9		9.3		ns
f_{IOMAX}	Maximum Frequency		125		100	MHz
Dedicated (Hard-Wired) Array Clock Network						
t_{HCKH}	Input Low to High (Pad to S-Module Input)		4.6		5.3	ns
t_{HCKL}	Input High to Low (Pad to S-Module Input)		4.6		5.3	ns
t_{HPWH}	Minimum Pulse Width High	3.9		4.4		ns
t_{HPWL}	Minimum Pulse Width Low	3.9		4.4		ns
t_{HCKSW}	Maximum Skew		0.4		0.4	ns
t_{HP}	Minimum Period	7.9		9.3		ns
f_{HMAX}	Maximum Frequency		125		100	MHz

Notes:

1. Delays based on 35 pF loading.
2. SSO information can be found in the Simultaneously Switching Output Limits for Actel FPGAs application note at <http://www.actel.com/appnotes>.

RT1425A, A1425A Timing Characteristics (continued)

(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
Routed Array Clock Networks						
t_{RCKH}	Input Low to High (FO=64)		5.5		6.4	ns
t_{RCKL}	Input High to Low (FO=64)		6.0		7.0	ns
t_{RPWH}	Min. Pulse Width High (FO=64)	4.9		5.7		ns
t_{RPWL}	Min. Pulse Width Low (FO=64)	4.9		5.7		ns
t_{RCKSW}	Maximum Skew (FO=128)		1.1		1.2	ns
t_{RP}	Minimum Period (FO=64)	10.1		11.6		ns
f_{RMAX}	Maximum Frequency (FO=64)		100		85	MHz
Clock-to-Clock Skews						
$t_{IOHCKSW}$	I/O Clock to H-Clock Skew	0.0	3.0	0.0	3.0	ns
$t_{IORCKSW}$	I/O Clock to R-Clock Skew	0.0	3.0	0.0	3.0	ns
t_{HRCKSW}	H-Clock to R-Clock Skew (FO = 64) (FO = 50% max.)	0.0	1.0	0.0	1.0	ns
		0.0	3.0	0.0	3.0	ns

RT1460A, A1460A Timing Characteristics

(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
Logic Module Propagation Delays¹						
t_{PD}	Internal Array Module		3.0		3.5	ns
t_{CO}	Sequential Clock to Q		3.0		3.5	ns
t_{CLR}	Asynchronous Clear to Q		3.0		3.5	ns
Logic Module Predicted Routing Delays²						
t_{RD1}	FO=1 Routing Delay		1.3		1.5	ns
t_{RD2}	FO=2 Routing Delay		1.9		2.1	ns
t_{RD3}	FO=3 Routing Delay		2.1		2.5	ns
t_{RD4}	FO=4 Routing Delay		2.6		2.9	ns
t_{RD8}	FO=8 Routing Delay		4.2		4.9	ns
Logic Module Sequential Timing						
t_{SUD}	Flip-Flop (Latch) Data Input Setup	0.9		1.0		ns
t_{HD}	Flip-Flop (Latch) Data Input Hold	0.0		0.0		ns
t_{SUENA}	Flip-Flop (Latch) Enable Setup	0.9		1.0		ns
t_{HENA}	Flip-Flop (Latch) Enable Hold	0.0		0.0		ns
t_{WASYN}	Asynchronous Pulse Width	4.8		5.6		ns
t_{WCLKA}	Flip-Flop Clock Pulse Width	4.8		5.6		ns
t_A	Flip-Flop Clock Input Period	9.9		11.6		ns
f_{MAX}	Flip-Flop Clock Frequency		100		85	MHz
Input Module Propagation Delays						
t_{INY}	Input Data Pad to Y		4.2		4.9	ns
t_{ICKY}	Input Reg IOCLK Pad to Y		7.0		8.2	ns
t_{OCKY}	Output Reg IOCLK Pad to Y		7.0		8.2	ns
t_{ICLRY}	Input Asynchronous Clear to Y		7.0		8.2	ns
t_{OCLRY}	Output Asynchronous Clear to Y		7.0		8.2	ns
Predicted Input Routing Delays^{2, 3}						
t_{IRD1}	FO=1 Routing Delay		1.3		1.5	ns
t_{IRD2}	FO=2 Routing Delay		1.9		2.1	ns
t_{IRD3}	FO=3 Routing Delay		2.1		2.5	ns
t_{IRD4}	FO=4 Routing Delay		2.6		2.9	ns
t_{IRD8}	FO=8 Routing Delay		4.2		4.9	ns

Notes:

- For dual-module macros, use $t_{PD} + t_{RD1} + t_{PDn}$, $t_{CO} + t_{RD1} + t_{PDn}$, or $t_{PD1} + t_{RD1} + t_{SUD}$, whichever is appropriate.
- Routing delays are for typical designs across worst-case operating conditions. These parameters should be used for estimating device performance. Post-route timing analysis or simulation is required to determine actual worst-case performance. Post-route timing is based on actual routing delay measurements performed on the device prior to shipment.
- Optimization techniques may further reduce delays by 0 to 4 ns.

RT1460A, A1460A Timing Characteristics (continued)

(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^\circ C$)

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
I/O Module Sequential Timing						
t_{INH}	Input F-F Data Hold (w.r.t. IOCLK Pad)	0.0		0.0		ns
t_{INSU}	Input F-F Data Setup (w.r.t. IOCLK Pad)	2.1		2.4		ns
t_{IDEH}	Input Data Enable Hold (w.r.t. IOCLK Pad)	0.0		0.0		ns
t_{IDESU}	Input Data Enable Setup (w.r.t. IOCLK Pad)	8.7		10.0		ns
t_{OUTH}	Output F-F Data Hold (w.r.t. IOCLK Pad)	1.1		1.2		ns
t_{OUTSU}	Output F-F Data Setup (w.r.t. IOCLK Pad)	1.1		1.2		ns
t_{ODEH}	Output Data Enable Hold (w.r.t. IOCLK Pad)	0.5		0.6		ns
t_{ODESU}	Output Data Enable Setup (w.r.t. IOCLK Pad)	2.0		2.4		ns
TTL Output Module Timing¹						
t_{DHS}	Data to Pad, High Slew		7.5		8.9	ns
t_{DLS}	Data to Pad, Low Slew		11.9		14.0	ns
t_{ENZHS}	Enable to Pad, Z to H/L, High Slew		6.0		7.0	ns
t_{ENZLS}	Enable to Pad, Z to H/L, Low Slew		10.9		12.8	ns
t_{ENHSZ}	Enable to Pad, H/L to Z, High Slew		11.5		13.5	ns
t_{ENLSZ}	Enable to Pad, H/L to Z, Low Slew		10.9		12.8	ns
t_{CKHS}	IOCLK Pad to Pad H/L, High Slew		11.6		13.4	ns
t_{CKLS}	IOCLK Pad to Pad H/L, Low Slew		17.8		19.8	ns
d_{TLHHS}	Delta Low to High, High Slew		0.04		0.04	ns/pF
d_{TLHLS}	Delta Low to High, Low Slew		0.07		0.08	ns/pF
d_{THLHS}	Delta High to Low, High Slew		0.05		0.06	ns/pF
d_{THLLS}	Delta High to Low, Low Slew		0.07		0.08	ns/pF

Note:

1. Delays based on 35 pF loading.

RT1460A, A1460A Timing Characteristics (continued)**(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)**

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
CMOS Output Module Timing¹						
t_{DHS}	Data to Pad, High Slew		9.2		10.8	ns
t_{DLS}	Data to Pad, Low Slew		17.3		20.3	ns
t_{ENZHS}	Enable to Pad, Z to H/L, High Slew		7.7		9.1	ns
t_{ENZLS}	Enable to Pad, Z to H/L, Low Slew		13.1		15.5	ns
t_{ENHSZ}	Enable to Pad, H/L to Z, High Slew		10.9		12.8	ns
t_{ENLSZ}	Enable to Pad, H/L to Z, Low Slew		10.9		12.8	ns
t_{CKHS}	IOCLK Pad to Pad H/L, High Slew		14.1		16.0	ns
t_{CKLS}	IOCLK Pad to Pad H/L, Low Slew		20.2		22.4	ns
d_{TLHHS}	Delta Low to High, High Slew		0.06		0.07	ns/pF
d_{TLHLS}	Delta Low to High, Low Slew		0.11		0.13	ns/pF
d_{THLHS}	Delta High to Low, High Slew		0.04		0.05	ns/pF
d_{THLLS}	Delta High to Low, Low Slew		0.05		0.06	ns/pF
Dedicated (Hard-Wired) I/O Clock Network						
t_{IOCKH}	Input Low to High (Pad to I/O Module Input)		3.5		4.1	ns
t_{IOPWH}	Minimum Pulse Width High	4.8		5.7		ns
t_{IOPWL}	Minimum Pulse Width Low	4.8		5.7		ns
t_{IOSAPW}	Minimum Asynchronous Pulse Width	3.9		4.4		ns
t_{IOCKSW}	Maximum Skew		0.9		1.0	ns
t_{IOP}	Minimum Period	9.9		11.6		ns
f_{IOMAX}	Maximum Frequency		100		85	MHz
Dedicated (Hard-Wired) Array Clock Network						
t_{HCKH}	Input Low to High (Pad to S-Module Input)		5.5		6.4	ns
t_{HCKL}	Input High to Low (Pad to S-Module Input)		5.5		6.4	ns
t_{HPWH}	Minimum Pulse Width High	4.8		5.7		ns
t_{HPWL}	Minimum Pulse Width Low	4.8		5.7		ns
t_{HCKSW}	Maximum Skew		0.9		1.0	ns
t_{HP}	Minimum Period	9.9		11.6		ns
f_{HMAX}	Maximum Frequency		100		85	MHz

Notes:

1. Delays based on 35 pF loading.
2. SSO information can be found the Simultaneously Switching Output Limits for Actel FPGAs application note at <http://www.actel.com/appnotes>.

