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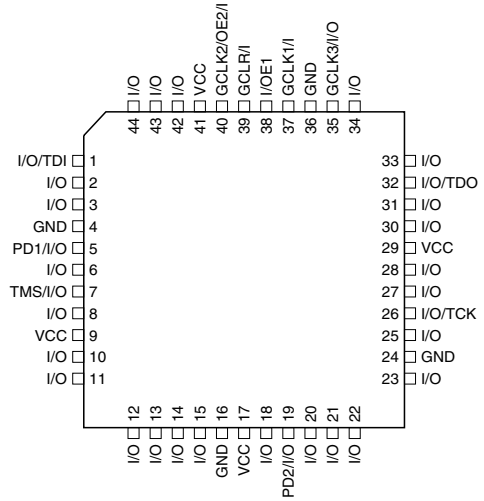
Understanding Embedded - CPLDs (Complex Programmable Logic Devices)

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

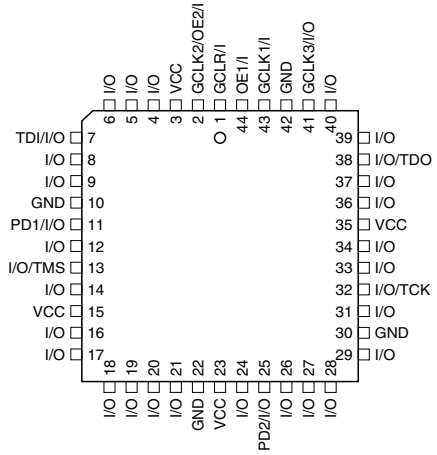
Applications of Embedded - CPLDs

Details	
Product Status	Obsolete
Programmable Type	In System Programmable (min 10K program/erase cycles)
Delay Time tpd(1) Max	15 ns
Voltage Supply - Internal	3V ~ 3.6V
Number of Logic Elements/Blocks	-
Number of Macrocells	64
Number of Gates	-
Number of I/O	48
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	68-LCC (J-Lead)
Supplier Device Package	68-PLCC (24.23x24.23)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/atf1504asv-15ji68

