

## Four Output Differential Buffer for PCI-Express

**Recommended Application:**

DB400 Intel Yellow Cover part with PCI-Express support.

**Output Features:**

- 4 - 0.7V current-mode differential output pairs
- Supports zero delay buffer mode and fanout mode
- Bandwidth programming available

**Key Specifications:**

- Outputs cycle-cycle jitter: < 50ps
- Outputs skew: < 50ps
- +/- 300ppm frequency accuracy on output clocks

**Features/Benefits:**

- Supports tight ppm accuracy clocks for Serial-ATA
- Spread spectrum modulation tolerant, 0 to -0.5% down spread and +/- 0.25% center spread
- Supports undriven differential output pair in PD# and SRC\_STOP# for power management.

**Pin Configuration**

VDD	1	28	VDDA
SRC_IN	2	27	GNDA
SRC_IN#	3	26	IREF
GND	4	25	GND
VDD	5	24	VDD
DIF_1	6	23	DIF_6
DIF_1#	7	22	DIF_6#
OE_1	8	21	OE_6
DIF_2	9	20	DIF_5
DIF_2#	10	19	DIF_5#
VDD	11	18	VDD
BYPASS#/PLL	12	17	HIGH_BW#
SCLK	13	16	SRC_STOP#
SDATA	14	15	PD#