RT1460A, A1460A Timing Characteristics (continued)

(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
Routed Array Clock Networks						
t_{RCKH}	Input Low to High (FO=256)		9.0		10.5	ns
t_{RCKL}	Input High to Low (FO=256)		9.0		10.5	ns
t_{RPWH}	Min. Pulse Width High (FO=256)	6.3		7.1		ns
t_{RPWL}	Min. Pulse Width Low (FO=256)	6.3		7.1		ns
t_{RCKSW}	Maximum Skew (FO=128)		1.9		2.1	ns
t_{RP}	Minimum Period (FO=256)	12.9		14.5		ns
f_{RMAX}	Maximum Frequency (FO=256)		75		65	MHz
Clock-to-Clock Skews						
$t_{IOHCKSW}$	I/O Clock to H-Clock Skew	0.0	3.0	0.0	3.0	ns
$t_{IORCKSW}$	I/O Clock to R-Clock Skew	0.0	5.0	0.0	5.0	ns
t_{HRCKSW}	H-Clock to R-Clock Skew (FO = 64) (FO = 50% max.)	0.0	1.0	0.0	1.0	ns
		0.0	3.0	0.0	3.0	ns

RT14100A, A14100A Timing Characteristics**(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)**

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
Logic Module Propagation Delays¹						
t_{PD}	Internal Array Module		3.0		3.5	ns
t_{CO}	Sequential Clock-to-Q		3.0		3.5	ns
t_{CLR}	Asynchronous Clear-to-Q		3.0		3.5	ns
Logic Module Predicted Routing Delays²						
t_{RD1}	FO=1 Routing Delay		1.3		1.5	ns
t_{RD2}	FO=2 Routing Delay		1.9		2.1	ns
t_{RD3}	FO=3 Routing Delay		2.1		2.5	ns
t_{RD4}	FO=4 Routing Delay		2.6		2.9	ns
t_{RD8}	FO=8 Routing Delay		4.2		4.9	ns
Logic Module Sequential Timing						
t_{SUD}	Flip-Flop (Latch) Data Input Set-Up	1.0		1.0		ns
t_{HD}	Flip-Flop (Latch) Data Input Hold	0.6		0.6		ns
t_{SUENA}	Flip-Flop (Latch) Enable Set-Up	1.0		1.0		ns
t_{HENA}	Flip-Flop (Latch) Enable Hold	0.6		0.6		ns
t_{WASYN}	Asynchronous Pulse Width	4.8		5.6		ns
t_{WCLKA}	Flip-Flop Clock Pulse Width	4.8		5.6		ns
t_A	Flip-Flop Clock Input Period	9.9		11.6		ns
f_{MAX}	Flip-Flop Clock Frequency		100		85	MHz
Input Module Propagation Delays						
t_{INY}	Input Data Pad-to-Y		4.2		4.9	ns
t_{ICKY}	Input Reg IOCLK Pad-to-Y		7.0		8.2	ns
t_{OCKY}	Output Reg IOCLK Pad-to-Y		7.0		8.2	ns
t_{ICLRY}	Input Asynchronous Clear-to-Y		7.0		8.2	ns
t_{OCLRY}	Output Asynchronous Clear-to-Y		7.0		8.2	ns
Input Module Predicted Routing Delays^{2, 3}						
t_{IRD1}	FO=1 Routing Delay		1.3		1.5	ns
t_{IRD2}	FO=2 Routing Delay		1.9		2.1	ns
t_{IRD3}	FO=3 Routing Delay		2.1		2.5	ns
t_{IRD4}	FO=4 Routing Delay		2.6		2.9	ns
t_{IRD8}	FO=8 Routing Delay		4.2		4.9	ns

Notes:

1. For dual-module macros, use $t_{PD} + t_{RD1} + t_{PDn}$, $t_{CO} + t_{RD1} + t_{PDn}$, or $t_{PDI} + t_{RD1} + t_{SUD}$, whichever is appropriate.
2. Routing delays are for typical designs across worst-case operating conditions. These parameters should be used for estimating device performance. Post-route timing analysis or simulation is required to determine actual worst-case performance. Post-route timing is based on actual routing delay measurements performed on the device prior to shipment.
3. Optimization techniques may further reduce delays by 0 to 4 ns.

RT14100A, A14100A Timing Characteristics (continued)

(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
I/O Module Sequential Timing						
t_{INH}	Input Flip-Flop Data Hold	0.0		0.0		ns
t_{INSU}	Input Flip-Flop Data Set-Up	2.1		2.4		ns
t_{IDEH}	Input Data Enable Hold	0.0		0.0		ns
t_{IDESU}	Input Data Enable Set-Up	8.7		10.0		ns
t_{OUTH}	Output Flip-Flop Data Hold	1.2		1.2		ns
t_{OUTSU}	Output Flip-Flop Data Set-Up	1.2		1.2		ns
t_{ODEH}	Output Data Enable Hold	0.6		0.6		ns
t_{ODESU}	Output Data Enable Set-Up	2.4		2.4		ns
TTL Output Module Timing¹						
t_{DHS}	Data-to-Pad, High Slew		7.5		8.9	ns
t_{DLS}	Data-to-Pad, Low Slew		11.9		14.0	ns
t_{ENZHS}	Enable-to-Pad, Z to H/L, High Slew		6.0		7.0	ns
t_{ENZLS}	Enable-to-Pad, Z to H/L, Low Slew		10.9		12.8	ns
t_{ENHSZ}	Enable-to-Pad, H/L to Z, High Slew		11.9		14.0	ns
t_{ENLSZ}	Enable-to-Pad, H/L to Z, Low Slew		10.9		12.8	ns
t_{CKHS}	IOCLK Pad-to-Pad H/L, High Slew		12.2		14.0	ns
t_{CKLS}	IOCLK Pad-to-Pad H/L, Low Slew		17.8		17.8	ns
d_{TLHHS}	Delta LOW to HIGH, High Slew		0.04		0.04	ns/pF
d_{TLHLS}	Delta LOW to HIGH, Low Slew		0.07		0.08	ns/pF
d_{THLHS}	Delta HIGH to LOW, High Slew		0.05		0.06	ns/pF
d_{THLLS}	Delta HIGH to LOW, Low Slew		0.07		0.08	ns/pF

Note:

1. Delays based on 35 pF loading.

RT14100A, A14100A Timing Characteristics (continued)**(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)**

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
CMOS Output Module Timing¹						
t_{DHS}	Data-to-Pad, High Slew		9.2		10.8	ns
t_{DLS}	Data-to-Pad, Low Slew		17.3		20.3	ns
t_{ENZHS}	Enable-to-Pad, Z to H/L, High Slew		7.7		9.1	ns
t_{ENZLS}	Enable-to-Pad, Z to H/L, Low Slew		13.1		15.5	ns
t_{ENHSZ}	Enable-to-Pad, H/L to Z, High Slew		11.6		14.0	ns
t_{ENLSZ}	Enable-to-Pad, H/L to Z, Low Slew		10.9		12.8	ns
t_{CKHS}	IOCLK Pad-to-Pad H/L, High Slew		14.4		16.0	ns
t_{CKLS}	IOCLK Pad-to-Pad H/L, Low Slew		20.2		22.4	ns
d_{TLHHS}	Delta LOW to HIGH, High Slew		0.06		0.07	ns/pF
d_{TLHLS}	Delta LOW to HIGH, Low Slew		0.11		0.13	ns/pF
d_{THLHS}	Delta HIGH to LOW, High Slew		0.04		0.05	ns/pF
d_{THLLS}	Delta HIGH to LOW, Low Slew		0.05		0.06	ns/pF
Dedicated (Hard-Wired) I/O Clock Network						
t_{IOCKH}	Input LOW to HIGH (Pad to I/O Module Input)		3.5		4.1	ns
t_{IOPWH}	Minimum Pulse Width HIGH	4.8		5.7		ns
t_{IOPWL}	Minimum Pulse Width LOW	4.8		5.7		ns
t_{IOSAPW}	Minimum Asynchronous Pulse Width	3.9		4.4		ns
t_{IOCKSW}	Maximum Skew		0.9		1.0	ns
t_{IOP}	Minimum Period	9.9		11.6		ns
f_{IOMAX}	Maximum Frequency		100		85	MHz
Dedicated (Hard-Wired) Array Clock Network						
t_{HCKH}	Input LOW to HIGH (Pad to S-Module Input)		5.5		6.4	ns
t_{HCKL}	Input HIGH to LOW (Pad to S-Module Input)		5.5		6.4	ns
t_{HPWH}	Minimum Pulse Width HIGH	4.8		5.7		ns
t_{HPWL}	Minimum Pulse Width LOW	4.8		5.7		ns
t_{HCKSW}	Maximum Skew		0.9		1.0	ns
t_{HP}	Minimum Period	9.9		11.6		ns
f_{HMAX}	Maximum Frequency		100		85	MHz

Notes:

1. Delays based on 35 pF loading.
2. SSO information can be found the Simultaneously Switching Output Limits for Actel FPGAs application note at <http://www.actel.com/appnotes>.