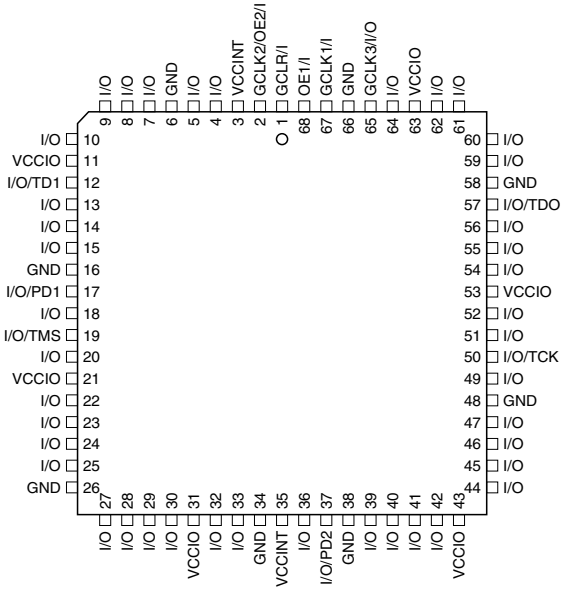
44-lead TQFP
Top View



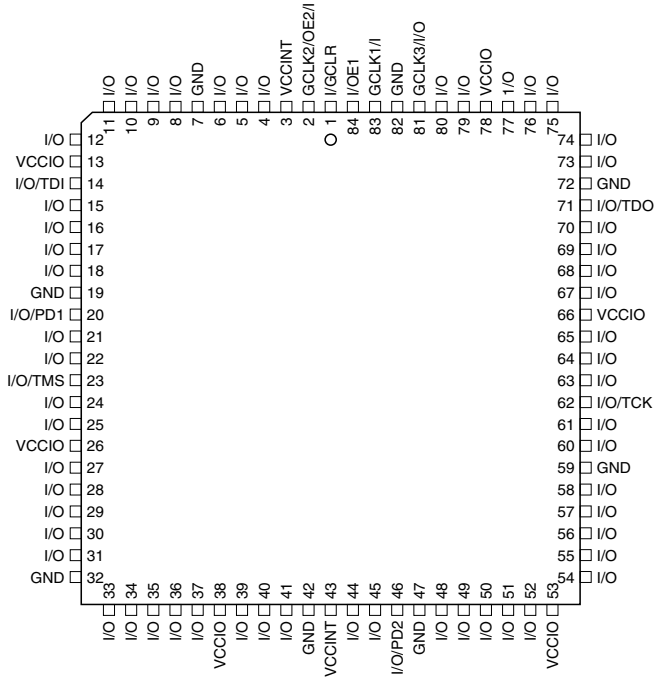
44-lead PLCC
Top View



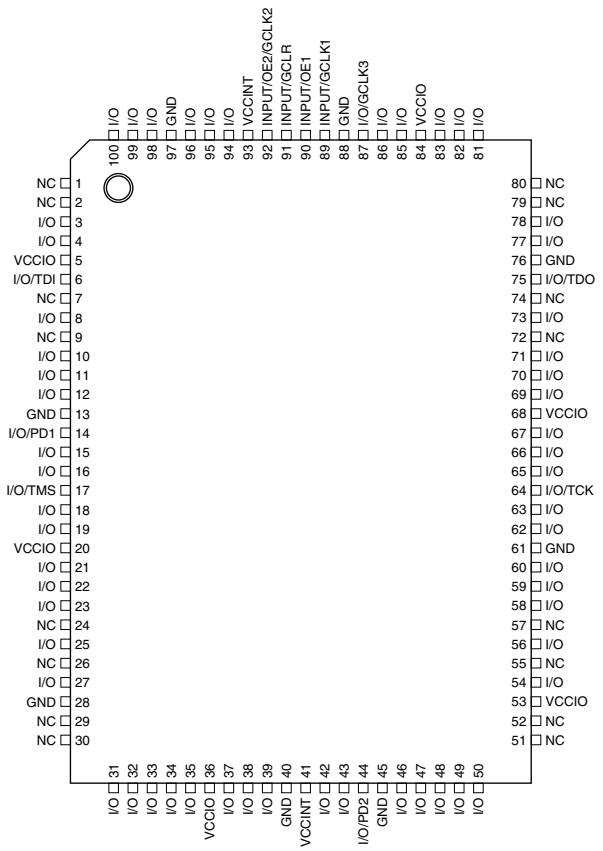
68-lead PLCC
Top View



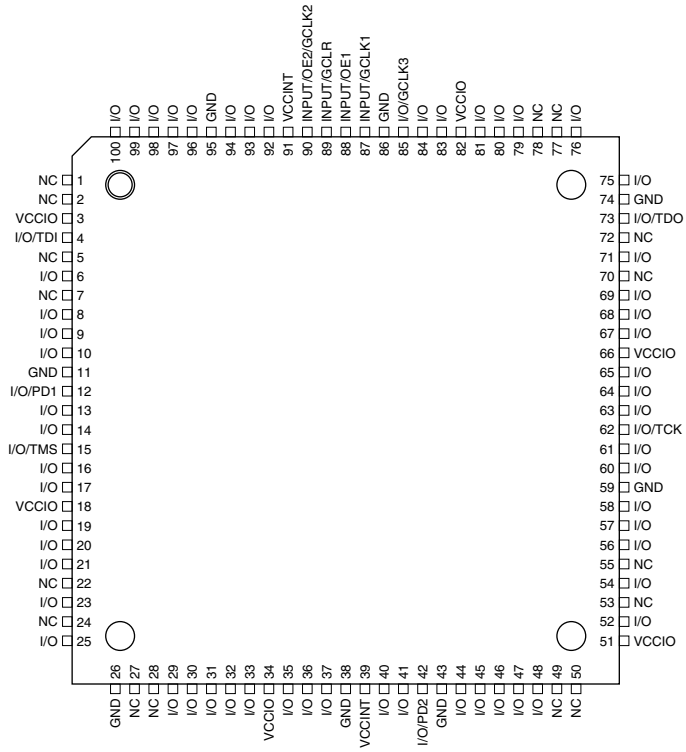
84-lead PLCC
Top View



100-lead PQFP
Top View



100-lead TQFP
Top View



Description

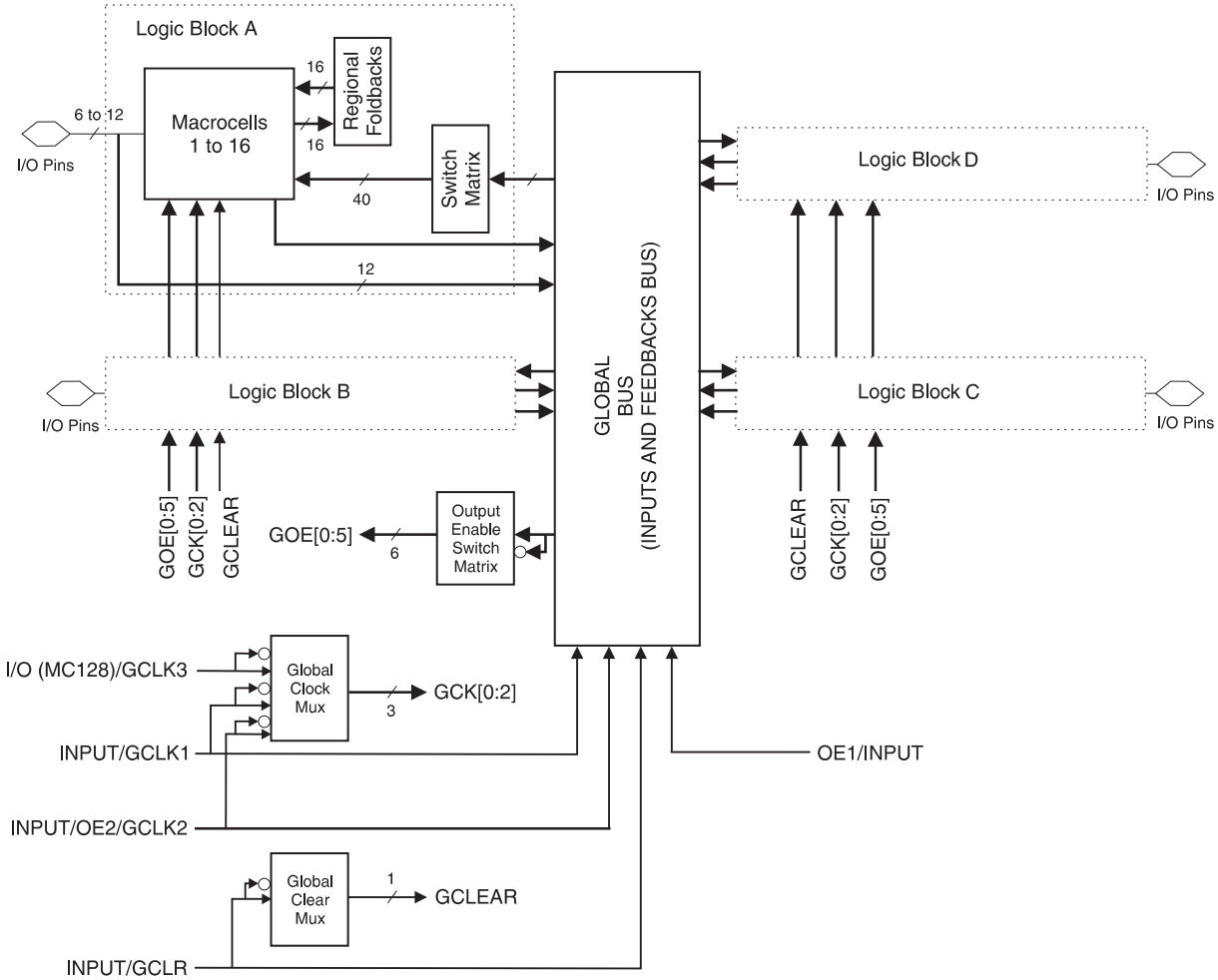
The ATF1504ASV(L) is a high-performance, high-density complex programmable logic device (CPLD) that utilizes Atmel's proven electrically-erasable memory technology. With 64 logic macrocells and up to 68 inputs, it easily integrates logic from several TTL, SSI, MSI, LSI and classic PLDs. The ATF1504ASV(L)'s enhanced routing switch matrices increase usable gate count and the odds of successful pin-locked design modifications.

The ATF1504ASV(L) has up to 68 bi-directional I/O pins and four dedicated input pins, depending on the type of device package selected. Each dedicated pin can also serve as a global control signal, register clock, register reset or output enable. Each of these control signals can be selected for use individually within each macrocell.

Each of the 64 macrocells generates a buried feedback that goes to the global bus. Each input and I/O pin also feeds into the global bus. The switch matrix in each logic block then selects 40 individual signals from the global bus. Each macrocell also generates a foldback logic term that goes to a regional bus. Cascade logic between macrocells in the ATF1504ASV(L) allows fast, efficient generation of complex logic functions. The ATF1504ASV(L) contains four such logic chains, each capable of creating sum term logic with a fan-in of up to 40 product terms.