ICS9DB104

**28-pin SSOP & TSSOP**

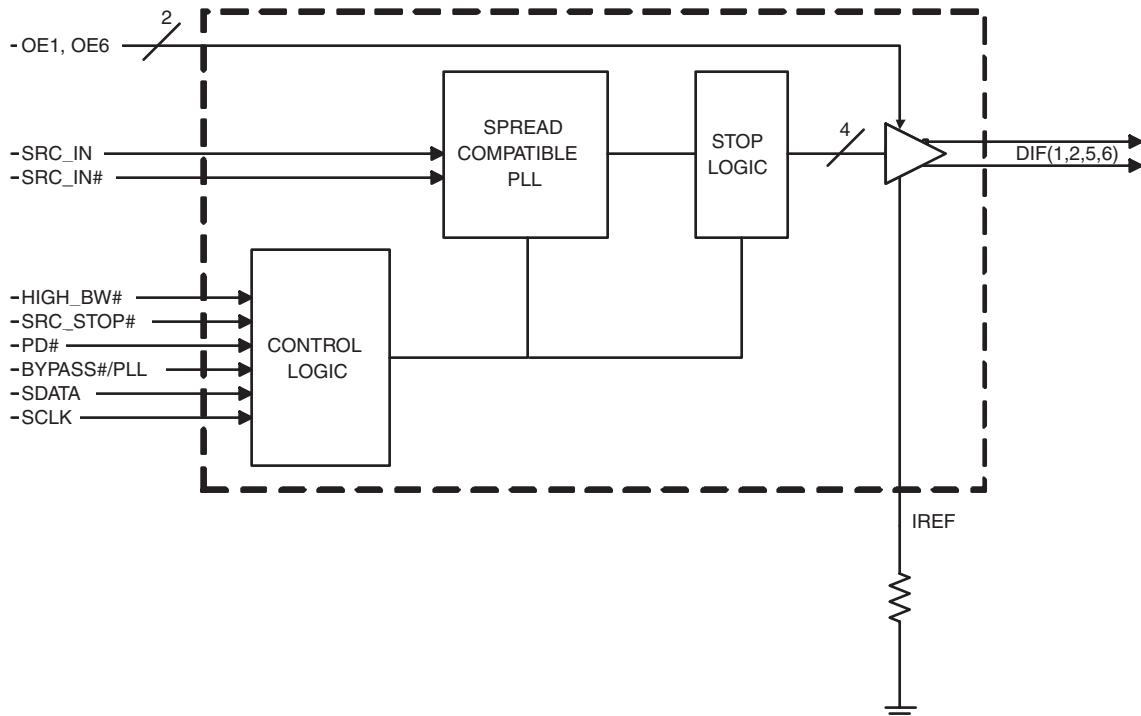
## Pin Description

PIN #	PIN NAME	PIN TYPE	DESCRIPTION
1	VDD	PWR	Power supply, nominal 3.3V
2	SRC_IN	IN	0.7 V Differential SRC TRUE input
3	SRC_IN#	IN	0.7 V Differential SRC COMPLEMENTARY input
4	GND	PWR	Ground pin.
5	VDD	PWR	Power supply, nominal 3.3V
6	DIF_1	OUT	0.7V differential true clock outputs
7	DIF_1#	OUT	0.7V differential complement clock outputs
8	OE_1	IN	Active high input for enabling outputs. 0 = tri-state outputs, 1= enable outputs
9	DIF_2	OUT	0.7V differential true clock outputs
10	DIF_2#	OUT	0.7V differential complement clock outputs
11	VDD	PWR	Power supply, nominal 3.3V
12	BYPASS#/PLL	IN	Input to select Bypass(fan-out) or PLL (ZDB) mode 0 = Bypass mode, 1= PLL mode
13	SCLK	IN	Clock pin of SMBus circuitry, 5V tolerant.
14	SDATA	I/O	Data pin for SMBus circuitry, 5V tolerant.
15	PD#	IN	Asynchronous active low input pin used to power down the device. The internal clocks are disabled and the VCO and the crystal are stopped.
16	SRC_STOP#	IN	Active low input to stop diff outputs.
17	HIGH_BW#	IN	3.3V input for selecting PLL Band Width 0 = High, 1= Low
18	VDD	PWR	Power supply, nominal 3.3V
19	DIF_5#	OUT	0.7V differential complement clock outputs
20	DIF_5	OUT	0.7V differential true clock outputs
21	OE_6	IN	Active high input for enabling outputs. 0 = tri-state outputs, 1= enable outputs
22	DIF_6#	OUT	0.7V differential complement clock outputs
23	DIF_6	OUT	0.7V differential true clock outputs
24	VDD	PWR	Power supply, nominal 3.3V
25	GND	PWR	Ground pin.
26	IREF	OUT	This pin establishes the reference current for the differential current-mode output pairs. This pin requires a fixed precision resistor tied to ground in order to establish the appropriate current. 475 ohms is the standard value.
27	GNDA	PWR	Ground pin for the PLL core.
28	VDDA	PWR	3.3V power for the PLL core.

## General Description

ICS9DB104 follows the Intel DB400 Differential Buffer Specification. This buffer provides four SRC clocks for PCI-Express, next generation I/O devices. ICS9DB104 is driven by a differential input pair from a CK409/CK410 main clock generator, such as the ICS952601 or ICS954101. ICS9DB104 can run at speeds up to 200MHz. It provides outputs meeting tight cycle-to-cycle jitter (50ps) and output-to-output skew (50ps) requirements.

## Block Diagram



## Power Groups

Pin Number		Description
VDD	GND	
1	4	SRC_IN/SRC_IN#
5,11,18,24	4,25	DIF Outputs
28	27	IREF
28	27	Analog VDD & GND for PLL core

## Absolute Max

Symbol	Parameter	Min	Max	Units
VDD_A	3.3V Core Supply Voltage		4.6	V
VDD_In	3.3V Logic Supply Voltage		4.6	V
V <sub>IL</sub>	Input Low Voltage	GND-0.5		V
V <sub>IH</sub>	Input High Voltage		V <sub>DD</sub> +0.5V	V
T <sub>s</sub>	Storage Temperature	-65	150	°C
T <sub>ambient</sub>	Ambient Operating Temp	0	70	°C
T <sub>case</sub>	Case Temperature		115	°C
ESD prot	Input ESD protection human body model	2000		V