RT14100A, A14100A Timing Characteristics (continued)
(Worst-Case Military Conditions, $V_{CC} = 4.5V$, $T_J = 125^{\circ}C$)

Parameter	Description	'-1' Speed		'Std' Speed		Units
		Min.	Max.	Min.	Max.	
Routed Array Clock Networks						
t_{RCKH}	Input LOW to HIGH (FO=256)		9.0		10.5	ns
t_{RCKL}	Input HIGH to LOW (FO=256)		9.0		10.5	ns
t_{RPWH}	Min. Pulse Width HIGH (FO=256)	6.3		7.1		ns
t_{RPWL}	Min. Pulse Width LOW (FO=256)	6.3		7.1		ns
t_{RCKSW}	Maximum Skew (FO=128)		1.9		2.1	ns
t_{RP}	Minimum Period (FO=256)	12.9		14.5		ns
f_{RMAX}	Maximum Frequency (FO=256)		75		65	MHz
Clock-to-Clock Skews						
$t_{IOHCKSW}$	I/O Clock to H-Clock Skew	0.0	3.5	0.0	3.5	ns
$t_{IORCKSW}$	I/O Clock to R-Clock Skew	0.0	5.0	0.0	5.0	ns
t_{HRCKSW}	H-Clock to R-Clock Skew (FO = 64) (FO = 50% max.)	0.0	1.0	0.0	1.0	ns
		0.0	3.0	0.0	3.0	

Pin Description

CLK **Clock (Input)**

RT1020 and A1020B only. TTL clock input for global clock distribution networks. The clock input is buffered prior to clocking the logic modules. This pin can also be used as an I/O.

CLKA **Clock A (Input)**

Not applicable for RT1020 and A1020B. TTL clock input for global clock distribution networks. The clock input is buffered prior to clocking the logic modules. This pin can also be used as an I/O.

CLKB **Clock B (Input)**

Not applicable for RT1020 and A1020B. TTL clock input for global clock distribution networks. The clock input is buffered prior to clocking the logic modules. This pin can also be used as an I/O.

DCLK **Diagnostic Clock (Input)**

TTL clock input for diagnostic probe and device programming. DCLK is active when the MODE pin is HIGH. This pin functions as an I/O when the MODE pin is LOW.

GND **Ground**

LOW supply voltage.

HCLK **Dedicated (Hard-Wired) Array Clock (Input)**

Not applicable for RT1020, A1020B, RT1280A and A1280A. TTL clock input for sequential modules. This input is directly wired to each S-module, offering clock speeds independent of the number of S-modules being driven. This pin can also be used as an I/O.

I/O **Input/Output (Input, Output)**

I/O pin functions as an input, output, tri-state, or bi-directional buffer. Input and output levels are compatible with standard TTL and CMOS specifications. In the RT1020, A1020B, RT1280, and A1280A devices, unused I/O pins are automatically driven LOW. In the RT1425, A1425A, RT1460, A1460A, RT14100, and A14100A devices, unused I/O pins are automatically tri-stated.

IOCLK **Dedicated (Hard-Wired) I/O Clock (Input)**

Not applicable for RT1020, A1020B, RT1280A and A1280A. TTL clock input for I/O modules. This input is directly wired to each I/O module, offering clock speeds independent of the number of I/O modules being driven. This pin can also be used as an I/O.

IOPCL **Dedicated (Hard-Wired) I/O Preset/Clear (Input)**

Not applicable for RT1020, A1020B, RT1280A and A1280A. TTL input for I/O preset or clear. This global input is directly wired to the preset and clear inputs of all I/O registers. This pin functions as an I/O when no I/O preset or clear macros are used.

MODE **Mode (Input)**

The MODE pin controls the use of diagnostic pins (DCLK, PRA, PRB, SDI). When the MODE pin is HIGH, the special functions are active. When the MODE pin is LOW, the pins function as I/Os. To provide debugging capability, the MODE pin should be terminated to GND through a 10 kΩ resistor so that the MODE pin can be pulled HIGH when required.

NC **No Connection**

This pin is not connected to circuitry within the device.

PRA, I/O **Probe A (Output)**

The Probe A pin is used to output data from any user-defined design node within the device. This independent diagnostic pin can be used in conjunction with the Probe B pin to allow real-time diagnostic output of any signal path within the device. The Probe A pin can be used as a user-defined I/O when verification has been completed. The pin's probe capabilities can be permanently disabled to protect programmed design confidentiality. PRA is accessible when the MODE pin is HIGH. This pin functions as an I/O when the MODE pin is LOW.

PRB, I/O **Probe B (Output)**

The Probe B pin is used to output data from any user-defined design node within the device. This independent diagnostic pin can be used in conjunction with the Probe A pin to allow real-time diagnostic output of any signal path within the device. The Probe B pin can be used as a user-defined I/O when verification has been completed. The pin's probe capabilities can be permanently disabled to protect programmed design confidentiality. PRB is accessible when the MODE pin is HIGH. This pin functions as an I/O when the MODE pin is LOW.

SDI **Serial Data Input (Input)**

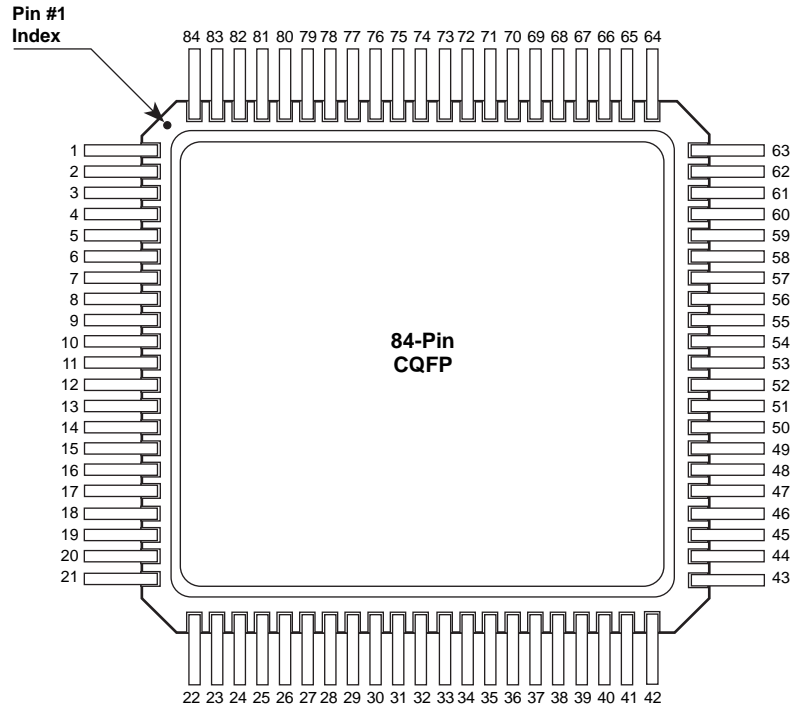
Serial data input for diagnostic probe and device programming. SDI is active when the MODE pin is HIGH. This pin functions as an I/O when the MODE pin is LOW.

V_{CC} **5.0V Supply Voltage**

HIGH supply voltage.

Package Pin Assignments

84-Pin CQFP (Top View)



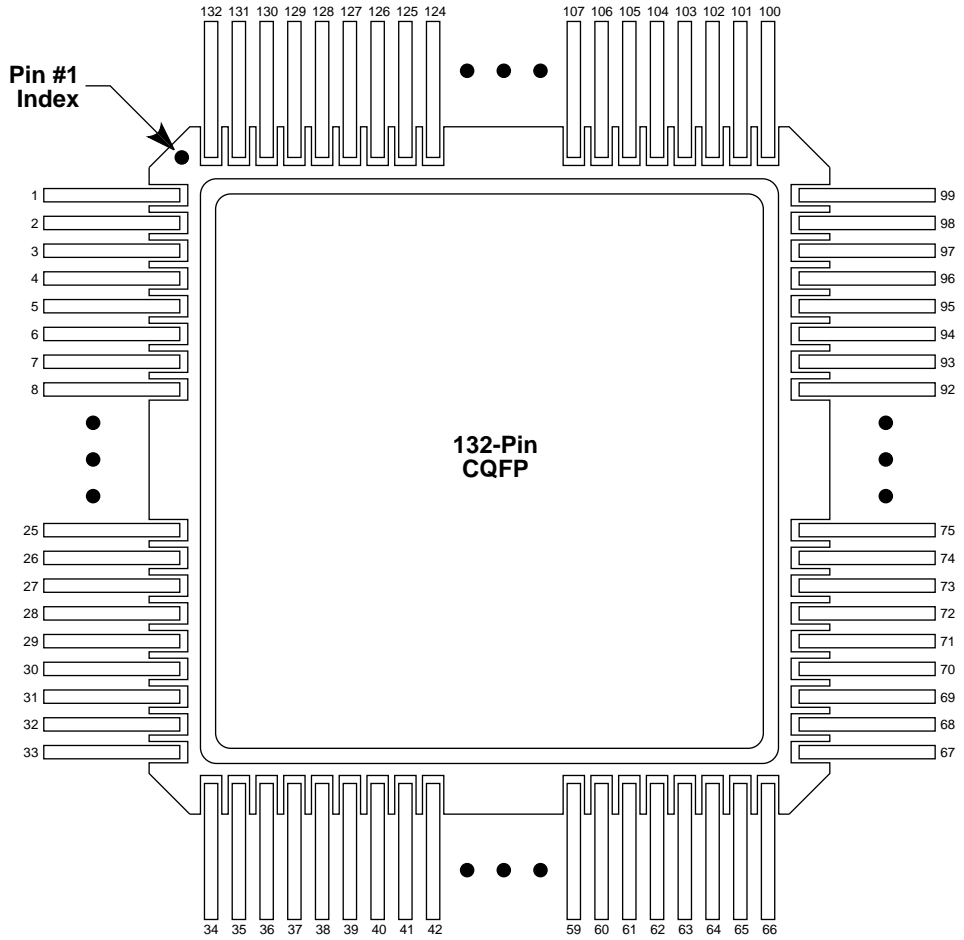
84-Pin CQFP

Pin Number	A1020B Function	RT1020 Function
1	NC	NC
2	I/O	I/O
3	I/O	I/O
4	I/O	I/O
5	I/O	I/O
6	I/O	I/O
7	GND	GND
8	GND	GND
9	I/O	I/O
10	I/O	I/O
11	I/O	I/O
12	I/O	I/O
13	I/O	I/O
14	V _{CC}	V _{CC}
15	V _{CC}	V _{CC}
16	I/O	I/O
17	I/O	I/O
18	I/O	I/O
19	I/O	I/O
20	I/O	I/O
21	I/O	I/O
22	V _{CC}	V _{CC}
23	I/O	I/O
24	I/O	I/O
25	I/O	I/O
26	I/O	I/O
27	I/O	I/O
28	I/O	I/O
29	GND	GND
30	I/O	I/O
31	I/O	I/O
32	I/O	I/O
33	I/O	I/O
34	I/O	I/O
35	V _{CC}	V _{CC}
36	I/O	I/O
37	I/O	I/O
38	I/O	I/O
39	I/O	I/O
40	I/O	I/O
41	I/O	I/O
42	I/O	I/O