The ATF1504ASV(L) macrocell, shown in Figure 1, is flexible enough to support highly-complex logic functions operating at high speed. The macrocell consists of five sections: product terms and product term select multiplexer, OR/XOR/CASCADE logic, a flip-flop, output select and enable, and logic array inputs.

Block Diagram



Unused product terms are automatically disabled by the compiler to decrease power consumption. A security fuse, when programmed, protects the contents of the ATF1504ASV(L). Two bytes (16 bits) of User Signature are accessible to the user for purposes such as storing project name, part number, revision or date. The User Signature is accessible regardless of the state of the security fuse.

The ATF1504ASV(L) device is an in-system programmable (ISP) device. It uses the industry-standard 4-pin JTAG interface (IEEE Std. 1149.1), and is fully-compliant with JTAG's Boundary-scan Description Language (BSDL). ISP allows the device to be programmed without removing it from the printed circuit board. In addition to simplifying the manufacturing flow, ISP also allows design modifications to be made in the field via software.

Product Terms and Select Mux

Each ATF1504ASV(L) macrocell has five product terms. Each product term receives as its inputs all signals from both the global bus and regional bus.

The product term select multiplexer (PTMUX) allocates the five product terms as needed to the macrocell logic gates and control signals. The PTMUX programming is determined by the design compiler, which selects the optimum macrocell configuration.

OR/XOR/CASCADE Logic

The ATF1504ASV(L)'s logic structure is designed to efficiently support all types of logic. Within a single macrocell, all the product terms can be routed to the OR gate, creating a 5-input AND/OR sum term. With the addition of the CASIN from neighboring macrocells, this can be expanded to as many as 40 product terms with little additional delay.

The macrocell's XOR gate allows efficient implementation of compare and arithmetic functions. One input to the XOR comes from the OR sum term. The other XOR input can be a product term or a fixed high- or low-level. For combinatorial outputs, the fixed level input allows polarity selection. For registered functions, the fixed levels allow DeMorgan minimization of product terms. The XOR gate is also used to emulate T- and JK-type flip-flops.

Flip-flop

The ATF1504ASV(L)'s flip-flop has very flexible data and control functions. The data input can come from either the XOR gate, from a separate product term or directly from the I/O pin. Selecting the separate product term allows creation of a buried registered feedback within a combinatorial output macrocell. (This feature is automatically implemented by the fitter software). In addition to D, T, JK and SR operation, the flip-flop can also be configured as a flow-through latch. In this mode, data passes through when the clock is high and is latched when the clock is low.

The clock itself can either be one of the Global CLK Signal (GCK[0 : 2]) or an individual product term. The flip-flop changes state on the clock's rising edge. When the GCK signal is used as the clock, one of the macrocell product terms can be selected as a clock enable. When the clock enable function is active and the enable signal (product term) is low, all clock edges are ignored. The flip-flop's asynchronous reset signal (AR) can be either the Global Clear (GCLEAR), a product term, or always off. AR can also be a logic OR of GCLEAR with a product term. The asynchronous preset (AP) can be a product term or always off.

Extra Feedback

The ATF1504ASV(L) macrocell output can be selected as registered or combinatorial. The extra buried feedback signal can be either combinatorial or a registered signal regardless of whether the output is combinatorial or registered. (This enhancement function is automatically implemented by the fitter software.) Feedback of a buried combinatorial output allows the creation of a second latch within a macrocell.

I/O Control

The output enable multiplexer (MOE) controls the output enable signal. Each I/O can be individually configured as an input, output or for bi-directional operation. The output enable for each macrocell can be selected from the true or compliment of the two output enable pins, a subset of the I/O pins, or a subset of the I/O macrocells. This selection is automatically done by the fitter software when the I/O is configured as an input, all macrocell resources are still available, including the buried feedback, expander and cascade logic.

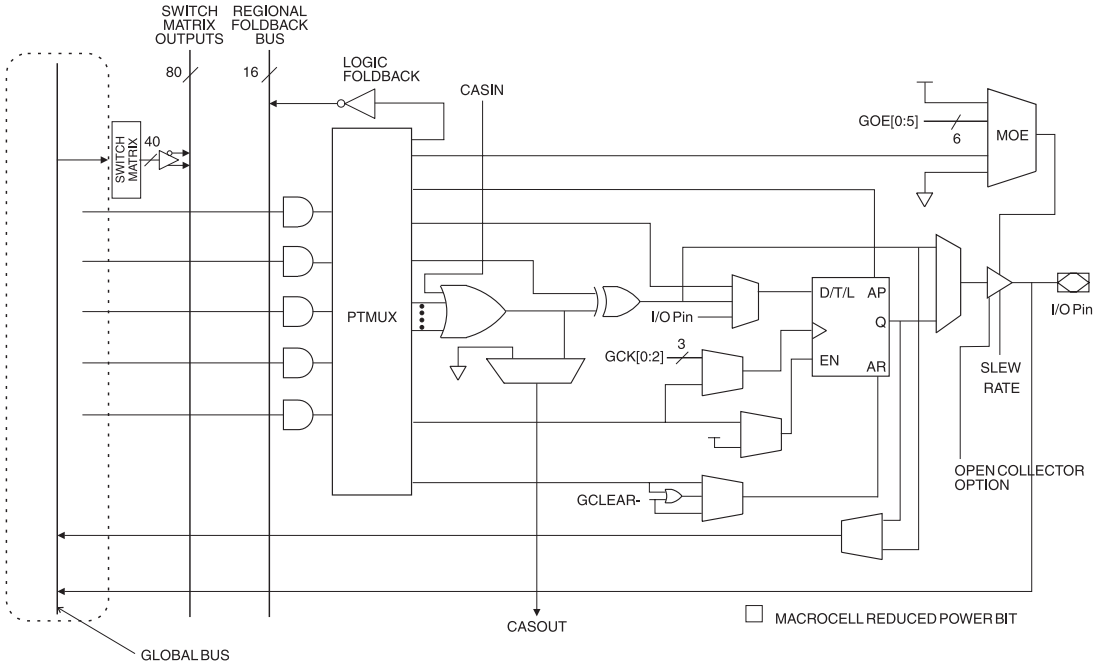
Global Bus/Switch Matrix

The global bus contains all input and I/O pin signals as well as the buried feedback signal from all 64 macrocells. The switch matrix in each logic block receives as its inputs all signals from the global bus. Under software control, up to 40 of these signals can be selected as inputs to the logic block.

