

### Recommended Application

Dual DDR zero delay buffer

### Features/Benefits

- High performance, low jitter zero delay buffer
- I<sup>2</sup>C for functional and output control
- Dual bank 1-6 differential clock distribution
- 2 separate feedback in & out for input to output synchronization for each bank
- Supports up to 4 DDR DIMMs
- Supports up to DDRII - 1066MHz
- Supports up to DDRIII (1.8V core) - 1333MHz
- Output-to-output skew: <100ps

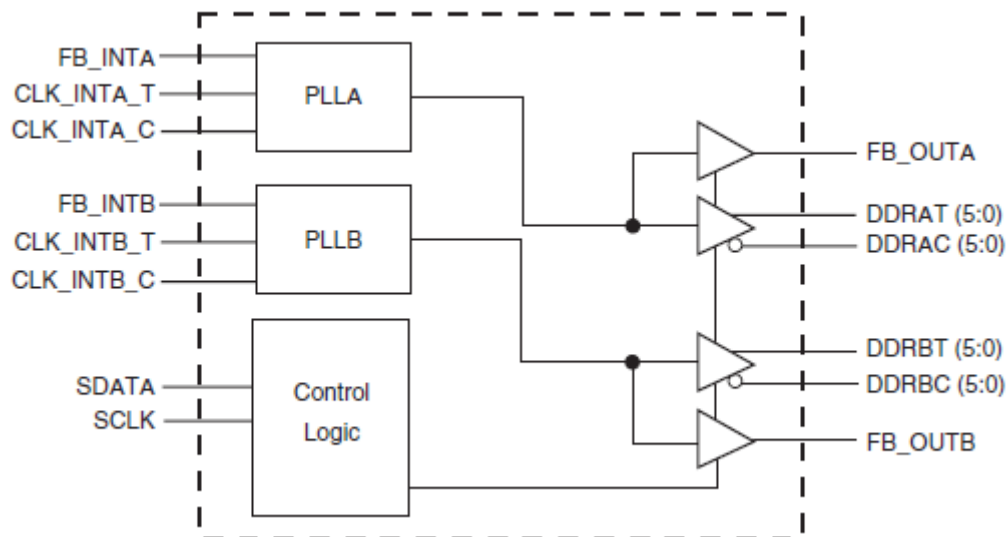
### Pin Configuration

DDRAT0	1	48	FB_OUTA
DDRAC0	2	47	FB_INTA
DDRAT1	3	46	VDD1.8/1.5
DDRAC1	4	45	CLK_INTA_T
DDRAT2	5	44	CLK_INTA_C
DDRAC2	6	43	GND
GND	7	42	DDRAT3
VDD1.8/1.5	8	41	DDRAC3
AGND	9	40	DDRAT4
AVDD1.8	10	39	DDRAC4
SCLK	11	38	DDRAT5
SDATA	12	37	DDRAC5
VDD1.8/1.5	13	36	VDD1.8/1.5
DDRBT0	14	35	GND
DRBC0	15	34	AVDD1.8
DDRBT1	16	33	AGND
DRBC1	17	32	GND
DDRBT2	18	31	VDD1.8/1.5
DRBC2	19	30	DDRBT5
CLK_INTB_T	20	29	DRBC5
CLK_INTB_C	21	28	DRBT4
GND	22	27	DRBC4
FB_INTB	23	26	DRBT3
FB_OUTB	24	25	DRBC3