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

T<sub>A</sub> = 0 - 70°C; Supply Voltage V<sub>DD</sub> = 3.3 V +/-5%

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
Input High Voltage	V <sub>IH</sub>	3.3 V +/-5%	2		V <sub>DD</sub> + 0.3	V	
Input Low Voltage	V <sub>IL</sub>	3.3 V +/-5%	GND - 0.3		0.8	V	
Input High Current	I <sub>IH</sub>	V <sub>IN</sub> = V <sub>DD</sub>	-5		5	uA	
Input Low Current	I <sub>IL1</sub>	V <sub>IN</sub> = 0 V; Inputs with no pull-up resistors	-5			uA	
	I <sub>IL2</sub>	V <sub>IN</sub> = 0 V; Inputs with pull-up resistors	-200			uA	
Operating Supply Current	I <sub>DD3.3OP</sub>	Full Active, C <sub>L</sub> = Full load;			200	mA	
Powerdown Current	I <sub>DD3.3PD</sub>	all diff pairs driven			40	mA	
		all differential pairs tri-stated			12	mA	
Input Frequency <sup>3</sup>	F <sub>i</sub>	V <sub>DD</sub> = 3.3 V	80	100/133 166/200	220	MHz	3
Pin Inductance <sup>1</sup>	L <sub>pin</sub>				7	nH	1
Input Capacitance <sup>1</sup>	C <sub>IN</sub>	Logic Inputs	1.5		5	pF	1
	C <sub>OUT</sub>	Output pin capacitance			6	pF	1
PLL Bandwidth	BW	PLL Bandwidth when PLL_BW=0		4		MHz	1
		PLL Bandwidth when PLL_BW=1		2		MHz	1
Clk Stabilization <sup>1,2</sup>	T <sub>STAB</sub>	From V <sub>DD</sub> Power-Up and after input clock stabilization or de-assertion of PD# to 1st clock			1	ms	1,2
Modulation Frequency		Triangular Modulation	30		33	kHz	1
Tdrive_SRC_STOP#		DIF output enable after SRC_Stop# de-assertion			10	ns	1,3
Tdrive_PD#		DIF output enable after PD# de-assertion			300	us	1,3
Tfall		Fall time of PD# and SRC_STOP#			5	ns	1
Trise		Rise time of PD# and SRC_STOP#			5	ns	2

<sup>1</sup>Guaranteed by design and characterization, not 100% tested in production.

<sup>2</sup>See timing diagrams for timing requirements.

<sup>3</sup>Time from deassertion until outputs are >200 mV

### Electrical Characteristics - DIF 0.7V Current Mode Differential Pair

$T_A = 0 - 70^\circ\text{C}$ ;  $V_{DD} = 3.3 \text{ V} \pm 5\%$ ;  $C_L = 2\text{pF}$ ,  $R_S = 33.2\Omega$ ,  $R_P = 49.9\Omega$ ,  $I_{REF} = 475\Omega$

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
Current Source Output Impedance	$Z_0^1$	$V_O = V_x$	3000			$\Omega$	1
Voltage High	VHigh	Statistical measurement on single ended signal using oscilloscope math function.	660		850	mV	1,3
Voltage Low	VLow		-150		150		1,3
Max Voltage	V <sub>ovs</sub>	Measurement on single ended signal using absolute value.			1150	mV	1
Min Voltage	V <sub>uds</sub>		-300				1
Crossing Voltage (abs)	V <sub>cross</sub> (abs)		250		550	mV	1
Crossing Voltage (var)	d-V <sub>cross</sub>	Variation of crossing over all edges			140	mV	1
Long Accuracy	ppm	see Tperiod min-max values			0	ppm	1,2
Average period	T <sub>period</sub>	200MHz nominal	4.9985		5.0015	ns	2
		200MHz spread	4.9985		5.0266	ns	2
		166.66MHz nominal	5.9982		6.0018	ns	2
		166.66MHz spread	5.9982		6.0320	ns	2
		133.33MHz nominal	7.4978		7.5023	ns	2
		133.33MHz spread	7.4978		5.4000	ns	2
		100.00MHz nominal	9.9970		10.0030	ns	2
		100.00MHz spread	9.9970		10.0533	ns	2
Absolute min period	T <sub>absmin</sub>	200MHz nominal	4.8735			ns	1,2
		166.66MHz nominal/spread	5.8732			ns	1,2
		133.33MHz nominal/spread	7.3728			ns	1,2
		100.00MHz nominal/spread	9.8720			ns	1,2
Rise Time	t <sub>r</sub>	$V_{OL} = 0.175\text{V}$ , $V_{OH} = 0.525\text{V}$	175		700	ps	1
Fall Time	t <sub>f</sub>	$V_{OH} = 0.525\text{V}$ $V_{OL} = 0.175\text{V}$	175		700	ps	1
Rise Time Variation	d-t <sub>r</sub>				125	ps	1
Fall Time Variation	d-t <sub>f</sub>				125	ps	1
Duty Cycle	d <sub>i3</sub>	Measurement from differential waveform	45		55	%	1
Skew	t <sub>sk3</sub>	$V_T = 50\%$			50	ps	1
Jitter, Cycle to cycle	t <sub>jcyc-cyc</sub>	PLL mode, Measurement from differential waveform			50	ps	1
		BYPASS mode as additive jitter			50	ps	1

<sup>1</sup>Guaranteed by design and characterization, not 100% tested in production.

