

## GENERAL DESCRIPTION

The 87608I has a selectable REF\_CLK or crystal input. The REF\_CLK input accepts LVCMOS or LVTTTL input levels. The 87608I has a fully integrated PLL along with frequency configurable clock and feedback outputs for multiplying and regenerating clocks with “zero delay”.

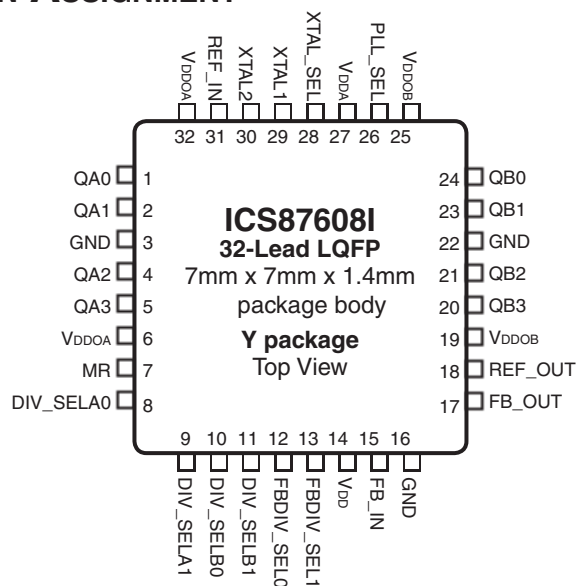
The 87608I is a 1:8 PCI/PCI-X Clock Generator. The 87608I has a selectable REF\_CLK or crystal input. The REF\_CLK input accepts LVCMOS or LVTTTL input levels. The 87608I has a fully integrated PLL along with frequency configurable clock and feedback outputs for multiplying and regenerating clocks with “zero delay”. The PLL’s VCO has an operating range of 250MHz-500MHz, allowing this device to be used in a variety of general purpose clocking applications. For PCI/PCI-X applications in particular, the VCO frequency should be set to 400MHz. This can be accomplished by supplying 33.33MHz, 25MHz, 20MHz, or 16.66MHz on the reference clock or crystal input and by selecting ÷12, ÷16, ÷20, or ÷24, respectively as the feedback divide value. The dividers on each of the two output banks can then be independently configured to generate 33.33MHz (÷12), 66.66MHz (÷6), 100MHz (÷4), or 133.33MHz (÷3).

The 87608I is characterized to operate with its core supply at 3.3V and each bank supply at 3.3V or 2.5V. The 87608I is packaged in a small 7x7mm body LQFP, making it ideal for use in space-constrained applications.