**ICS9P960**

**48-SSOP**

### Block Diagram



## Pin Descriptions

Pin#	Pin Name	Type	Pin Description
1	DDRAT0	OUT	"True" Clock of differential pair output.
2	DDRAC0	OUT	"Complementary" Clock of differential pair output.
3	DDRAT1	OUT	"True" Clock of differential pair output.
4	DDRAC1	OUT	"Complementary" Clock of differential pair output.
5	DDRAT2	OUT	"True" Clock of differential pair output.
6	DDRAC2	OUT	"Complementary" Clock of differential pair output.
7	GND	PWR	Ground pin.
8	VDD1.8/1.5	PWR	Power supply, nominal 1.8V or 1.5V
9	AGND	PWR	Analog Ground pin for Core PLL
10	AVDD1.8	PWR	1.8V Analog Power pin for Core PLL
11	SCLK	IN	Clock pin of SMBus circuitry, 5V tolerant.
12	SDATA	I/O	Data pin for SMBus circuitry, 5V tolerant.
13	VDD1.8/1.5	PWR	Power supply, nominal 1.8V or 1.5V
14	DDRBT0	OUT	"True" Clock of differential pair output.
15	DDRBC0	OUT	"Complementary" Clock of differential pair output.
16	DDRBT1	OUT	"True" Clock of differential pair output.
17	DDRBC1	OUT	"Complementary" Clock of differential pair output.
18	DDRBT2	OUT	"True" Clock of differential pair output.
19	DDRBC2	OUT	"Complementary" Clock of differential pair output.
20	CLK_INTB T	IN	True' reference clock input for bank B.
21	CLK_INTB C	IN	Complementary' reference clock input for bank B.
22	GND	PWR	Ground pin.
23	FB_INTB	IN	True single-ended feedback input, provides feedback signal to internal PLL for synchronization with CLK_INTB to eliminate phase error on bank B.
24	FB_OUTB	OUT	Feedback output, dedicated external feedback for bank B outputs.
25	DDRBC3	OUT	"Complementary" Clock of differential pair output.
26	DDRBT3	OUT	"True" Clock of differential pair output.
27	DDRBC4	OUT	"Complementary" Clock of differential pair output.
28	DDRBT4	OUT	"True" Clock of differential pair output.
29	DDRBC5	OUT	"Complementary" Clock of differential pair output.
30	DDRBT5	OUT	"True" Clock of differential pair output.
31	VDD1.8/1.5	PWR	Power supply, nominal 1.8V or 1.5V
32	GND	PWR	Ground pin.
33	AGND	PWR	Analog Ground pin for Core PLL
34	AVDD1.8	PWR	1.8V Analog Power pin for Core PLL
35	GND	PWR	Ground pin.
36	VDD1.8/1.5	PWR	Power supply, nominal 1.8V or 1.5V
37	DDRAC5	OUT	"Complementary" Clock of differential pair output.
38	DDRAT5	OUT	"True" Clock of differential pair output.
39	DDRAC4	OUT	"Complementary" Clock of differential pair output.
40	DDRAT4	OUT	"True" Clock of differential pair output.
41	DDRAC3	OUT	"Complementary" Clock of differential pair output.
42	DDRAT3	OUT	"True" Clock of differential pair output.
43	GND	PWR	Ground pin.
44	CLK_INTA C	IN	Complementary' reference clock input for bank A.
45	CLK_INTA T	IN	True' reference clock input for bank A.
46	VDD1.8/1.5	PWR	Power supply, nominal 1.8V or 1.5V
47	FB_INTA	IN	True single-ended feedback input, provides feedback signal to internal PLL for synchronization with CLK_INTA to eliminate phase error on bank A.
48	FB_OUTA	OUT	Feedback output, dedicated external feedback for bank A outputs.

## Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the 9P960. These ratings, which are standard values for IDT commercially rated parts, are stress ratings only. Functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods can affect product reliability. Electrical parameters are guaranteed only over the recommended operating temperature range.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
1.8/1.5V Core Voltage	AVDD1.8	With respect to GND	-0.5		2.3	V
1.8/1.5V Logic Voltage	VDD1.8/1.5	With respect to GND	-0.5		2.3	V
Storage Temperature	T <sub>s</sub>	-	-65		150	°C
Ambient Operating Temp	T <sub>ambient</sub>	-	0		70	°C
	T <sub>case</sub>	-			95	°C
Input ESD protection HBM	ESD prot	-	2000			V

1. Guaranteed by design and characterization, not 100% tested in production.
2. Operation under these conditions is neither implied nor guaranteed.

## DDRII Specifications

### Recommended Operating Conditions

T<sub>A</sub> = 0 - 70°C; Supply Voltage AVDD1.8, VDD1.8/1.5 = 1.8 V +/- 0.1V (unless otherwise stated)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V <sub>DD1.8/1.5</sub>		1.7	1.8	1.9	V
	A <sub>VDD1.8</sub>		1.7	1.8	1.9	V
Low level input voltage	V <sub>IL</sub>	CLK_INT, CLK_INC, FB_IN			0.35V <sub>DD</sub>	V
High level input voltage	V <sub>IH</sub>	CLK_INT, CLK_INC, FB_IN	0.65V <sub>DD</sub>			V
Operating free-air temperature	T <sub>A</sub>		0		70	°C