Pin Number	A1020B Function	RT1020 Function
43	I/O	I/O
44	I/O	I/O
45	I/O	I/O
46	I/O	I/O
47	I/O	I/O
48	I/O	I/O
49	GND	GND
50	GND	GND
51	I/O	I/O
52	I/O	I/O
53	CLKA, I/O	CLKA, I/O
54	I/O	I/O
55	MODE	MODE
56	V _{CC}	V _{CC}
57	V _{CC}	V _{CC}
58	I/O	I/O
59	I/O	I/O
60	I/O	I/O
61	SDI, I/O	SDI, I/O
62	DCLK, I/O	DCLK, I/O
63	PRA, I/O	PRA, I/O
64	PRB, I/O	PRB, I/O
65	I/O	I/O
66	I/O	I/O
67	I/O	I/O
68	I/O	I/O
69	I/O	I/O
70	I/O	I/O
71	GND	GND
72	I/O	I/O
73	I/O	I/O
74	I/O	I/O
75	I/O	I/O
76	I/O	I/O
77	V _{CC}	V _{CC}
78	I/O	I/O
79	I/O	I/O
80	I/O	I/O
81	I/O	I/O
82	I/O	I/O
83	I/O	I/O
84	I/O	I/O

Package Pin Assignments (continued)

132-Pin CQFP (Top View)

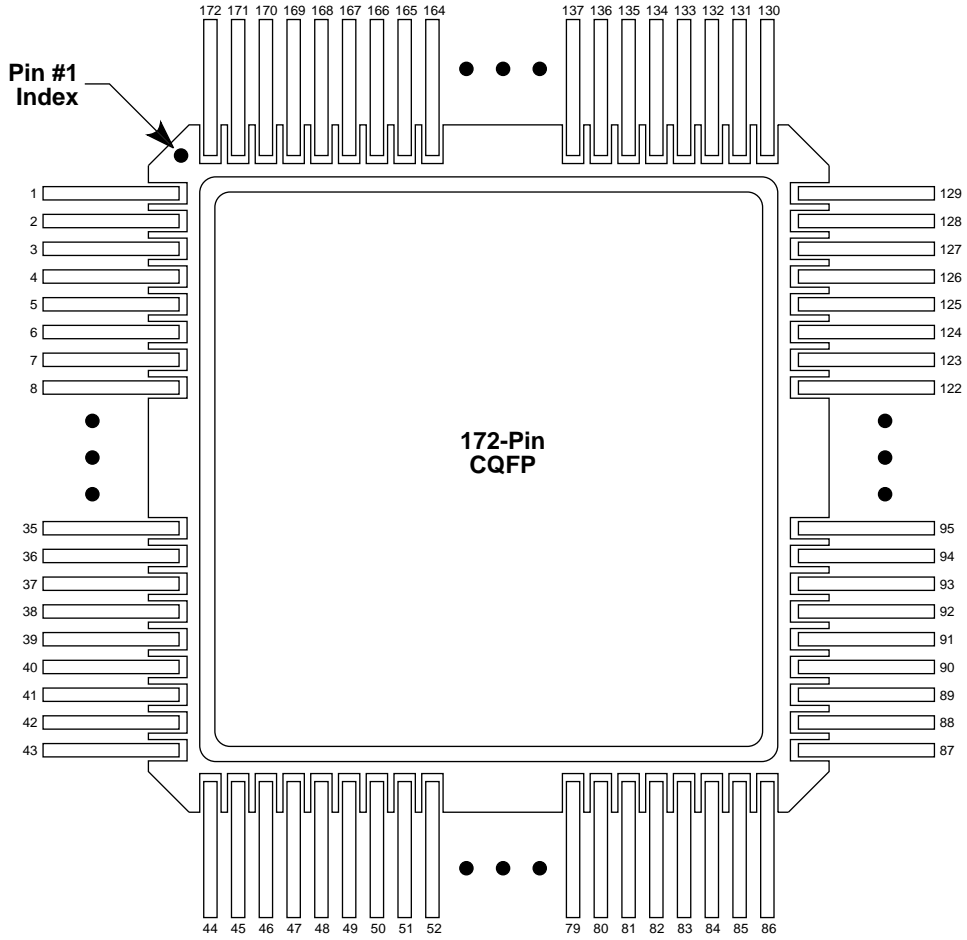


132-Pin CQFP

Pin Number	A1425A Function	RT1425A Function	Pin Number	A1425A Function	RT1425A Function	Pin Number	A1425A Function	RT1425A Function
1	NC	NC	45	I/O	I/O	89	V _{CC}	V _{CC}
2	GND	GND	46	I/O	I/O	90	GND	GND
3	SDI, I/O	SDI, I/O	47	I/O	I/O	91	V _{CC}	V _{CC}
4	I/O	I/O	48	PRB, I/O	PRB, I/O	92	GND	GND
5	I/O	I/O	49	I/O	I/O	93	I/O	I/O
6	I/O	I/O	50	HCLK, I/O	HCLK, I/O	94	I/O	I/O
7	I/O	I/O	51	I/O	I/O	95	I/O	I/O
8	I/O	I/O	52	I/O	I/O	96	I/O	I/O
9	MODE	MODE	53	I/O	I/O	97	I/O	I/O
10	GND	GND	54	I/O	I/O	98	IOCLK, I/O	IOCLK, I/O
11	V _{CC}	V _{CC}	55	I/O	I/O	99	NC	NC
12	I/O	I/O	56	I/O	I/O	100	NC	NC
13	I/O	I/O	57	I/O	I/O	101	GND	GND
14	I/O	I/O	58	GND	GND	102	I/O	I/O
15	I/O	I/O	59	V _{CC}	V _{CC}	103	I/O	I/O
16	I/O	I/O	60	I/O	I/O	104	I/O	I/O
17	I/O	I/O	61	I/O	I/O	105	I/O	I/O
18	I/O	I/O	62	I/O	I/O	106	GND	GND
19	I/O	I/O	63	I/O	I/O	107	V _{CC}	V _{CC}
20	I/O	I/O	64	IOPCL, I/O	IOPCL, I/O	108	I/O	I/O
21	I/O	I/O	65	GND	GND	109	I/O	I/O
22	V _{CC}	V _{CC}	66	NC	NC	110	I/O	I/O
23	I/O	I/O	67	NC	NC	111	I/O	I/O
24	I/O	I/O	68	I/O	I/O	112	I/O	I/O
25	I/O	I/O	69	I/O	I/O	113	I/O	I/O
26	GND	GND	70	I/O	I/O	114	I/O	I/O
27	V _{CC}	V _{CC}	71	I/O	I/O	115	I/O	I/O
28	I/O	I/O	72	I/O	I/O	116	CLKA, I/O	CLKA, I/O
29	I/O	I/O	73	I/O	I/O	117	CLKB, I/O	CLKB, I/O
30	I/O	I/O	74	GND	GND	118	PRA, I/O	PRA, I/O
31	I/O	I/O	75	V _{CC}	V _{CC}	119	I/O	I/O
32	I/O	I/O	76	I/O	I/O	120	I/O	I/O
33	I/O	I/O	77	I/O	I/O	121	I/O	I/O
34	NC	NC	78	V _{CC}	V _{CC}	122	GND	GND
35	I/O	I/O	79	I/O	I/O	123	V _{CC}	V _{CC}
36	GND	GND	80	I/O	I/O	124	I/O	I/O
37	I/O	I/O	81	I/O	I/O	125	I/O	I/O
38	I/O	I/O	82	I/O	I/O	126	I/O	I/O
39	I/O	I/O	83	I/O	I/O	127	I/O	I/O
40	I/O	I/O	84	I/O	I/O	128	I/O	I/O
41	I/O	I/O	85	I/O	I/O	129	I/O	I/O
42	GND	GND	86	I/O	I/O	130	I/O	I/O
43	V _{CC}	V _{CC}	87	I/O	I/O	131	DCLK, I/O	DCLK, I/O
44	I/O	I/O	88	I/O	I/O	132	NC	NC

Package Pin Assignments (continued)

172-Pin CQFP (Top View)