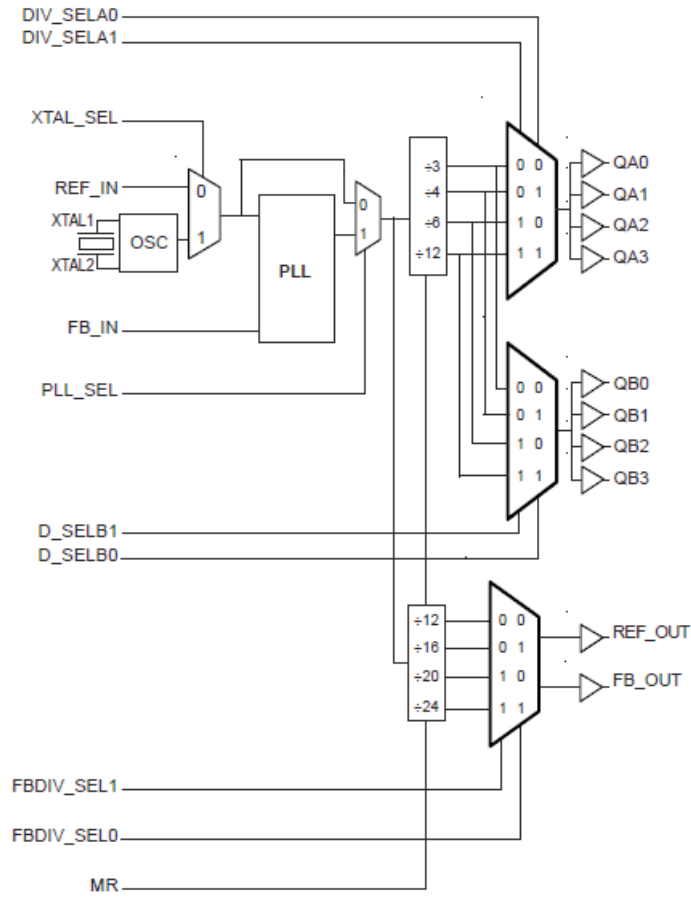
## FEATURES

- Fully integrated PLL
- Eight LVCMOS/LVTTTL outputs, 15Ω typical output impedance
- Selectable crystal oscillator interface or LVCMOS/LVTTTL REF\_IN clock input
- Maximum output frequency: 166.67MHz
- Maximum crystal input frequency: 38MHz
- Maximum REF\_IN input frequency: 41.67MHz
- Individual banks with selectable output dividers for generating 33.333MHz, 66.66MHz, 100MHz and 133.333MHz
- Separate feedback control for generating PCI / PCI-X frequencies from a 16.66MHz or 20MHz crystal, or 25MHz or 33.33MHz reference frequency
- VCO range: 200MHz to 500MHz
- Cycle-to-cycle jitter: 120ps (maximum), @ 3.3V
- Period jitter, RMS: 20ps (maximum)
- Output skew: 250ps (maximum)
- Bank skew: 60ps (maximum)
- Static phase offset: 160ps ± 160ps
- Voltage Supply Modes:  
 $V_{DD}$  (core/inputs),  $V_{DDA}$  (analog supply for PLL),  
 $V_{DDOA}$  (output bank A),  
 $V_{DDOB}$  (output bank B, REF\_OUT, FB\_OUT)  
 $V_{DD}/V_{DDA}/V_{DDOA}/V_{DDOB}$   
 3.3/3.3/3.3/3.3  
 3.3/3.3/2.5/3.3  
 3.3/3.3/3.3/2.5  
 3.3/3.3/2.5/2.5
- -40°C to 85°C ambient operating temperature
- Available in lead-free RoHS compliant package

## PIN ASSIGNMENT



# BLOCK DIAGRAM



**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1, 2, 4, 5	QA0, QA1, QA2, QA3	Output		Bank A clock outputs. 15Ω typical output impedance. LVCMOS / LVTTTL interface levels.
3, 16, 22	GND	Power		Power supply ground.
6, 32	V <sub>DDOA</sub>	Power		Output supply pins for Bank A outputs.
7	MR	Input	Pulldown	Active HIGH Master Reset. When logic HIGH, the internal dividers are reset causing the outputs go low. When logic LOW, the internal dividers and the outputs are enabled. LVCMOS / LVTTTL interface levels.
8, 9, 10, 11	DIV_SELA0, DIV_SELA1, DIV_SELB0, DIV_SELB1	Input	Pulldown	Selects divide value for clock outputs as described in Table 3. LVCMOS / LVTTTL interface levels.
12, 13	FBDIV_SELO, FBDIV_SEL1	Input	Pulldown	Selects divide value for reference clock output and feedback output. LVCMOS / LVTTTL interface levels.
14	V <sub>DD</sub>	Power		Core supply pin.
15	FB_IN	Input	Pulldown	Feedback input to phase detector for generating clocks with “zero delay”. LVCMOS / LVTTTL interface levels.
17	FB_OUT	Output		Feedback output. Connect to FB_IN. LVCMOS / LVTTTL interface levels.
18	REF_OUT	Output		Reference clock output. LVCMOS / LVTTTL interface levels.
19, 25	V <sub>DDOB</sub>	Power		Output supply pins for Bank B and REF_OUT, FB_OUT outputs.
20, 21, 23, 24	QB3, QB2, QB1, QB0	Output		Bank B clock outputs. 15Ω typical output impedance. LVCMOS / LVTTTL interface levels.
26	PLL_SEL	Input	Pullup	Selects between PLL and bypass mode. When HIGH, selects PLL. When LOW, selects reference clock. LVCMOS / LVTTTL interface levels.
27	V <sub>DDA</sub>	Power		Analog supply pin. See Applications Note for filtering.
28	XTAL_SEL	Input	Pullup	Selects between crystal oscillator or reference clock as the PLL reference source. Selects XTAL inputs when HIGH. Selects REF_IN when LOW. LVCMOS / LVTTTL interface levels.
29, 30	XTAL1, XTAL2	Input		Crystal oscillator interface. XTAL1 is the input. XTAL2 is the output.
31	REF_IN	Input	Pulldown	Reference clock input. LVCMOS / LVTTTL interface levels.