#### Notes:

1. Unused inputs must be held high or low to prevent them from floating.

## Electrical Characteristics—Input/Supply/Common Output Parameters

T<sub>A</sub> = 0 - 70°C; Supply Voltage AVDD1.8, VDD1.8/1.5 = 1.8 V +/- 0.1V (unless otherwise stated)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input High Current	I <sub>IH</sub>	V <sub>I</sub> = V <sub>DD</sub> or GND			10	μA
Input Low Current	I <sub>IL</sub>	V <sub>I</sub> = V <sub>DD</sub> or GND			-10	μA
Output Disabled Low Current	I <sub>ODL</sub>	OE = L, V <sub>ODL</sub> = 100mV	100			μA
Operating Supply Current	I <sub>DDA</sub>	AVDD1.8 @ 400MHz		34	45	mA
	I <sub>DD1.8</sub>	VDD1.8/1.5 @ 400MHz		436	500	mA
	I <sub>DDL</sub>	C <sub>L</sub> = 0pf			500	μA
Input Clamp Voltage	V <sub>IK</sub>	V <sub>DDQ</sub> = 1.8V I <sub>in</sub> = -18mA			-1.2	V
High-level output voltage	V <sub>OH</sub>	I <sub>OH</sub> = -100μA	V <sub>DD</sub> -0.2			V
		I <sub>OH</sub> = -9mA	1.1			V
Low-level output voltage	V <sub>OL</sub>	I <sub>OL</sub> = 100μA			0.1	V
		I <sub>OL</sub> = 9mA			0.6	V
Input Capacitance	C <sub>IN</sub>	V <sub>I</sub> = GND or V <sub>DD</sub>	2	3	5	pF
Output Capacitance	C <sub>OUT</sub>	V <sub>OUT</sub> = GND or V <sub>DD</sub>	2	3	5	pF

## Timing

$T_A = 0 - 70^\circ\text{C}$ ; Supply Voltage AVDD1.8, VDD1.8/1.5 = 1.8 V +/- 0.1V (unless otherwise stated)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Max clock frequency	freq <sub>op</sub>	1.8V±0.1V @ 25°C	150		600	MHz
Application Frequency Range	freq <sub>App</sub>	1.8V+0.1V @ 25°C	160		533	MHz
Input clock duty cycle	d <sub>tin</sub>		40		60	%
CLK stabilization	T <sub>STAB</sub>				15	µs

## Switching Characteristics<sup>1</sup>

$T_A = 0 - 70^\circ\text{C}$ ; Supply Voltage AVDD1.8, VDD1.8/1.5 = 1.8 V +/- 0.1V (unless otherwise stated)

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS
Output enable time	t <sub>en</sub>	OE to any output			8	ns
Output disable time	t <sub>dis</sub>	OE to any output			8	ns
Period jitter	t <sub>jit(per)</sub>		-30		30	ps
Half-period jitter	t <sub>jit(hper)</sub>		-40		40	ps
Input slew rate	SLr1(i)	Input Clock	1	2.5	4	v/ns
		Output Enable (OE), (OS)	0.5			v/ns
Output clock slew rate	SLr1(o)		1.5	2.5	3	v/ns
Cycle-to-cycle jitter	t <sub>jit(cc+)</sub>				40	ps
	t <sub>jit(cc-)</sub>				-40	ps
Dynamic Phase Offset	t <sub>( )dyn</sub>		-20		20	ps
Static Phase Offset	t <sub>(spo)</sub>		-60	0	60	ps
Output to Output Skew	t <sub>skew</sub>				100	ps
SSC modulation frequency	f <sub>SSCMOD</sub>	PLL will track SSC and meet dynamic phase offset in the specified range.	30.00		33	kHz
SSC clock input frequency deviation	f <sub>SSC%</sub>		0.00		-0.50	%

### Notes:

1. Switching characteristics guaranteed for application frequency range.

## DDRIII Specifications

### Recommended Operating Conditions

$T_A = 0 - 70^\circ\text{C}$ ; Supply Voltage AVDD = 1.8V +/- 0.1V, VDD = 1.5 V +/- 5% (unless otherwise stated)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	$V_{DD1.8/1.5}$		1.425	1.5	1.575	V
	$A_{VDD1.8}$		1.7	1.8	1.9	V
Low level input voltage	$V_{IL}$	CLK_INT, CLK_INC, FB_IN			0.35V <sub>DD</sub>	V
High level input voltage	$V_{IH}$	CLK_INT, CLK_INC, FB_IN	0.65V <sub>DD</sub>			V
Operating free-air temperature	$T_A$		0		70	°C