Foldback Bus

Each macrocell also generates a foldback product term. This signal goes to the regional bus and is available to four macrocells. The foldback is an inverse polarity of one of the macrocell's product terms. The four foldback terms in each region allow generation of high fan-in sum terms (up to nine product terms) with little additional delay.

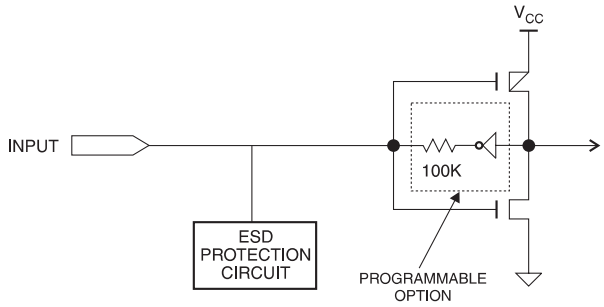
Figure 1. ATF1504ASV(L) Macrocell



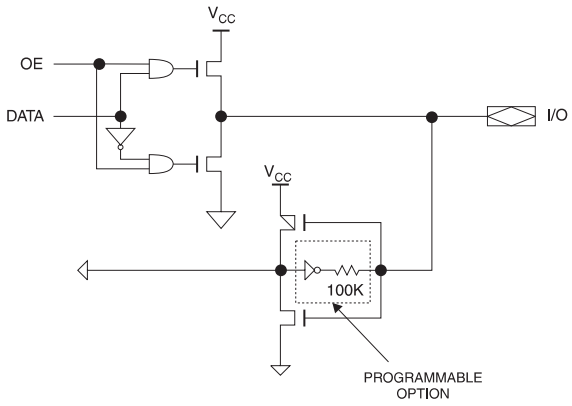
Programmable Pin-keeper Option for Inputs and I/Os

The ATF1504ASV(L) offers the option of programming all input and I/O pins so that pin keeper circuits can be utilized. When any pin is driven high or low and then subsequently left floating, it will stay at that previous high- or low-level. This circuitry prevents unused input and I/O lines from floating to intermediate voltage levels, which causes unnecessary power consumption and system noise. The keeper circuits eliminate the need for external pull-up resistors and eliminate their DC power consumption.

Input Diagram



I/O Diagram



Speed/Power Management

The ATF1504ASV(L) has several built-in speed and power management features. The ATF1504ASV(L) contains circuitry that automatically puts the device into a low power standby mode when no logic transitions are occurring. This not only reduces power consumption during inactive periods, but also provides proportional power savings for most applications running at system speeds below 5 MHz. This feature may be selected as a device option.

To further reduce power, each ATF1504ASV(L) macrocell has a reduced-power bit feature. This feature allows individual macrocells to be configured for maximum power savings. This feature may be selected as a design option.

All ATF1504ASV(L) also have an optional power-down mode. In this mode, current drops to below 5 mA. When the power-down option is selected, either PD1 or PD2 pins (or both) can be used to power down the part. The power-down option is selected in the design source file. When enabled, the device goes into power down when either PD1 or PD2 is high. In the power-down mode, all internal logic signals are latched and held, as are any enabled outputs.

All pin transitions are ignored until the PD pin is brought low. When the power-down feature is enabled, the PD1 or PD2 pin cannot be used as a logic input or output. However, the pin's macrocell may still be used to generate buried foldback and cascade logic signals.

All power-down AC characteristic parameters are computed from external input or I/O pins, with reduced-power bit turned on. For macrocells in reduced-power mode (reduced-power bit turned on), the reduced-power adder, t_{RPA}, must be added to the AC parameters, which include the data paths t_{LAD}, t_{LAC}, t_{IC}, t_{ACL}, t_{ACH} and t_{SEXP}.

The ATF1504ASV(L) macrocell also has an option whereby the power can be reduced on a per macrocell basis. By enabling this power-down option, macrocells that are not used in an application can be turned down, thereby reducing the overall power consumption of the device.

Each output also has individual slew rate control. This may be used to reduce system noise by slowing down outputs that do not need to operate at maximum speed. Outputs default to slow switching, and may be specified as fast switching in the design file.

Design Software Support

ATF1504ASV(L) designs are supported by several industry standard third party tools. Automated fitters allow logic synthesis using a variety of high-level description languages and formats.

Power-up Reset

The ATF1504ASV is designed with a power-up reset, a feature critical for state machine initialization. At a point delayed slightly from V_{CC} crossing V_{RST}, all registers will be initialized, and the state of each output will depend on the polarity of its buffer. However, due to the asynchronous nature of reset and uncertainty of how V_{CC} actually rises in the system, the following conditions are required:

1. The V_{CC} rise must be monotonic,
2. After reset occurs, all input and feedback setup times must be met before driving the clock pin high, and,
3. The clock must remain stable during T_D.

The ATF1504ASV has two options for the hysteresis about the reset level, V_{RST}, Small and Large. To ensure a robust operating environment in applications where the device is operated near 3.0V, Atmel recommends that during the fitting process users configure the device with the Power-up Reset hysteresis set to Large. For conversions, Atmel POF2JED users should include the flag “-power_reset” on the command line after “filename.POF”. To allow the registers to be properly reinitialized with the Large hysteresis option selected, the following condition is added:

4. If V_{CC} falls below 2.0V, it must shut off completely before the device is turned on again.

When the Large hysteresis option is active, I_{CC} is reduced by several hundred microamps as well.

Security Fuse Usage

A single fuse is provided to prevent unauthorized copying of the ATF1504ASV(L) fuse patterns. Once programmed, fuse verify is inhibited. However, the 16-bit User Signature remains accessible.