172-Pin CQFP

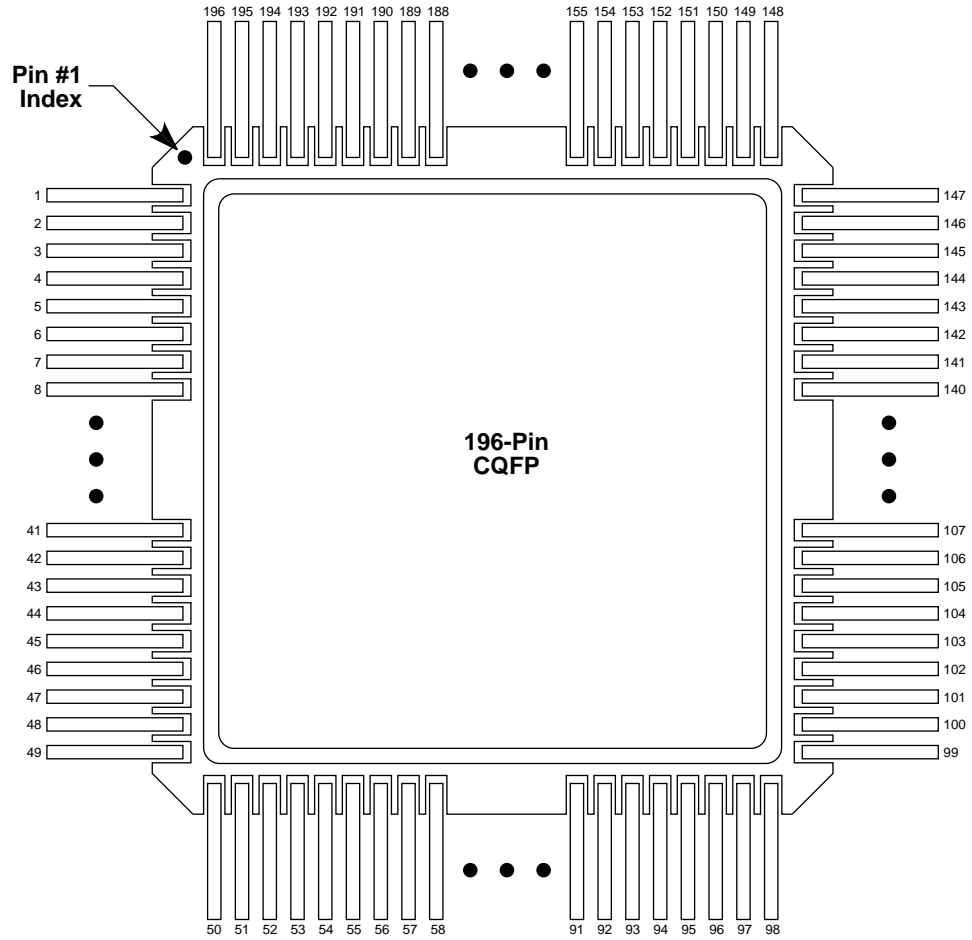
Pin Number	A1280A Function	RT1280A Function
1	MODE	MODE
2	I/O	I/O
3	I/O	I/O
4	I/O	I/O
5	I/O	I/O
6	I/O	I/O
7	GND	GND
8	I/O	I/O
9	I/O	I/O
10	I/O	I/O
11	I/O	I/O
12	V _{CC}	V _{CC}
13	I/O	I/O
14	I/O	I/O
15	I/O	I/O
16	I/O	I/O
17	GND	GND
18	I/O	I/O
19	I/O	I/O
20	I/O	I/O
21	I/O	I/O
22	GND	GND
23	V _{CC}	V _{CC}
24	V _{CC}	V _{CC}
25	I/O	I/O
26	I/O	I/O
27	V _{CC}	V _{CC}
28	I/O	I/O
29	I/O	I/O
30	I/O	I/O
31	I/O	I/O
32	GND	GND
33	I/O	I/O
34	I/O	I/O
35	I/O	I/O
36	I/O	I/O
37	GND	GND
38	I/O	I/O
39	I/O	I/O
40	I/O	I/O
41	I/O	I/O
42	I/O	I/O
43	I/O	I/O
44	I/O	I/O

Pin Number	A1280A Function	RT1280A Function
45	I/O	I/O
46	I/O	I/O
47	I/O	I/O
48	I/O	I/O
49	I/O	I/O
50	V _{CC}	V _{CC}
51	I/O	I/O
52	I/O	I/O
53	I/O	I/O
54	I/O	I/O
55	GND	GND
56	I/O	I/O
57	I/O	I/O
58	I/O	I/O
59	I/O	I/O
60	I/O	I/O
61	I/O	I/O
62	I/O	I/O
63	I/O	I/O
64	I/O	I/O
65	GND	GND
66	V _{CC}	V _{CC}
67	I/O	I/O
68	I/O	I/O
69	I/O	I/O
70	I/O	I/O
71	I/O	I/O
72	I/O	I/O
73	I/O	I/O
74	I/O	I/O
75	GND	GND
76	I/O	I/O
77	I/O	I/O
78	I/O	I/O
79	I/O	I/O
80	V _{CC}	V _{CC}
81	I/O	I/O
82	I/O	I/O
83	I/O	I/O
84	I/O	I/O
85	I/O	I/O
86	I/O	I/O
87	I/O	I/O
88	I/O	I/O

172-Pin CQFP (Continued)

Pin Number	A1280A Function	RT1280A Function
89	I/O	I/O
90	I/O	I/O
91	I/O	I/O
92	I/O	I/O
93	I/O	I/O
94	I/O	I/O
95	I/O	I/O
96	I/O	I/O
97	I/O	I/O
98	GND	GND
99	I/O	I/O
100	I/O	I/O
101	I/O	I/O
102	I/O	I/O
103	GND	GND
104	I/O	I/O
105	I/O	I/O
106	GND	GND
107	V _{CC}	V _{CC}
108	GND	GND
109	V _{CC}	V _{CC}
110	V _{CC}	V _{CC}
111	I/O	I/O
112	I/O	I/O
113	V _{CC}	V _{CC}
114	I/O	I/O
115	I/O	I/O
116	I/O	I/O
117	I/O	I/O
118	GND	GND
119	I/O	I/O
120	I/O	I/O
121	I/O	I/O
122	I/O	I/O
123	GND	GND
124	I/O	I/O
125	I/O	I/O
126	I/O	I/O
127	I/O	I/O
128	I/O	I/O
129	I/O	I/O
130	I/O	I/O

Pin Number	A1280A Function	RT1280A Function
131	SDI, I/O	SDI, I/O
132	I/O	I/O
133	I/O	I/O
134	I/O	I/O
135	I/O	I/O
136	V _{CC}	V _{CC}
137	I/O	I/O
138	I/O	I/O
139	I/O	I/O
140	I/O	I/O
141	GND	GND
142	I/O	I/O
143	I/O	I/O
144	I/O	I/O
145	I/O	I/O
146	I/O	I/O
147	I/O	I/O
148	PRA, I/O	PRA, I/O
149	I/O	I/O
150	CLKA, I/O	CLKA, I/O
151	V _{CC}	V _{CC}
152	GND	GND
153	I/O	I/O
154	CLKB, I/O	CLKB, I/O
155	I/O	I/O
156	PRB, I/O	PRB, I/O
157	I/O	I/O
158	I/O	I/O
159	I/O	I/O
160	I/O	I/O
161	GND	GND
162	I/O	I/O
163	I/O	I/O
164	I/O	I/O
165	I/O	I/O
166	V _{CC}	V _{CC}
167	I/O	I/O
168	I/O	I/O
169	I/O	I/O
170	I/O	I/O
171	DCLK, I/O	DCLK, I/O
172	I/O	I/O

Package Pin Assignments (continued)**196-Pin CQFP (Top View)**

196-Pin CQFP

Pin Number	A1460A Function	RT1460A Function
1	GND	GND
2	SDI, I/O	SDI, I/O
3	I/O	I/O
4	I/O	I/O
5	I/O	I/O
6	I/O	I/O
7	I/O	I/O
8	I/O	I/O
9	I/O	I/O
10	I/O	I/O
11	MODE	MODE
12	V _{CC}	V _{CC}
13	GND	GND
14	I/O	I/O
15	I/O	I/O
16	I/O	I/O
17	I/O	I/O
18	I/O	I/O
19	I/O	I/O
20	I/O	I/O
21	I/O	I/O
22	I/O	I/O
23	I/O	I/O
24	I/O	I/O
25	I/O	I/O
26	I/O	I/O
27	I/O	I/O
28	I/O	I/O
29	I/O	I/O
30	I/O	I/O
31	I/O	I/O
32	I/O	I/O
33	I/O	I/O
34	I/O	I/O
35	I/O	I/O
36	I/O	I/O
37	GND	GND
38	V _{CC}	V _{CC}
39	V _{CC}	V _{CC}
40	I/O	I/O
41	I/O	I/O
42	I/O	I/O
43	I/O	I/O

Pin Number	A1460A Function	RT1460A Function
44	I/O	I/O
45	I/O	I/O
46	I/O	I/O
47	I/O	I/O
48	I/O	I/O
49	I/O	I/O
50	I/O	I/O
51	GND	GND
52	GND	GND
53	I/O	I/O
54	I/O	I/O
55	I/O	I/O
56	I/O	I/O
57	I/O	I/O
58	I/O	I/O
59	V _{CC}	V _{CC}
60	I/O	I/O
61	I/O	I/O
62	I/O	I/O
63	I/O	I/O
64	GND	GND
65	I/O	I/O
66	I/O	I/O
67	I/O	I/O
68	I/O	I/O
69	I/O	I/O
70	I/O	I/O
71	I/O	I/O
72	I/O	I/O
73	I/O	I/O
74	I/O	I/O
75	PRB, I/O	PRB, I/O
76	I/O	I/O
77	HCLK, I/O	HCLK, I/O
78	I/O	I/O
79	I/O	I/O
80	I/O	I/O
81	I/O	I/O
82	I/O	I/O
83	I/O	I/O
84	I/O	I/O
85	I/O	I/O
86	GND	GND