<sup>2</sup>All Long Term Accuracy and Clock Period specifications are guaranteed with the assumption that the input clock complies with CK409/CK410 accuracy requirements

<sup>3</sup> $I_{REF} = V_{DD}/(3 \times R_R)$ . For  $R_R = 475\Omega$  (1%),  $I_{REF} = 2.32\text{mA}$ .  $I_{OH} = 6 \times I_{REF}$  and  $V_{OH} = 0.7\text{V}$  @  $Z_O=50\Omega$ .

## General SMBus serial interface information for the ICS9DB104

### How to Write:

- Controller (host) sends a start bit.
- Controller (host) sends the write address  $DC_{(h)}$
- ICS clock will **acknowledge**
- Controller (host) sends the begining byte location = N
- ICS clock will **acknowledge**
- Controller (host) sends the data byte count = X
- ICS clock will **acknowledge**
- Controller (host) starts sending **Byte N through Byte N + X - 1**
- ICS clock will **acknowledge** each byte **one at a time**
- Controller (host) sends a Stop bit

### How to Read:

- Controller (host) will send start bit.
- Controller (host) sends the write address  $DC_{(h)}$
- ICS clock will **acknowledge**
- Controller (host) sends the begining byte location = N
- ICS clock will **acknowledge**
- Controller (host) will send a separate start bit.
- Controller (host) sends the read address  $DD_{(h)}$
- ICS clock will **acknowledge**
- ICS clock will send the data byte count = X
- ICS clock sends **Byte N + X - 1**
- ICS clock sends **Byte 0 through byte X (if  $X_{(h)}$  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 Write Operation		
Controller (Host)		ICS (Slave/Receiver)
T	starT bit	
	Slave Address $DC_{(h)}$	
WR	WRite	
		ACK
Beginning Byte = N		ACK
		ACK
Data Byte Count = X		
		ACK
Beginning Byte N	X Byte	
○		ACK
○		○
○		○
○		○
Byte N + X - 1		
		ACK
P	stoP bit	

Index Block Read Operation		
Controller (Host)		ICS (Slave/Receiver)
T	starT bit	
	Slave Address $DC_{(h)}$	
WR	WRite	
		ACK
Beginning Byte = N		ACK
		ACK
RT	Repeat starT	
	Slave Address $DD_{(h)}$	
RD	ReaD	
		ACK
		Data Byte Count = X
		ACK
		Beginning Byte N
		○
		○
		○
		○
		Byte N + X - 1
N	Not acknowledge	
P	stoP bit	

**SMBus Table: Frequency Select Register, READ/WRITE ADDRESS (DC/DD)**

Byte 0		Pin #	Name	Control Function	Type	0	1	PWD
Bit 7	-		PD# drive mode	RW	driven	Hi-Z	0	
Bit 6	-		SRC_Stop# drive	RW	driven	Hi-Z	0	
Bit 5	-		Reserved	RW		Reserved	X	
Bit 4	-		Reserved	RW		Reserved	X	
Bit 3	-		Reserved	RW		Reserved	X	
Bit 2	-		PLL_BW# adjust	RW	High BW	Low BW	1	
Bit 1	-		BYPASS#/PLL	RW	fan-out	ZDB	1	
Bit 0	-		SRC_DIV#	RW	div /2	x1	1	

**SMBus Table: Output Control Register**

Byte 1		Pin #	Name	Control Function	Type	0	1	PWD
Bit 7	-		Reserved	RW	User should write '0' to minimize power			1
Bit 6	23,22	DIF_6	Output Control	RW	Disable	Enable	1	
Bit 5	20,19	DIF_5	Output Control	RW	Disable	Enable	1	
Bit 4	-	Reserved		RW	User should write '0' to minimize power			1
Bit 3	-	Reserved		RW	User should write '0' to minimize power			1
Bit 2	9,10	DIF_2	Output Control	RW	Disable	Enable	1	
Bit 1	6,7	DIF_1	Output Control	RW	Disable	Enable	1	
Bit 0	-	Reserved		RW	User should write '0' to minimize power			1