#### Notes:

1. Unused inputs must be held high or low to prevent them from floating.

### Electrical Characteristics–Input/Supply/Common Output Parameters

$T_A = 0 - 70^\circ\text{C}$ ; Supply Voltage AVDD = 1.8V +/- 0.1V, VDD = 1.5 V +/- 5% (unless otherwise stated)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input High Current	$I_{IH}$	$V_i = V_{DD}$ or GND			10	μA
Input Low Current	$I_{IL}$	$V_i = V_{DD}$ or GND			-10	μA
Output Disabled Low Current	$I_{ODL}$	OE = L, V <sub>ODL</sub> = 100mV	100			μA
Operating Supply Current	$I_{DDA}$	AVDD1.8 @ 400MHz		34	45	mA
	$I_{DD1.5}$	VDD 1.8/1.5 @ 400MHz		331	375	mA
	$I_{DLDL}$	$C_L = 0\text{pf}$			500	μA
Input Clamp Current	$V_{IK}$	$V_i < 0$ or $V_i > V_{DD}$			-50	mA
Differential output clock swing	$V_{OD}$	$I_{OH} = -11\text{mA}$	500		VDD1.8/1.5	mV
Input Capacitance <sup>1</sup>	$C_{IN}$	$V_i = \text{GND}$ or $V_{DD}$	2		5	pF
Output Capacitance <sup>1</sup>	$C_{OUT}$	$V_{OUT} = \text{GND}$ or $V_{DD}$	2		5	pF

### Timing

$T_A = 0 - 70^\circ\text{C}$ ; Supply Voltage AVDD = 1.8V +/- 0.1V, VDD = 1.5 V +/- 5% (unless otherwise stated)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Max clock frequency	freq <sub>op</sub>	1.5V±5% @ 25°C	300		700	MHz
Application Frequency Range	freq <sub>AApp</sub>	1.5V+5% @ 25°C	300		670	MHz
Input clock duty cycle	$d_{in}$		40		60	%
CLK stabilization	$T_{STAB}$				15	μs

## Switching Characteristics<sup>1</sup>

$T_A = 0 - 70^\circ\text{C}$ ; Supply Voltage  $AVDD = 1.8\text{V} \pm 0.1\text{V}$ ,  $VDD = 1.5\text{V} \pm 5\%$  (unless otherwise stated)

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS
Output enable time	$t_{en}$	OE to any output			8	ns
Output disable time	$t_{dis}$	OE to any output			8	ns
Period jitter	$t_{jit(per)}$		-30		30	ps
Half-period jitter	$t_{jit(hper)}$		-40		40	ps
Input slew rate	SLr1(i)	Input Clock	1	2.5	4	v/ns
		Output Enable (OE), (OS)	0.5			v/ns
Output clock slew rate	SLr1(o)		2	2.3	5.5	v/ns
Cycle-to-cycle jitter	$t_{jit(cc+)}$		0		40	ps
	$t_{jit(cc-)}$		0		-40	ps
Dynamic Phase Offset	$t_{(dyn)}$		-20		20	ps
Static Phase Offset	$t_{(spo)}$		-60	0	60	ps
Output to Output Skew	$t_{skew}$				100	ps
SSC modulation frequency	$f_{SSCMOD}$	PLL will track SSC and meet dynamic phase offset in the specified range.	30.00		33	kHz
SSC clock input frequency deviation	$f_{SSC\%}$		0.00		-0.50	%

### Notes:

- Switching characteristics guaranteed for application frequency range.

## General SMBus Serial Interface Information

### How to Write

- Controller (host) sends a start bit
- Controller (host) sends the write address
- IDT clock will **acknowledge**
- Controller (host) sends the beginning byte location = N
- IDT clock will **acknowledge**
- Controller (host) sends the byte count = X
- IDT clock will **acknowledge**
- Controller (host) starts sending Byte N through Byte N+X-1
- IDT clock will **acknowledge** each byte **one at a time**
- Controller (host) sends a Stop bit

Index Block Write Operation			
Controller (Host)		IDT (Slave/Receiver)	
T	starT bit		
Slave Address			
WR	WRite		
Beginning Byte = N			ACK
Data Byte Count = X			ACK
Beginning Byte N		X Byte	ACK
O			O
O			O
O			O
Byte N + X - 1			ACK
P	stoP bit		