DC and AC Operating Conditions

	Commercial	Industrial
Operating Temperature (Ambient))	0°C - 70°C	-40°C - 85°C
V_{CC} (3.3V) Power Supply	3.0V - 3.6V	3.0V - 3.6V

DC Characteristics

Symbol	Parameter	Condition			Min	Typ	Max	Units
I_{IL}	Input or I/O Low Leakage Current	$V_{IN} = V_{CC}$				-2	-10	µA
I_{IH}	Input or I/O High Leakage Current					2	10	
I_{OZ}	Tri-State Output Off-State Current	$V_O = V_{CC}$ or GND			-40		40	µA
I_{CC1}	Power Supply Current, Standby	V_{CC} = Max V_{IN} = 0, V_{CC}	Std Mode	Com.		60		mA
				Ind.		75		mA
			"L" Mode	Com.		5		µA
				Ind.		5		µA
I_{CC2}	Power Supply Current, Power-down Mode	V_{CC} = Max V_{IN} = 0, V_{CC}	"PD" Mode			0.1	5	mA
I_{CC3} (2)	Reduced-power Mode Supply Current, Standby	V_{CC} = Max V_{IN} = 0, V_{CC}	Std Power	Com		40		ma
				Ind		55		
V_{IL}	Input Low Voltage				-0.3		0.8	V
V_{IH}	Input High Voltage				1.7		V_{CCIO} + 0.3	V
V_{OL}	Output Low Voltage (TTL)	$V_{IN} = V_{IH}$ or V_{IL} V_{CCIO} = Min, I_{OL} = 8 mA		Com.			0.45	V
				Ind.			0.45	
	Output Low Voltage (CMOS)	$V_{IN} = V_{IH}$ or V_{IL} V_{CC} = Min, I_{OL} = 0.1 mA		Com.			0.2	V
				Ind.			0.2	V
V_{OH}	Output High Voltage - 3.3V (TTL)	$V_{IN} = V_{IH}$ or V_{IL} V_{CCIO} = Min, I_{OH} = -2.0 mA			2.4			V
	Output High Voltage - 3.3V (CMOS)	$V_{IN} = V_{IH}$ or V_{IL} V_{CCIO} = Min, I_{OH} = -0.1 mA			V_{CCIO} - 0.2			V

Notes: 1. Not more than one output at a time should be shorted. Duration of short circuit test should not exceed 30 sec.
2. When microcell reduced-power feature is enabled.

Pin Capacitance

	Typ	Max	Units	Conditions
C_{IN}		8	pF	V_{IN} = 0V; f = 1.0 MHz
$C_{I/O}$		8	pF	V_{OUT} = 0V; f = 1.0 MHz

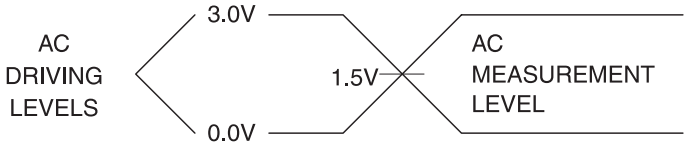
Note: Typical values for nominal supply voltage. This parameter is only sampled and is not 100% tested.
The OGI pin (high-voltage pin during programming) has a maximum capacitance of 12 pF.

AC Characteristics (Continued)

Symbol	Parameter	-15		-20		Units
		Min	Max	Min	Max	
t_{ZX2}	Output Buffer Enable Delay (Slow slew rate = OFF; V_{CCIO} = 3.3V; C_L = 35 pF)		7		9	ns
t_{ZX3}	Output Buffer Enable Delay (Slow slew rate = ON; V_{CCIO} = 5.0V/3.3V; C_L = 35 pF)		10		11	ns
t_{XZ}	Output Buffer Disable Delay (C_L = 5 pF)		6		7	ns
t_{SU}	Register Setup Time	5		6		ns
t_H	Register Hold Time	4		5		ns
t_{FSU}	Register Setup Time of Fast Input	2		2		ns
t_{FH}	Register Hold Time of Fast Input	2		2		ns
t_{RD}	Register Delay		2		2.5	ns
t_{COMB}	Combinatorial Delay		2		3	ns
t_{IC}	Array Clock Delay		6		7	ns
t_{EN}	Register Enable Time		6		7	ns
t_{GLOB}	Global Control Delay		2		3	ns
t_{PRE}	Register Preset Time		4		5	ns
t_{CLR}	Register Clear Time		4		5	ns
t_{UIM}	Switch Matrix Delay		2		2.5	ns
t_{RPA}	Reduced-power Adder[2]		10		13	ns

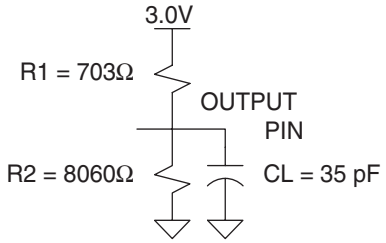
Notes: 1. See ordering information for valid part numbers.
2. The t_{RPA} parameter must be added to the t_{LAD}, t_{LAC},t_{TIC}, t_{ACL}, and t_{SEXP} parameters for macrocells running in the reduced-power mode.
3. See ordering information for valid part numbers.

Input Test Waveforms and Measurement Levels



t_R, t_F = 1.5 ns typical

Output AC Test Loads



Power-down Mode

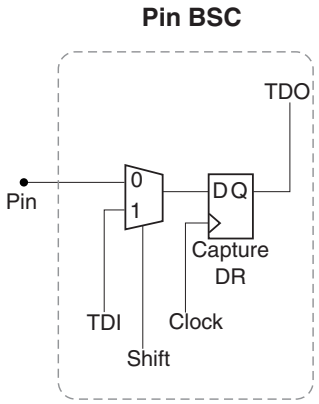
The ATF1504ASV(L) includes an optional pin-controlled power-down feature. When this mode is enabled, the PD pin acts as the power-down pin. When the PD pin is high, the device supply current is reduced to less than 3 mA. During power down, all output data and internal logic states are latched internally and held. Therefore, all registered and combinatorial output data remain valid. Any outputs that were in a High-Z state at the onset will remain at High-Z. During power down, all input signals except the power-down pin are blocked. Input and I/O hold latches remain active to ensure that pins do not float to indeterminate levels, further reducing system power. The power-down mode feature is enabled in the logic design file or as a fitted or translated s/w option. Designs using the power-down pin may not use the PD pin as a logic array input. However, all other PD pin macrocell resources may still be used, including the buried feedback and foldback product term array inputs.