**SMBus Table: Output Control Register**

Byte 2		Pin #	Name	Control Function	Type	0	1	PWD
Bit 7	-		Reserved	RW	Reserved			0
Bit 6	23,22	DIF_6	Output Control	RW	Free-run	Stoppable	0	
Bit 5	20,19	DIF_5	Output Control	RW	Free-run	Stoppable	0	
Bit 4	-	Reserved		RW	Reserved			0
Bit 3	-	Reserved		RW	Reserved			0
Bit 2	9,10	DIF_2	Output Control	RW	Free-run	Stoppable	0	
Bit 1	6,7	DIF_1	Output Control	RW	Free-run	Stoppable	0	
Bit 0	-	Reserved		RW	Reserved			0

**SMBus Table: Output Control Register**

Byte 3		Pin #	Name	Control Function	Type	0	1	PWD
Bit 7				Reserved	RW	Reserved		X
Bit 6				Reserved	RW	Reserved		X
Bit 5				Reserved	RW	Reserved		X
Bit 4				Reserved	RW	Reserved		X
Bit 3				Reserved	RW	Reserved		X
Bit 2				Reserved	RW	Reserved		X
Bit 1				Reserved	RW	Reserved		X
Bit 0				Reserved	RW	Reserved		X

**SMBus Table: Vendor & Revision ID Register**

Byte 4		Pin #	Name	Control Function	Type	0	1	PWD
Bit 7	-		RID3	REVISION ID	R	-	-	X
Bit 6	-		RID2		R	-	-	X
Bit 5	-		RID1		R	-	-	X
Bit 4	-		RID0		R	-	-	X
Bit 3	-		VID3	VENDOR ID	R	-	-	0
Bit 2	-		VID2		R	-	-	0
Bit 1	-		VID1		R	-	-	0
Bit 0	-		VID0		R	-	-	1

**SMBus Table: DEVICE ID**

Byte 5		Pin #	Name	Control Function	Type	0	1	PWD
Bit 7	-		Device ID 7 (MSB)	RW	Reserved			0
Bit 6	-		Device ID 6	RW	Reserved			0
Bit 5	-		Device ID 5	RW	Reserved			0
Bit 4	-		Device ID 4	RW	Reserved			0
Bit 3	-		Device ID 3	RW	Reserved			1
Bit 2	-		Device ID 2	RW	Reserved			0
Bit 1	-		Device ID 1	RW	Reserved			0
Bit 0	-		Device ID 0	RW	Reserved			0

**SMBus Table: Byte Count Register**

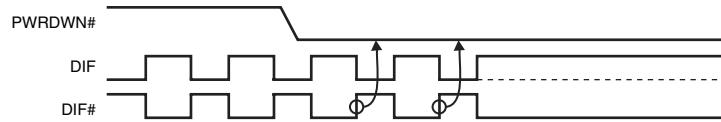
Byte 6		Pin #	Name	Control Function	Type	0	1	PWD
Bit 7	-		BC7	Writing to this register configures how many bytes will be read back.	RW	-	-	0
Bit 6	-		BC6		RW	-	-	0
Bit 5	-		BC5		RW	-	-	0
Bit 4	-		BC4		RW	-	-	0
Bit 3	-		BC3		RW	-	-	0
Bit 2	-		BC2		RW	-	-	1
Bit 1	-		BC1		RW	-	-	0
Bit 0	-		BC0		RW	-	-	1

## PD#

The PD# pin cleanly shuts off all clocks and places the device into a power saving mode. PD# must be asserted before shutting off the input clock or power to insure an orderly shutdown. PD is asynchronous active-low input for both powering down the device and powering up the device. When PD# is asserted, all clocks will be driven high, or tri-stated (depending on the PD# drive mode and Output control bits) before the PLL is shut down.

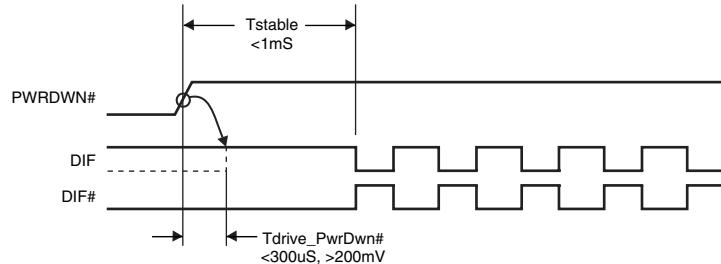
### PD# Assertion

When PD# is sampled low by two consecutive rising edges of DIF#, all DIF outputs must be held High, or tri-stated (depending on the PD# drive mode and Output control bits) on the next High-Low transition of the DIF# outputs. When the PD# drive mode bit is set to '0', all clock outputs will be held with DIF driven High with  $2 \times I_{REF}$  and DIF# tri-stated. If the PD# drive mode bit is set to '1', both DIF and DIF# are tri-stated.