Pin Number	A1460A Function	RT1460A Function
87	I/O	I/O
88	I/O	I/O
89	I/O	I/O
90	I/O	I/O
91	I/O	I/O
92	I/O	I/O
93	I/O	I/O
94	V _{CC}	V _{CC}
95	I/O	I/O
96	I/O	I/O
97	I/O	I/O
98	GND	GND
99	I/O	I/O
100	IOPCL, I/O	IOPCL, I/O
101	GND	GND
102	I/O	I/O
103	I/O	I/O
104	I/O	I/O
105	I/O	I/O
106	I/O	I/O
107	I/O	I/O
108	I/O	I/O
109	I/O	I/O
110	V _{CC}	V _{CC}
111	V _{CC}	V _{CC}
112	GND	GND
113	I/O	I/O
114	I/O	I/O
115	I/O	I/O
116	I/O	I/O
117	I/O	I/O
118	I/O	I/O
119	I/O	I/O
120	I/O	I/O
121	I/O	I/O
122	I/O	I/O
123	I/O	I/O
124	I/O	I/O
125	I/O	I/O
126	I/O	I/O
127	I/O	I/O
128	I/O	I/O
129	I/O	I/O

196-Pin CQFP (Continued)

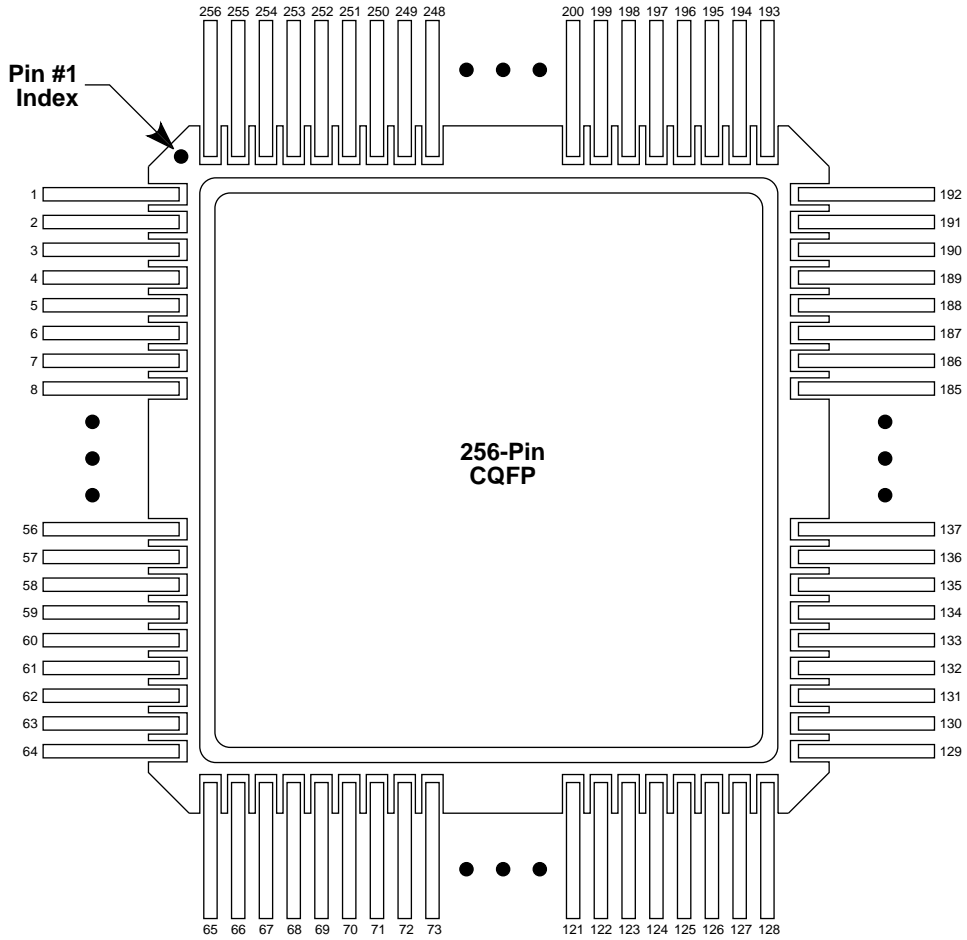
Pin Number	A1460A Function	RT1460A Function
130	I/O	I/O
131	I/O	I/O
132	I/O	I/O
133	I/O	I/O
134	I/O	I/O
135	I/O	I/O
136	I/O	I/O
137	V _{CC}	V _{CC}
138	GND	GND
139	GND	GND
140	V _{CC}	V _{CC}
141	I/O	I/O
142	I/O	I/O
143	I/O	I/O
144	I/O	I/O
145	I/O	I/O
146	I/O	I/O
147	I/O	I/O
148	IOCLK, I/O	IOCLK, I/O
149	GND	GND
150	I/O	I/O
151	I/O	I/O
152	I/O	I/O

Pin Number	A1460A Function	RT1460A Function
153	I/O	I/O
154	I/O	I/O
155	V _{CC}	V _{CC}
156	I/O	I/O
157	I/O	I/O
158	I/O	I/O
159	I/O	I/O
160	I/O	I/O
161	I/O	I/O
162	GND	GND
163	I/O	I/O
164	I/O	I/O
165	I/O	I/O
166	I/O	I/O
167	I/O	I/O
168	I/O	I/O
169	I/O	I/O
170	I/O	I/O
171	I/O	I/O
172	CLKA, I/O	CLKA, I/O
173	CLKB, I/O	CLKB, I/O
174	PRA, I/O	PRA, I/O
175	I/O	I/O

Pin Number	A1460A Function	RT1460A Function
176	I/O	I/O
177	I/O	I/O
178	I/O	I/O
179	I/O	I/O
180	I/O	I/O
181	I/O	I/O
182	I/O	I/O
183	GND	GND
184	I/O	I/O
185	I/O	I/O
186	I/O	I/O
187	I/O	I/O
188	I/O	I/O
189	V _{CC}	V _{CC}
190	I/O	I/O
191	I/O	I/O
192	I/O	I/O
193	GND	GND
194	I/O	I/O
195	I/O	I/O
196	DCLK, I/O	DCLK, I/O

Package Pin Assignments (continued)

256-Pin CQFP (Top View)



256-Pin CQFP

Pin Number	A14100A Function	RT14100A Function	Pin Number	A14100A Function	RT14100A Function	Pin Number	A14100A Function	RT14100A Function
1	GND	GND	45	I/O	I/O	89	I/O	I/O
2	SDI, I/O	SDI, I/O	46	V _{CC}	V _{CC}	90	PRB, I/O	PRB, I/O
3	I/O	I/O	47	I/O	I/O	91	GND	GND
4	I/O	I/O	48	I/O	I/O	92	V _{CC}	V _{CC}
5	I/O	I/O	49	I/O	I/O	93	GND	GND
6	I/O	I/O	50	I/O	I/O	94	V _{CC}	V _{CC}
7	I/O	I/O	51	I/O	I/O	95	I/O	I/O
8	I/O	I/O	52	I/O	I/O	96	HCLK, I/O	HCLK, I/O
9	I/O	I/O	53	I/O	I/O	97	I/O	I/O
10	I/O	I/O	54	I/O	I/O	98	I/O	I/O
11	MODE	MODE	55	I/O	I/O	99	I/O	I/O
12	I/O	I/O	56	I/O	I/O	100	I/O	I/O
13	I/O	I/O	57	I/O	I/O	101	I/O	I/O
14	I/O	I/O	58	I/O	I/O	102	I/O	I/O
15	I/O	I/O	59	GND	GND	103	I/O	I/O
16	I/O	I/O	60	I/O	I/O	104	I/O	I/O
17	I/O	I/O	61	I/O	I/O	105	I/O	I/O
18	I/O	I/O	62	I/O	I/O	106	I/O	I/O
19	I/O	I/O	63	I/O	I/O	107	I/O	I/O
20	I/O	I/O	64	I/O	I/O	108	I/O	I/O
21	I/O	I/O	65	I/O	I/O	109	I/O	I/O
22	I/O	I/O	66	I/O	I/O	110	GND	GND
23	I/O	I/O	67	I/O	I/O	111	I/O	I/O
24	I/O	I/O	68	I/O	I/O	112	I/O	I/O
25	I/O	I/O	69	I/O	I/O	113	I/O	I/O
26	I/O	I/O	70	I/O	I/O	114	I/O	I/O
27	I/O	I/O	71	I/O	I/O	115	I/O	I/O
28	V _{CC}	V _{CC}	72	I/O	I/O	116	I/O	I/O
29	GND	GND	73	I/O	I/O	117	I/O	I/O
30	V _{CC}	V _{CC}	74	I/O	I/O	118	I/O	I/O
31	GND	GND	75	I/O	I/O	119	I/O	I/O
32	I/O	I/O	76	I/O	I/O	120	I/O	I/O
33	I/O	I/O	77	I/O	I/O	121	I/O	I/O
34	I/O	I/O	78	I/O	I/O	122	I/O	I/O
35	I/O	I/O	79	I/O	I/O	123	I/O	I/O
36	I/O	I/O	80	I/O	I/O	124	IOPCL, I/O	IOPCL, I/O
37	I/O	I/O	81	I/O	I/O	125	I/O	I/O
38	I/O	I/O	82	I/O	I/O	126	I/O	I/O
39	I/O	I/O	83	I/O	I/O	127	I/O	I/O
40	I/O	I/O	84	I/O	I/O	128	GND	GND
41	I/O	I/O	85	I/O	I/O	129	I/O	I/O
42	I/O	I/O	86	I/O	I/O	130	I/O	I/O
43	I/O	I/O	87	I/O	I/O	131	I/O	I/O
44	I/O	I/O	88	I/O	I/O	132	I/O	I/O