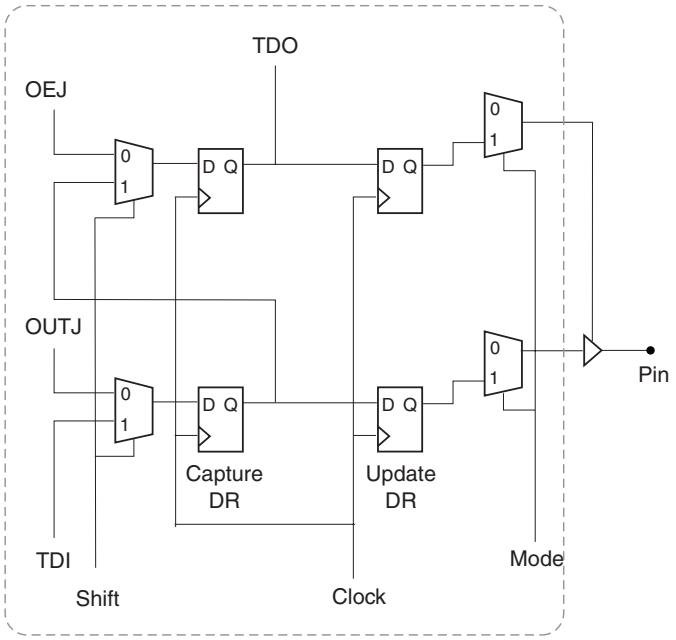
Power Down AC Characteristics(1)(2)

		-15		-20		
Symbol	**Parameter**	**Min**	**Max**	**Min**	**Max**	**Units**
t_{IVDH}	Valid I, I/O before PD High	15		20		ns
t_{GVDH}	Valid OE(2) before PD High	15		20		ns
t_{CVDH}	Valid Clock(2) before PD High	15		20		ns
t_{DHIX}	I, I/O Don't Care after PD High		25		30	ns
t_{DHGX}	OE(2) Don't Care after PD High		25		30	ns
t_{DHCX}	Clock(2) Don't Care after PD High		25		30	ns
t_{DLIV}	PD Low to Valid I, I/O		1		1	µs
t_{DLGV}	PD Low to Valid OE (Pin or Term)		1		1	µs
t_{DLCV}	PD Low to Valid Clock (Pin or Term)		1		1	µs
t_{DLOV}	PD Low to Valid Output		1		1	µs

Notes: 1. For slow slew outputs, add t_{SSO}.
2. Pin or product term.
3. Includes t_{RPA} for reduced-power bit enabled.

BSC Configuration for Macrocell





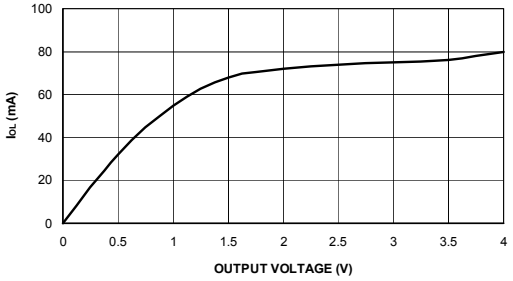
Macrocell BSC

ATF1504ASV Dedicated Pinouts

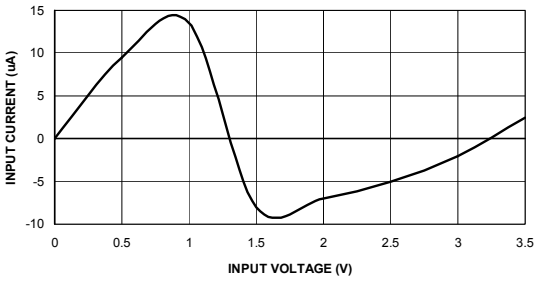
Dedicated Pin	44-lead TQFP	44-lead J-lead	68-lead J-lead	84-lead J-lead	100-lead PQFP	100-lead TQFP
INPUT/OE2/GCLK2	40	2	2	2	92	90
INPUT/GCLR	39	1	1	1	91	89
INPUT/OE1	38	44	68	84	90	88
INPUT/GCLK1	37	43	67	83	89	87
I/O /GCLK3	35	41	65	81	87	85
I/O / PD (1,2)	5, 19	11, 25	17, 37	20, 46	14, 44	12, 42
I/O / TDI (JTAG)	1	7	12	14	6	4
I/O / TMS (JTAG)	7	13	19	23	17	15
I/O / TCK (JTAG)	26	32	50	62	64	62
I/O / TDO (JTAG)	32	38	57	71	75	73
GND	4, 16, 24, 36	10, 22, 30, 42	6, 16, 26, 34, 38, 48, 58, 66	7, 19, 32, 42, 47, 59, 72, 82	13, 28, 40, 45, 61, 76, 88, 97	11, 26, 38, 43, 59, 74, 86, 95
V_{CC}	9, 17, 29, 41	3, 15, 23, 35	3, 11, 21, 31, 35, 43, 53, 63	3,13, 26, 38, 43, 53, 66, 78	5, 20, 36, 41, 53, 68, 84, 93	3, 18, 34, 39, 51, 66, 82, 91
N/C	–	–	–	–	1, 2, 7, 9, 24, 26, 29, 30, 51, 52, 55, 57, 72, 74, 79, 80	1, 2, 5, 7, 22, 24, 27, 28, 49, 50, 53, 55, 70, 72, 77, 78
# of Signal Pins	36	36	52	68	68	68
# User I/O Pins	32	32	48	64	64	64

OE (1, 2)	Global OE pins
GCLR	Global Clear pin
GCLK (1, 2, 3)	Global Clock pins
PD (1, 2)	Power-down pins
TDI, TMS, TCK, TDO	JTAG pins used for boundary-scan testing or in-system programming
GND	Ground pins
VCC	VCC pins for the device

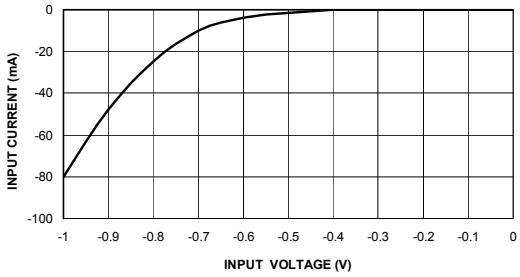
OUTPUT SINK CURRENT VS. OUTPUT VOLTAGE
(V_{CC} = 3.3V, T_A = 25°C)