### PD# De-assertion

Power-up latency is less than 1 ms. This is the time from de-assertion of the PD# pin, or VDD reaching 3.3V, or the time from valid SRC\_IN clocks until the time that stable clocks are output from the device (PLL Locked). If the PD# drive mode bit is set to '1', all the DIF outputs must driven to a voltage of >200 mV within 300 ms of PD# de-assertion.



## SRC\_STOP#

The SRC\_STOP# signal is an active-low asynchronous input that cleanly stops and starts the DIF outputs. A valid clock must be present on SRC\_IN for this input to work properly. The SRC\_STOP# signal is de-bounced and must remain stable for two consecutive rising edges of DIF# to be recognized as a valid assertion or de-assertion.

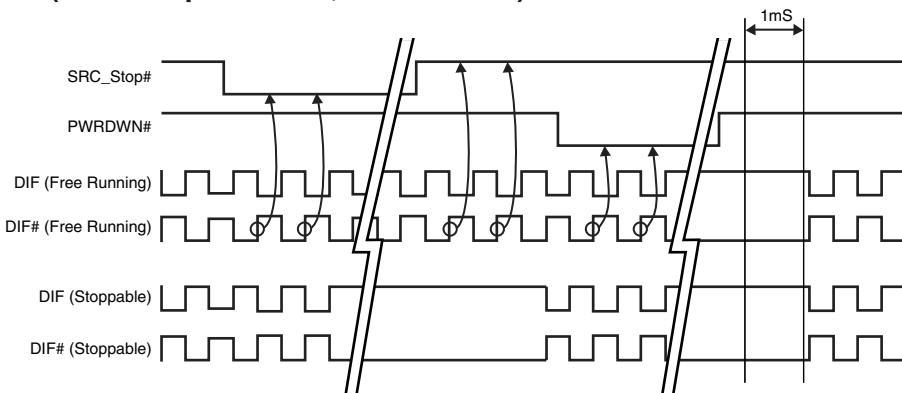
### SRC\_STOP# - Assertion (transition from '1' to '0')

Asserting SRC\_STOP# causes all DIF outputs to stop after their next transition (if the control register settings allow the output to stop). When the SRC\_STOP# drive bit is '0', the final state of all stopped DIF outputs is DIF = High and DIF# = Low. There is no change in output drive current. DIF is driven with  $6xI_{REF}$ , DIF# is not driven, but pulled low by the termination. When the SRC\_STOP# drive bit is '1', the final state of all DIF output pins is Low. Both DIF and DIF# are not driven.

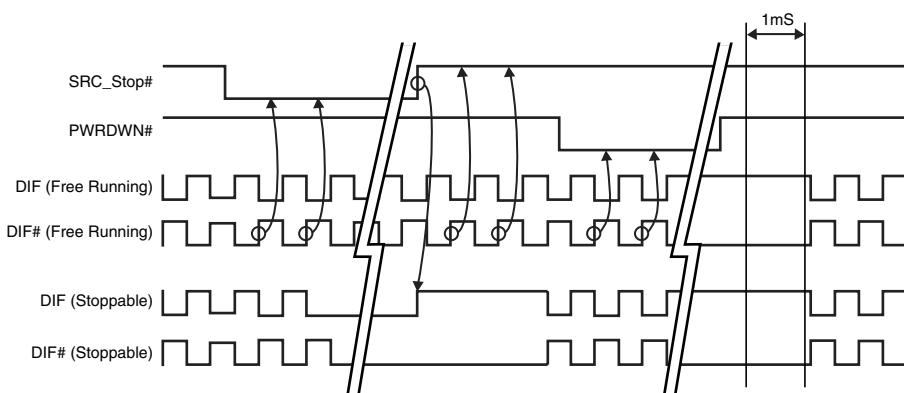
### SRC\_STOP# - De-assertion (transition from '0' to '1')

All stopped differential outputs resume normal operation in a glitch-free manner. The de-assertion latency to active outputs is 2-6 DIF clock periods, with all DIF outputs resuming simultaneously. If the SRC\_STOP# drive control bit is '1' (tri-state), all stopped DIF outputs must be driven High (>200 mV) within 10 ns of de-assertion.