256-Pin CQFP (Continued)

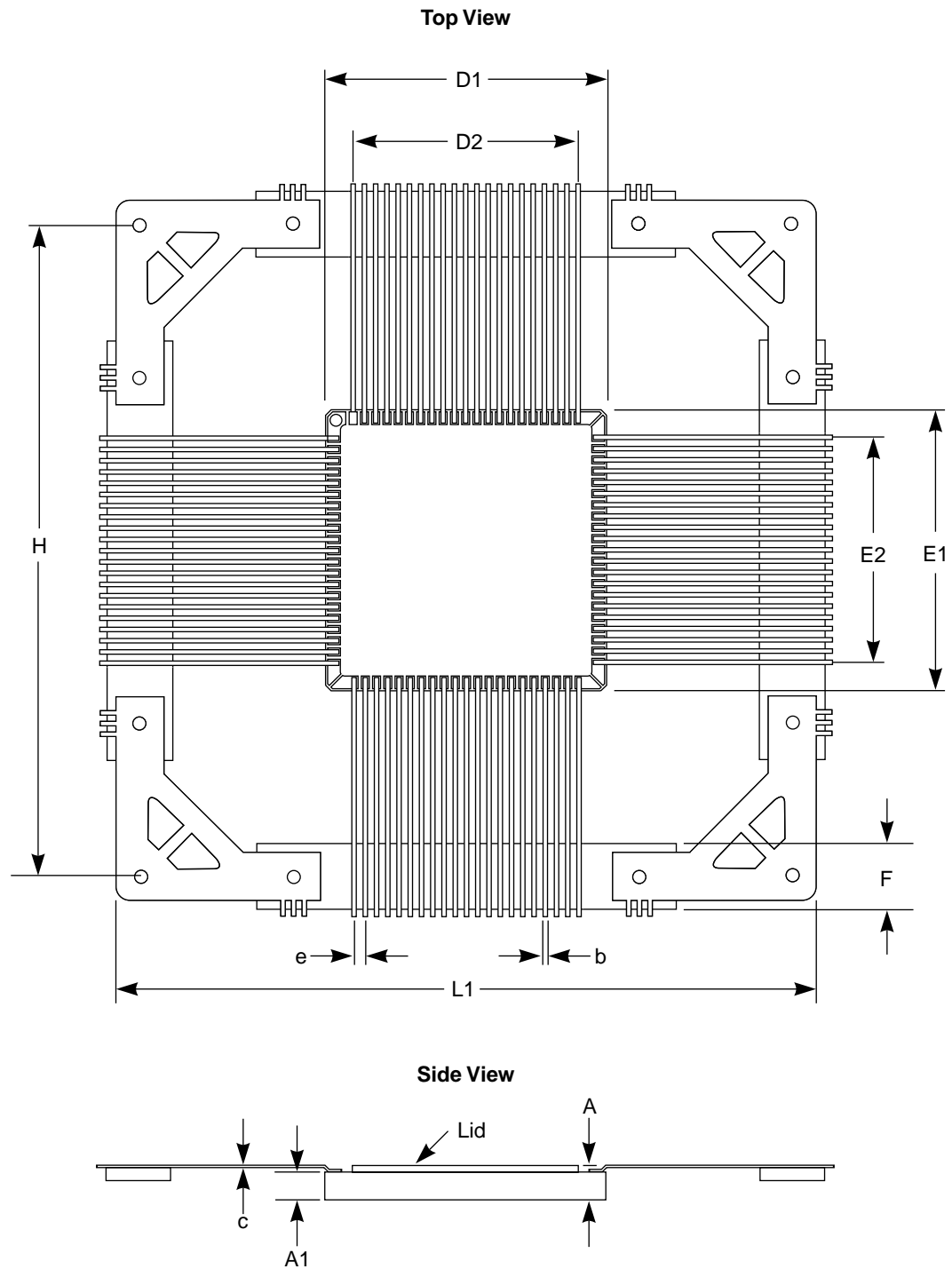
Pin Number	A14100A Function	RT14100A Function
133	I/O	I/O
134	I/O	I/O
135	I/O	I/O
136	I/O	I/O
137	I/O	I/O
138	I/O	I/O
139	I/O	I/O
140	I/O	I/O
141	V _{CC}	V _{CC}
142	I/O	I/O
143	I/O	I/O
144	I/O	I/O
145	I/O	I/O
146	I/O	I/O
147	I/O	I/O
148	I/O	I/O
149	I/O	I/O
150	I/O	I/O
151	I/O	I/O
152	I/O	I/O
153	I/O	I/O
154	I/O	I/O
155	I/O	I/O
156	I/O	I/O
157	I/O	I/O
158	GND	GND
159	V _{CC}	V _{CC}
160	GND	GND
161	V _{CC}	V _{CC}
162	I/O	I/O
163	I/O	I/O
164	I/O	I/O
165	I/O	I/O
166	I/O	I/O
167	I/O	I/O
168	I/O	I/O
169	I/O	I/O
170	I/O	I/O
171	I/O	I/O
172	I/O	I/O
173	I/O	I/O
174	V _{CC}	V _{CC}

Pin Number	A14100A Function	RT14100A Function
175	GND	GND
176	GND	GND
177	I/O	I/O
178	I/O	I/O
179	I/O	I/O
180	I/O	I/O
181	I/O	I/O
182	I/O	I/O
183	I/O	I/O
184	I/O	I/O
185	I/O	I/O
186	I/O	I/O
187	I/O	I/O
188	IOCLK, I/O	IOCLK, I/O
189	GND	GND
190	I/O	I/O
191	I/O	I/O
192	I/O	I/O
193	I/O	I/O
194	I/O	I/O
195	I/O	I/O
196	I/O	I/O
197	I/O	I/O
198	I/O	I/O
199	I/O	I/O
200	I/O	I/O
201	I/O	I/O
202	I/O	I/O
203	I/O	I/O
204	I/O	I/O
205	I/O	I/O
206	I/O	I/O
207	I/O	I/O
208	I/O	I/O
209	I/O	I/O
210	I/O	I/O
211	I/O	I/O
212	I/O	I/O
213	I/O	I/O
214	I/O	I/O
215	I/O	I/O
216	I/O	I/O

Pin Number	A14100A Function	RT14100A Function
217	I/O	I/O
218	I/O	I/O
219	CLKA, I/O	CLKA, I/O
220	CLKB, I/O	CLKB, I/O
221	V _{CC}	V _{CC}
222	GND	GND
223	V _{CC}	V _{CC}
224	GND	GND
225	PRA, I/O	PRA, I/O
226	I/O	I/O
227	I/O	I/O
228	I/O	I/O
229	I/O	I/O
230	I/O	I/O
231	I/O	I/O
232	I/O	I/O
233	I/O	I/O
234	I/O	I/O
235	I/O	I/O
236	I/O	I/O
237	I/O	I/O
238	I/O	I/O
239	I/O	I/O
240	GND	GND
241	I/O	I/O
242	I/O	I/O
243	I/O	I/O
244	I/O	I/O
245	I/O	I/O
246	I/O	I/O
247	I/O	I/O
248	I/O	I/O
249	I/O	I/O
250	I/O	I/O
251	I/O	I/O
252	I/O	I/O
253	I/O	I/O
254	I/O	I/O
255	I/O	I/O
256	DCLK, I/O	DCLK, I/O

Package Mechanical Drawings

84-Pin CQFP (Cavity Up)