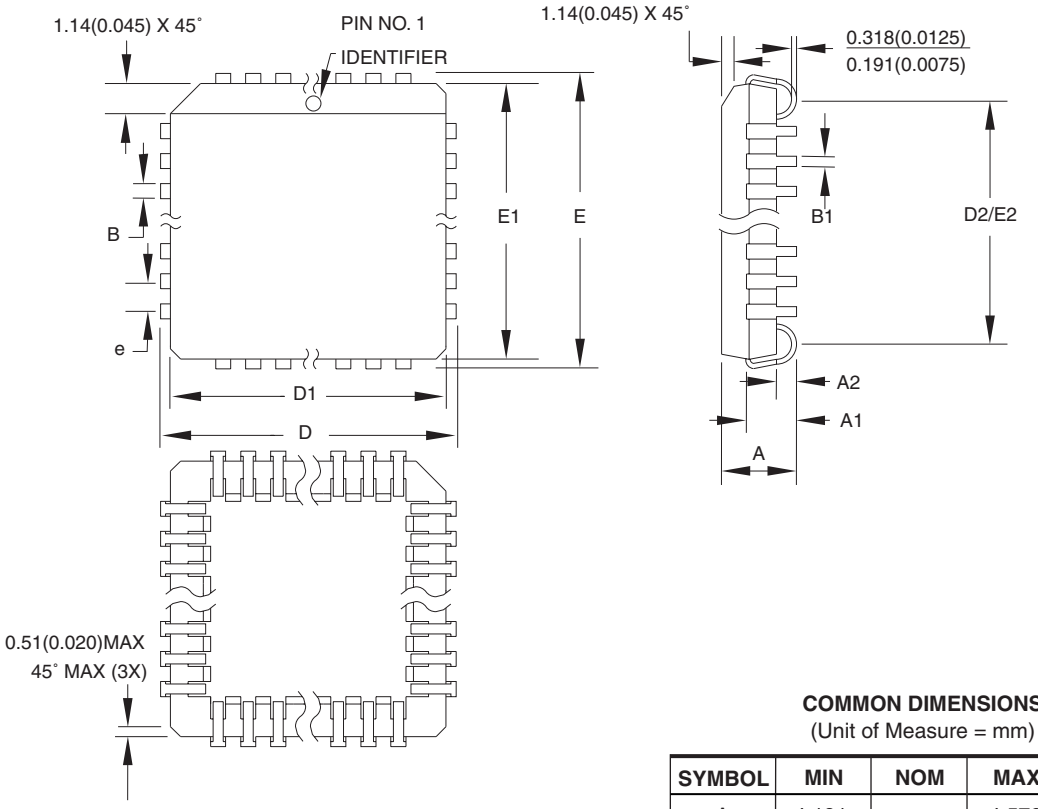
INPUT CURRENT VS. INPUT VOLTAGE
(V_{CC} = 3.3V, T_A = 25°C)



INPUT CLAMP CURRENT VS. INPUT VOLTAGE
(V_{CC} = 3.3V, T_A = 25°C)



44J – PLCC



COMMON DIMENSIONS
(Unit of Measure = mm)

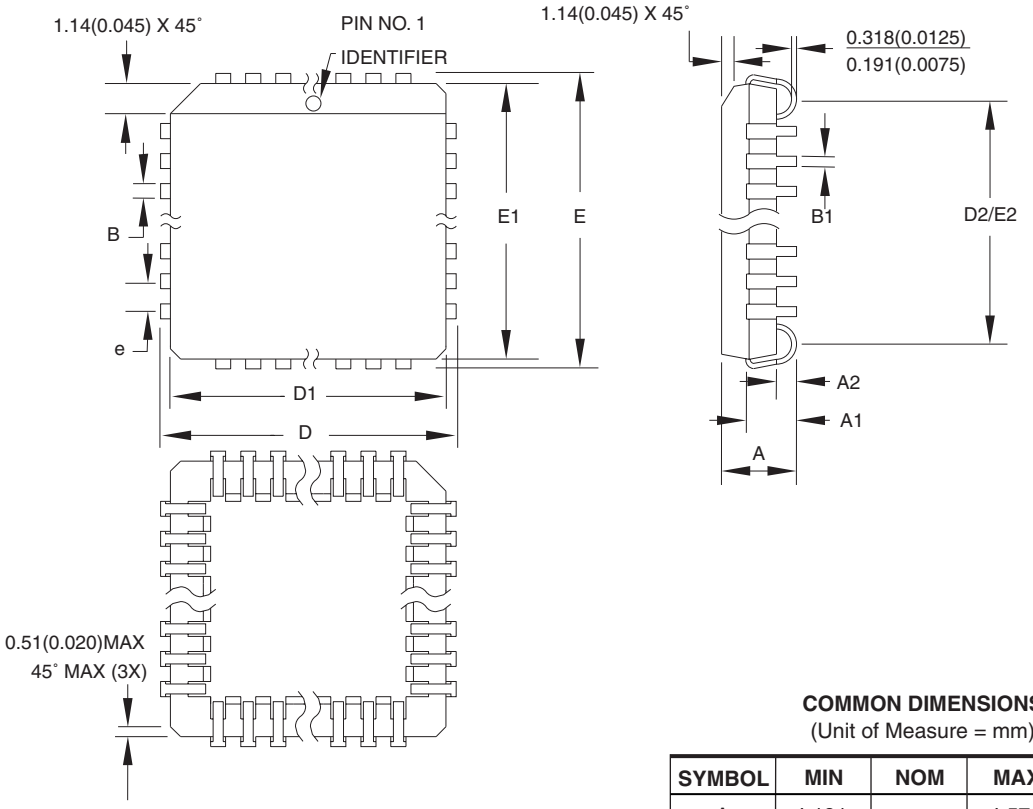
SYMBOL	MIN	NOM	MAX	NOTE
A	4.191	–	4.572	
A1	2.286	–	3.048	
A2	0.508	–	–	
D	17.399	–	17.653	
D1	16.510	–	16.662	Note 2
E	17.399	–	17.653	
E1	16.510	–	16.662	Note 2
D2/E2	14.986	–	16.002	
B	0.660	–	0.813	
B1	0.330	–	0.533	
e	1.270 TYP			

Notes:
1. This package conforms to JEDEC reference MS-018, Variation AC.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is .010"(0.254 mm) per side. Dimension D1 and E1 include mold mismatch and are measured at the extreme material condition at the upper or lower parting line.
3. Lead coplanarity is 0.004" (0.102 mm) maximum.

10/04/01

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	**44J**, 44-lead, Plastic J-leaded Chip Carrier (PLCC)	44J	B

84J – PLCC



COMMON DIMENSIONS
(Unit of Measure = mm)

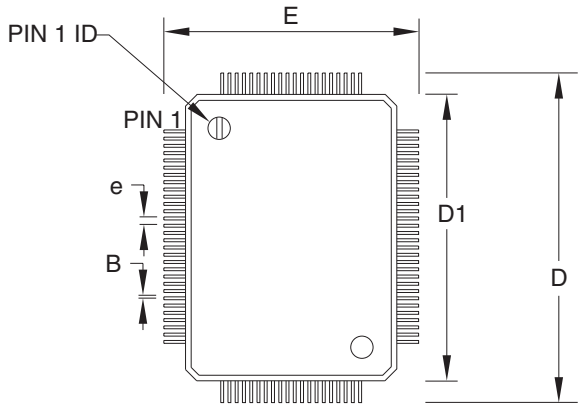
SYMBOL	MIN	NOM	MAX	NOTE
A	4.191	–	4.572	
A1	2.286	–	3.048	
A2	0.508	–	–	
D	30.099	–	30.353	
D1	29.210	–	29.413	Note 2
E	30.099	–	30.353	
E1	29.210	–	29.413	Note 2
D2/E2	27.686	–	28.702	
B	0.660	–	0.813	
B1	0.330	–	0.533	
e	1.270 TYP			