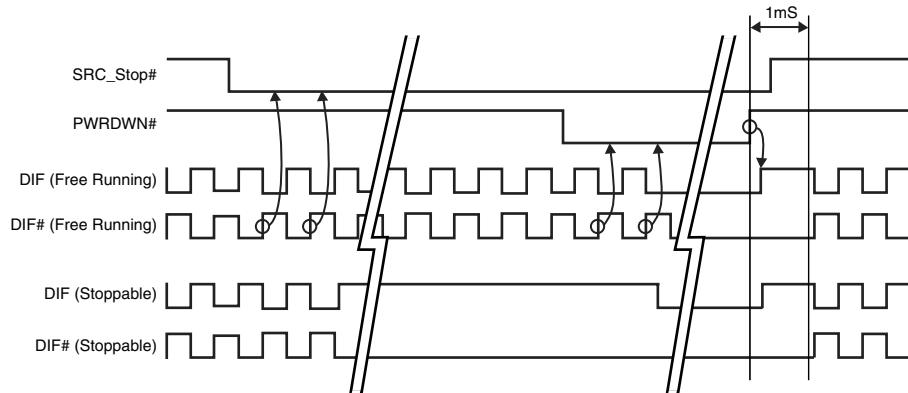
#### SRC\_STOP\_1 (SRC\_Stop = Driven, PD = Driven)



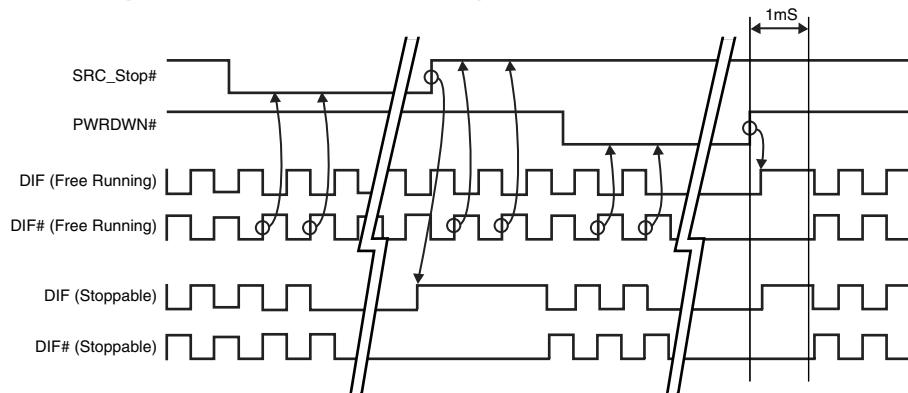
#### SRC\_STOP\_2 (SRC\_Stop = Tristate, PD = Driven)

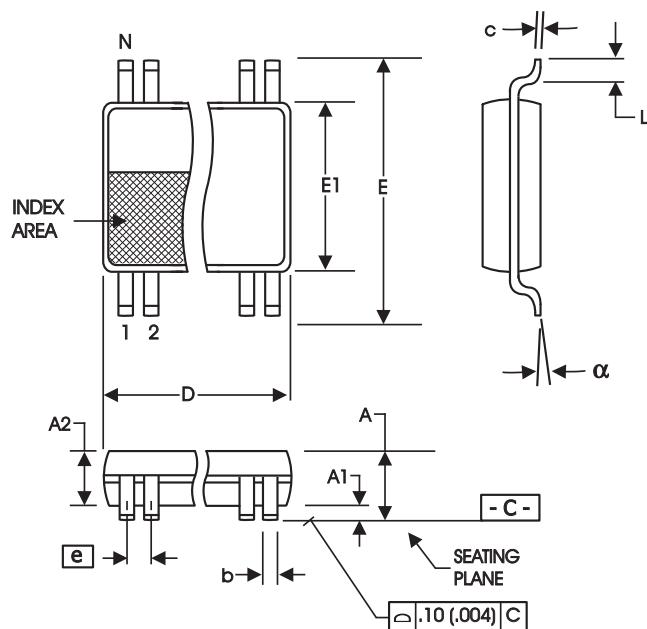


**SRC\_STOP\_3 (SRC\_Stop = Driven, PD = Tristate)**



**SRC\_STOP\_4 (SRC\_Stop = Tristate, PD = Tristate)**





SYMBOL	In Millimeters COMMON DIMENSIONS		In Inches COMMON DIMENSIONS	
	MIN	MAX	MIN	MAX
A	--	2.00	--	.079
A1	0.05	--	.002	--
A2	1.65	1.85	.065	.073
b	0.22	0.38	.009	.015
c	0.09	0.25	.0035	.010
D	SEE VARIATIONS		SEE VARIATIONS	
E	7.40	8.20	.291	.323
E1	5.00	5.60	.197	.220
e	0.65 BASIC		0.0256 BASIC	
L	0.55	0.95	.022	.037
N	SEE VARIATIONS		SEE VARIATIONS	
alpha	0°		8°	