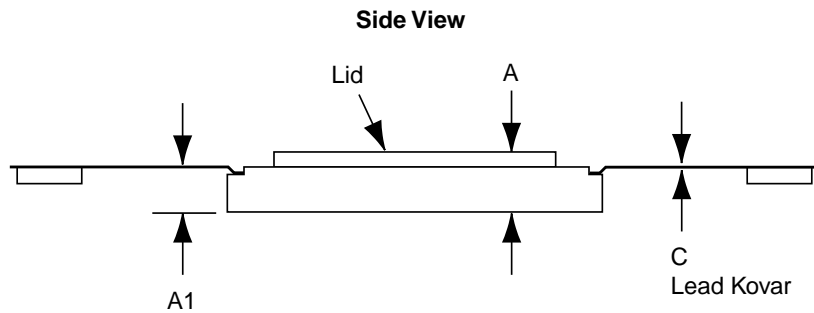
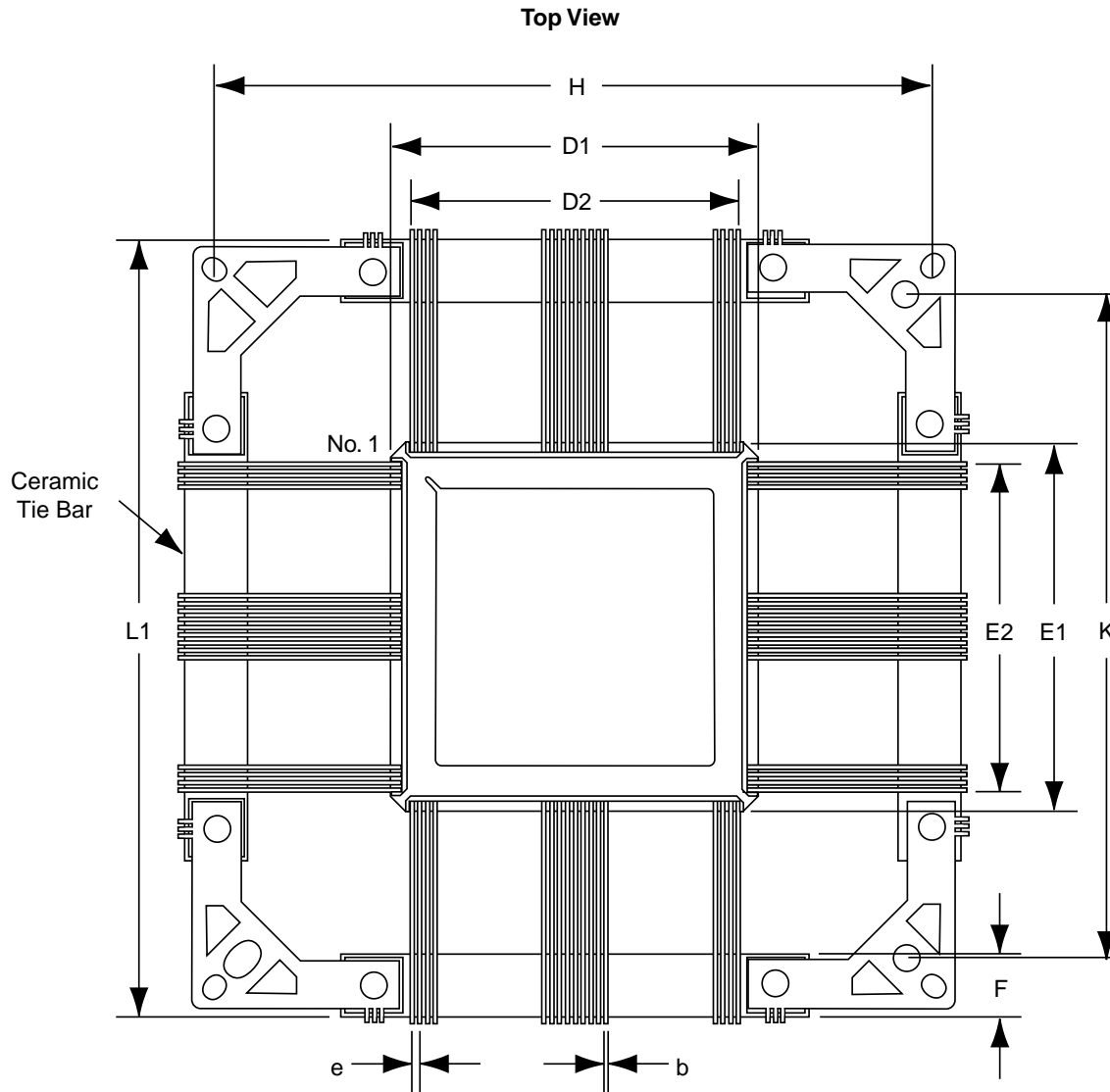


Notes:

1. Seal ring and lid are connected to Ground.
2. Lead material is Kovar with minimum 50 microinches gold plate over nickel.
3. Packages are shipped unformed with the ceramic tie bar in a test carrier.

Package Mechanical Drawings (continued)

172-Pin CQFP (Cavity Up)

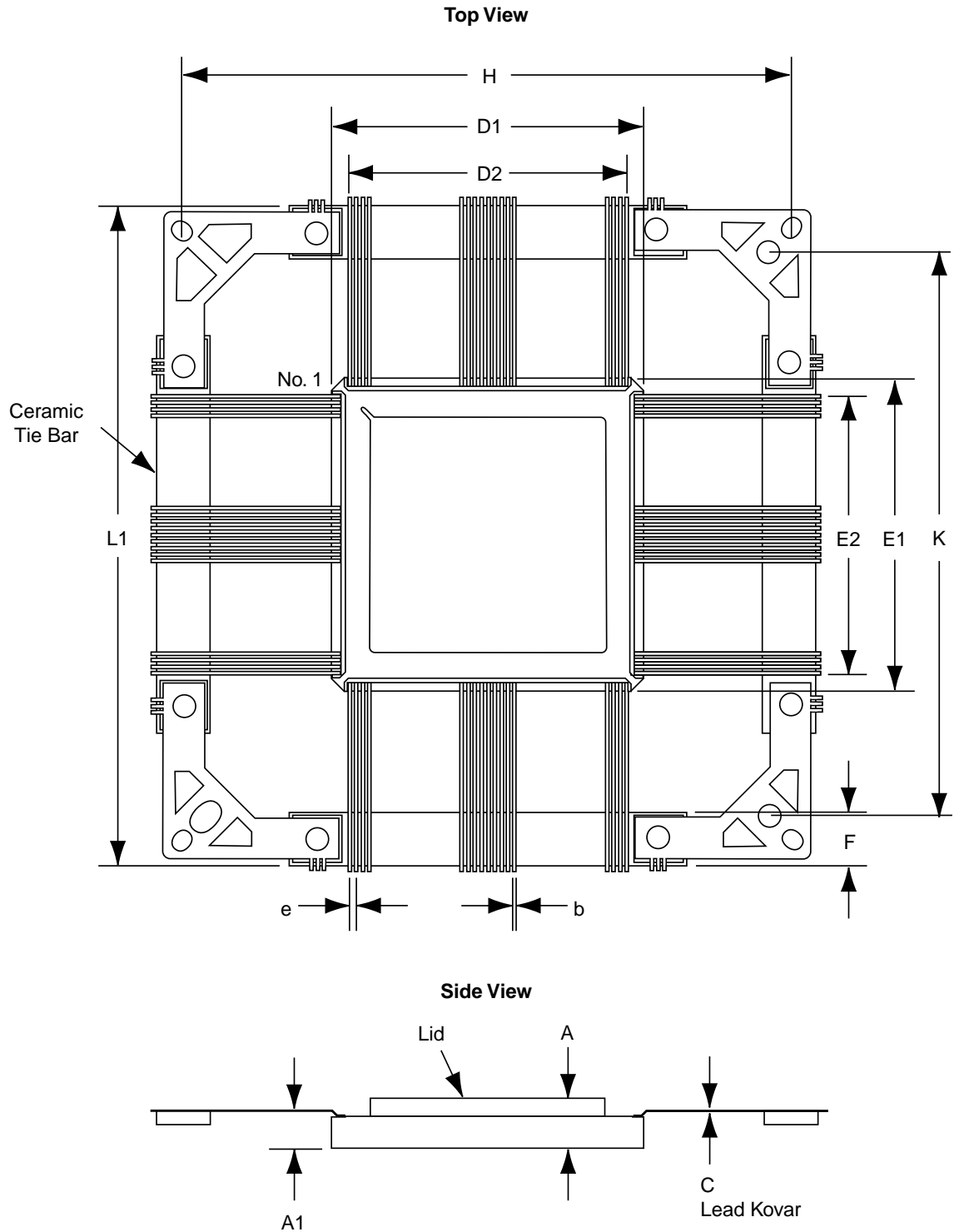


Notes:

1. Seal ring and lid are connected to Ground.
2. Lead material is Kovar with minimum 50 microinches gold plate over nickel.
3. Packages are shipped unformed with the ceramic tie bar.

Package Mechanical Drawings (continued)

132-Pin, 196-Pin, and 256-Pin CQFP (Cavity Up)



Notes:

1. Outside leadframe holes (from dimension H) are circular for CQ256.
2. Seal ring and lid are connected to Ground.
3. Lead material is Kovar with minimum 50 microinches gold plate over nickel.
4. Packages are shipped unformed with the ceramic tie bar.

Ceramic Quad Flat Pack

Symbol	CQFP 84			CQFP 132			CQFP 172		
	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.
A	0.070	0.090	0.100	0.094	0.105	0.116	0.094	0.105	0.116
A1	0.060	0.075	0.080	0.080	0.090	0.100	0.080	0.090	0.100
b	0.008	0.010	0.012	0.007	0.008	0.010	0.007	0.008	0.010
c	0.004	0.006	0.008	0.004	0.006	0.008	0.004	0.006	0.008
D1/E1	0.640	0.650	0.660	0.940	0.950	0.960	1.168	1.180	1.192
D2/E2	0.500 BSC			0.800 BSC			1.050 BSC		
e	0.025 BSC			0.025 BSC			0.025 BSC		
F	0.130	0.140	0.150	0.325	0.350	0.375	0.175	0.200	0.225
H	1.460 BSC			2.320 BSC			2.320 BSC		
K	—			2.140 BSC			2.140 BSC		
L1	1.595	1.600	1.615	2.485	2.500	2.505	2.485	2.495	2.505

Note:

1. All dimensions are in inches except CQ256, which is in millimeters.
2. BSC equals Basic Spacing between Centers. This is a theoretical true position dimension and so has no tolerance.

Ceramic Quad Flat Pack

Symbol	CQFP 196			CQFP 256		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	0.094	0.105	0.116	2.28	2.67	3.06
A1	0.080	0.090	0.100	1.93	2.29	2.65
b	0.007	0.008	0.010	0.18	0.20	0.22
c	0.004	0.006	0.008	0.11	0.15	0.18
D1/E1	1.336	1.350	1.364	35.64	36.00	36.36
D2/E2	1.200 BSC			31.5 BSC		
e	0.025 BSC			0.50 BSC		
F	0.175	0.200	0.225	7.05	7.75	8.45
H	2.320 BSC			70.00 BSC		
K	2.140 BSC			65.90 BSC		
L1	2.485	2.495	2.505	74.60	75.00	75.40

Note:

1. All dimensions are in inches except CQ256, which is in millimeters.
2. BSC equals Basic Spacing between Centers. This is a theoretical true position dimension and so has no tolerance.

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