Read Address	Write Address
D5 <sub>(H)</sub>	D4 <sub>(H)</sub>

### How to Read

- Controller (host) will send a start bit
- Controller (host) sends the write address
- IDT clock will **acknowledge**
- Controller (host) sends the beginning byte location = N
- IDT clock will **acknowledge**
- Controller (host) will send a separate start bit
- Controller (host) sends the read address
- IDT clock will **acknowledge**
- IDT clock will send the data byte count = X
- IDT clock sends Byte N+X-1
- IDT clock sends **Byte 0 through Byte X (if X<sub>(H)</sub> was written to Byte 8)**
- Controller (host) will need to acknowledge each byte
- Controller (host) will send a not acknowledge bit
- Controller (host) will send a stop bit

Index Block Read Operation			
Controller (Host)		IDT (Slave/Receiver)	
T	starT bit		
Slave Address			
WR	WRite		
Beginning Byte = N			ACK
Repeat starT			ACK
Slave Address			
RD	ReaD		ACK
Data Byte Count=X			
ACK		X Byte	Beginning Byte N
ACK			O
O			O
O			O
ACK			Byte N + X - 1
N	Not acknowledge		
P	stoP bit		

I2C Table: Output Control Register

Byte 6	Name	Control Function	Type	0	1	Default
Bit 7	Freq Detect A	Low Frequency Detect PLLA OFF Control	RW	OFF	ON	1
Bit 6	FB_IN/OUTA	FB_OUTA Control	RW	Disable	Enable	1
Bit 5	DDRA_T5/C5	Output Control	RW	Disable	Enable	1
Bit 4	DDRA_T4/C4	Output Control	RW	Disable	Enable	1
Bit 3	DDRA_T3/C3	Output Control	RW	Disable	Enable	1
Bit 2	DDRA_T2/C2	Output Control	RW	Disable	Enable	1
Bit 1	DDRA_T1/C1	Output Control	RW	Disable	Enable	1
Bit 0	DDRA_T0/C0	Output Control	RW	Disable	Enable	1

I2C Table: Output Control Register

Byte 7	Name	Control Function	Type	0	1	Default
Bit 7	Freq Detect B	Low Frequency Detect PLLB OFF Control	RW	OFF	ON	1
Bit 6	FB_IN/OUTB	FB_OUTB Control	RW	Disable	Enable	1
Bit 5	DDRB_T5/C5	Output Control	RW	Disable	Enable	1
Bit 4	DDRB_T4/C4	Output Control	RW	Disable	Enable	1
Bit 3	DDRB_T3/C3	Output Control	RW	Disable	Enable	1
Bit 2	DDRB_T2/C2	Output Control	RW	Disable	Enable	1
Bit 1	DDRB_T1/C1	Output Control	RW	Disable	Enable	1
Bit 0	DDRB_T0/C0	Output Control	RW	Disable	Enable	1

I2C Table: Group Skew Control Register

Byte 8	Name	Control Function	Type	0	1	Default
Bit 7	CLKINA Skw3	CLKINA Skew Control	RW	See Table 1: 7-Step Skew Programming Table		0
Bit 6	CLKINA Skw2		RW			0
Bit 5	CLKINA Skw1		RW			0
Bit 4	CLKINA Skw0		RW			0
Bit 3	FB_INTA Skw3	FB_INTA Skew Control	RW	See Table 1: 7-Step Skew Programming Table		0
Bit 2	FB_INTA Skw2		RW			0
Bit 1	FB_INTA Skw1		RW			0
Bit 0	FB_INTA Skw0		RW			0

I2C Table: Group Skew Control Register

Byte 9	Name	Control Function	Type	0	1	Default
Bit 7	CLKINB Skw3	CLKINB Skew Control	RW	See Table 1: 7-Step Skew Programming Table		0
Bit 6	CLKINB Skw2		RW			0
Bit 5	CLKINB Skw1		RW			0
Bit 4	CLKINB Skw0		RW			0
Bit 3	FB_INTB Skw3	FB_INTB Skew Control	RW	See Table 1: 7-Step Skew Programming Table		0
Bit 2	FB_INTB Skw2		RW			0
Bit 1	FB_INTB Skw1		RW			0
Bit 0	FB_INTB Skw0		RW			0



I2C Table: Revision ID and Vendor ID Register

Byte 10	Name	Control Function	Type	0	1	Default
Bit 7	Revision_ID bit 3	Rev ID	RW	-	-	0
Bit 6	Revision_ID bit 2		RW	-	-	0
Bit 5	Revision_ID bit 1		RW	-	-	0
Bit 4	Revision_ID bit 0		RW	-	-	0
Bit 3	Vendor_ID bit3	Vendor ID	RW	-	-	0
Bit 2	Vendor_ID bit2		RW	-	-	0
Bit 1	Vendor_ID bit1		RW	-	-	0
Bit 0	Vendor_ID bit0		RW	-	-	1