#### VARIATIONS

N	D mm.		D (inch)	
	MIN	MAX	MIN	MAX
28	9.90	10.50	.390	.413

Reference Doc.: JEDEC Publication 95, MO-150  
10-0033

## Ordering Information

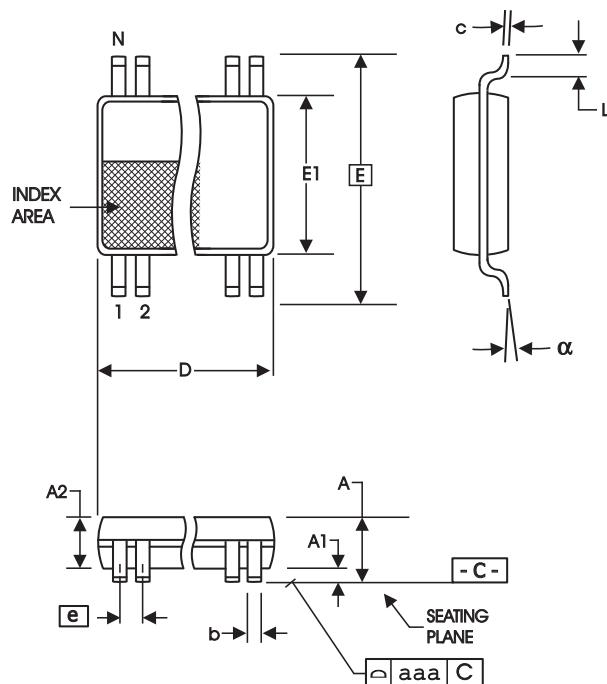
**ICS9DB104yFLxT**

Example:

**ICS XXXX y F LxT**

- Designation for tape and reel packaging
- LF or LN =
- Lead Free, RoHS Compliant (Optional)
- Package Type
- F = SSOP
- Revision Designator (will not correlate with datasheet revision)
- Device Type (consists of 3 to 7 digit numbers)
- Prefix

ICS = Standard Device



4.40 mm. Body, 0.65 mm. Pitch TSSOP

(173 mil) (25.6 mil)

SYMBOL	In Millimeters COMMON DIMENSIONS		In Inches COMMON DIMENSIONS	
	MIN	MAX	MIN	MAX
A	--	1.20	--	.047
A1	0.05	0.15	.002	.006
A2	0.80	1.05	.032	.041
b	0.19	0.30	.007	.012
c	0.09	0.20	.0035	.008
D	SEE VARIATIONS		SEE VARIATIONS	
E	6.40 BASIC		0.252 BASIC	
E1	4.30	4.50	.169	.177
e	0.65 BASIC		0.0256 BASIC	
L	0.45	0.75	.018	.030
N	SEE VARIATIONS		SEE VARIATIONS	
a	0°	8°	0°	8°
aaa	--	0.10	--	.004

#### VARIATIONS

N	D mm.		D (inch)	
	MIN	MAX	MIN	MAX
28	9.60	9.80	.378	.386

Reference Doc.: JEDEC Publication 95, MO-153

10-0035

## Ordering Information

**ICS9DB104yGLxT**

Example:

**ICS XXXX y G LxT**

- Designation for tape and reel packaging
- LF or LN =
- Lead Free, RoHS Compliant (Optional)
- Package Type  
G = TSSOP
- Revision Designator (will not correlate with datasheet revision)
- Device Type (consists of 3 to 7 digit numbers)

Prefix

ICS = Standard Device

**Revision History**

<b>Rev.</b>	<b>Issue Date</b>	<b>Description</b>	<b>Page #</b>
D	10/26/05	Updated LF Ordering Information to LN or LF.	12, 13
E	12/14/07	Updated SMBus serial Interface Information.	6

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