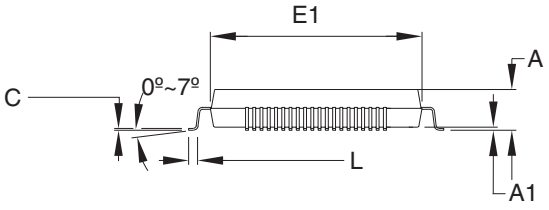
Notes:
1. This package conforms to JEDEC reference MS-018, Variation AF.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is .010"(0.254 mm) per side. Dimension D1 and E1 include mold mismatch and are measured at the extreme material condition at the upper or lower parting line.
3. Lead coplanarity is 0.004" (0.102 mm) maximum.

10/04/01

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	**84J**, 84-lead, Plastic J-leaded Chip Carrier (PLCC)	84J	B

100Q1 – PQFP





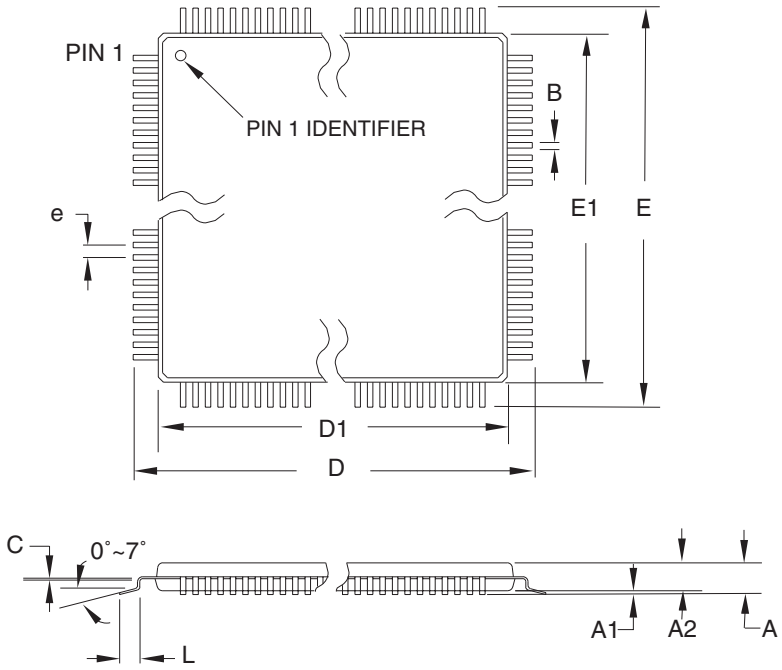
COMMON DIMENSIONS
(Unit of Measure = mm)
JEDEC STANDARD MS-022, GC-1

SYMBOL	MIN	NOM	MAX	NOTE
A	–	3.04	3.4	
A1	0.25	0.33	0.5	
D		23.20 BSC		
E		17.20 BSC		
E1		14.00 BSC		
B	0.22	–	0.40	
D1		20 BSC		
L	0.73	–	1.03	
e		0.65 BSC		

09/10/2002

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	**100Q1**, 100-lead, 14 x 20 mm Body, 3.2 mm Footprint, 0.65 mm Pitch, Plastic Quad Flat Package (PQFP)	100Q1	B

100A – TQFP



COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	1.20	
A1	0.05	–	0.15	
A2	0.95	1.00	1.05	
D	15.75	16.00	16.25	
D1	13.90	14.00	14.10	Note 2
E	15.75	16.00	16.25	
E1	13.90	14.00	14.10	Note 2
B	0.17	–	0.27	
C	0.09	–	0.20	
L	0.45	–	0.75	
e	0.50 TYP			

Notes:
1. This package conforms to JEDEC reference MS-026, Variation AED.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25 mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.08 mm maximum.

10/5/2001

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	**100A,** 100-lead, 14 x 14 mm Body Size, 1.0 mm Body Thickness, 0.5 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)	100A	C

Revision History

Revision	Comments
1409J	Green package options added.

Atmel Corporation

2325 Orchard Parkway
San Jose, CA 95131, USA
Tel: 1(408) 441-0311
Fax: 1(408) 487-2600

Regional Headquarters

Europe

Atmel Sarl
Route des Arsenaux 41
Case Postale 80
CH-1705 Fribourg
Switzerland
Tel: (41) 26-426-5555
Fax: (41) 26-426-5500

Asia

Room 1219
Chinachem Golden Plaza
77 Mody Road Tsimshatsui
East Kowloon
Hong Kong
Tel: (852) 2721-9778
Fax: (852) 2722-1369

Japan

9F, Tonetsu Shinkawa Bldg.
1-24-8 Shinkawa
Chuo-ku, Tokyo 104-0033
Japan
Tel: (81) 3-3523-3551
Fax: (81) 3-3523-7581

Atmel Operations

Memory

2325 Orchard Parkway
San Jose, CA 95131, USA
Tel: 1(408) 441-0311
Fax: 1(408) 436-4314

Microcontrollers

2325 Orchard Parkway
San Jose, CA 95131, USA
Tel: 1(408) 441-0311
Fax: 1(408) 436-4314

La Chantrerie
BP 70602
44306 Nantes Cedex 3, France
Tel: (33) 2-40-18-18-18
Fax: (33) 2-40-18-19-60

ASIC/ASSP/Smart Cards

Zone Industrielle
13106 Rousset Cedex, France
Tel: (33) 4-42-53-60-00
Fax: (33) 4-42-53-60-01

1150 East Cheyenne Mtn. Blvd.
Colorado Springs, CO 80906, USA
Tel: 1(719) 576-3300
Fax: 1(719) 540-1759

Scottish Enterprise Technology Park
Maxwell Building
East Kilbride G75 0QR, Scotland
Tel: (44) 1355-803-000
Fax: (44) 1355-242-743

RF/Automotive

Theresienstrasse 2
Postfach 3535
74025 Heilbronn, Germany
Tel: (49) 71-31-67-0
Fax: (49) 71-31-67-2340

1150 East Cheyenne Mtn. Blvd.
Colorado Springs, CO 80906, USA
Tel: 1(719) 576-3300
Fax: 1(719) 540-1759

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BP 123
38521 Saint-Egreve Cedex, France
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Fax: (33) 4-76-58-34-80

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