I2C Table: Byte Count Register

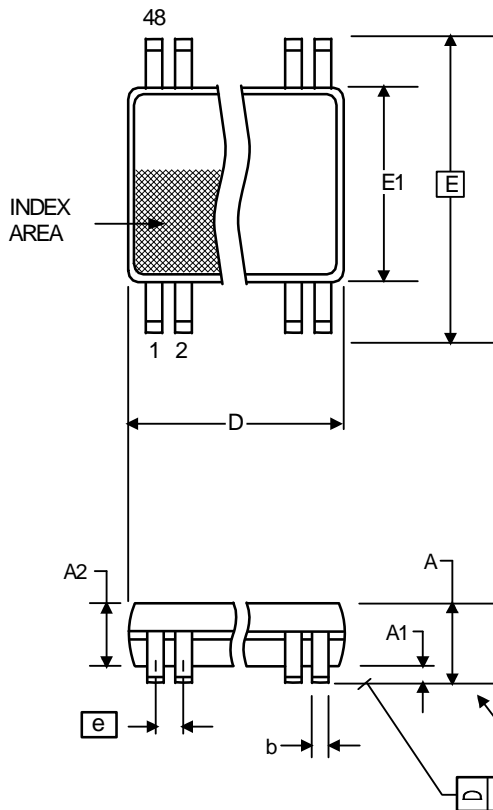
Byte 15	Name	Control Function	Type	0	1	Default
Bit 7	BC7	Byte Count Programming b(7:0)	RW	Writing to this register will configure how many bytes will be read back, default is 0F = 15 bytes		0
Bit 6	BC6		RW			0
Bit 5	BC5		RW			0
Bit 4	BC4		RW			0
Bit 3	BC3		RW			1
Bit 2	BC2		RW			1
Bit 1	BC1		RW			1
Bit 0	BC0		RW			1

Table 1: 7-Steps Skew Programming Table

7 Step	11	10	01	00	LSB
11	900 ps	750 ps	600 ps	450 ps	
10	N/A	N/A	N/A	300 ps	
01	N/A	N/A	N/A	150 ps	
00	N/A	N/A	N/A	0.0 ps	
MSB					

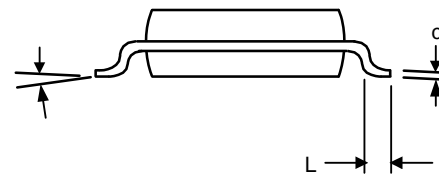
## Package Outline and Package Dimensions (48-pin SSOP, 300 Mil. Body)

Package dimensions are kept current with JEDEC Publication No. 95



Symbol	Millimeters		Inches*	
	Min	Max	Min	Max
A	2.41	2.80	.095	.110
A1	0.20	0.40	.008	.016
b	0.20	0.34	.008	.0135
c	0.13	0.25	.005	.010
D	15.75	16.00	.620	.630
E	10.03	10.68	.395	.420
E1	7.40	7.60	.291	.299
e	0.635 BASIC		0.025 BASIC	
h	0.38	0.64	.015	.025
L	0.50	1.02	.020	.040
$\alpha$	0°	8°	0°	8°

\*For reference only. Controlling dimensions in mm.



## Ordering Information

Part / Order Number	Shipping Packaging	Package	Temperature
9P960AFLF	Tubes	48-pin SSOP	0 to +70° C
9P960AFLFT	Tape and Reel	48-pin SSOP	0 to +70° C

"LF" suffix to the part number are the Pb-Free configuration and are RoHS compliant.

"A" is the device revision designator (will not correlate with the datasheet revision).

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**Revision History**

<b>Rev.</b>	<b>Issue Date</b>	<b>Description</b>	<b>Page #</b>
0.1	5/17/2007	Initial Release	-
0.2	7/1/2007	Updated Product description and Pinout	Various
0.3	9/9/2008	Updated Max Frequency for DDR2 (1.8V) setting	8
0.4	10/19/2009	Updated pin description table	2
A	5/18/2011	1. Removed advance information water marks from electrical tables. 2. Updated ordering information 3. Updated electrical tables 4. Updated SMBus tables 5. Updated to current datasheet template	Various



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