NOTE: Pullup and Pulldown refer to internal input resistors. See Table 2, Pin Characteristics, for typical values.

**TABLE 2. PIN CHARACTERISTICS**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C <sub>IN</sub>	Input Capacitance			4		pF
R <sub>PULLUP</sub>	Input Pullup Resistor			51		kΩ
R <sub>PULLDOWN</sub>	Input Pulldown Resistor			51		kΩ
C <sub>PD</sub>	Power Dissipation Capacitance (per output); NOTE 1	V <sub>DD</sub> , V <sub>DDA</sub> , V <sub>DDOX</sub> = 3.465V			9	pF
		V <sub>DD</sub> , V <sub>DDA</sub> = 3.465V; V <sub>DDOX</sub> = 2.625V			11	pF
R <sub>OUT</sub>	Output Impedance			15		Ω

V<sub>DDOX</sub> denotes V<sub>DDOA</sub> and V<sub>DDOB</sub>.

**TABLE 3A. OUTPUT CONTROL PIN FUNCTION TABLE**

Inputs		Outputs	
MR	QA0:QA3	QB0:QB3, FB_OUT, REF_OUT	
1	LOW	LOW	
0	Active	Active	

**TABLE 3B. OPERATING MODE FUNCTION TABLE**

Inputs		Operating Mode
PLL_SEL		
0		Bypass
1		PLL

**TABLE 3C. PLL INPUT FUNCTION TABLE**

Inputs	
XTAL_SEL	PLL Input
0	REF_IN
1	XTAL Oscillator

**TABLE 3D. CONTROL FUNCTION TABLE**

Inputs							Outputs		
							PLL_SEL =1	Frequency	
FBDIV_SEL1	FBDIV_SEL0	Bank B DIV_SELB1	Bank B DIV_SELB0	Bank A DIV SELA1	Bank A DIV SELA0	Reference Frequency Range (MHz)	QX0:QX3	QX0:QX3 (MHz)	FB_OUT (MHz)
0	0	0	0	0	0	16.67 - 41.67	x 4	66.68 - 166.68	16.67 - 41.67
0	0	0	1	0	1	16.67 - 41.67	x 3	50 - 125	16.67 - 41.67
0	0	1	0	1	0	16.67 - 41.67	x 2	33.34 - 83.34	16.67 - 41.67
0	0	1	1	1	1	16.67 - 41.67	x 1	16.67 - 41.67	16.67 - 41.67
0	1	0	0	0	0	12.5 - 31.25	x 5.33	66.63 - 166.56	12.5 - 31.25
0	1	0	1	0	1	12.5 - 31.25	x 4	50 - 125	12.5 - 31.25
0	1	1	0	1	0	12.5 - 31.25	x 2.667	33.34 - 83.34	12.5 - 31.25
0	1	1	1	1	1	12.5 - 31.25	x 1.33	16.63 - 41.56	12.5 - 31.25
1	0	0	0	0	0	10 - 25	x 6.667	66.67 - 166.68	10 - 25
1	0	0	1	0	1	10 - 25	x 5	50 - 125	10 - 25
1	0	1	0	1	0	10 - 25	x 3.33	33.30 - 83.25	10 - 25
1	0	1	1	1	1	10 - 25	x 1.66	16.60 - 41.50	10 - 25
1	1	0	0	0	0	8.33 - 20.83	x 8	66.64 - 166.64	8.33 - 20.83
1	1	0	1	0	1	8.33 - 20.83	x 6	50 - 125	8.33 - 20.83
1	1	1	0	1	0	8.33 - 20.83	x 4	33.32 - 83.32	8.33 - 20.83
1	1	1	1	1	1	8.33 - 20.83	x 2	16.66 - 41.66	8.33 - 20.83

NOTE: VCO frequency range for all configurations above is 200MHz to 500MHz.

**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, $V_{DD}$	4.6V
Inputs, $V_I$	-0.5V to $V_{DD} + 0.5V$
Outputs, $V_O$	-0.5V to $V_{DDO} + 0.5V$
Package Thermal Impedance, $\theta_{JA}$	47.9°C/W (0 lfpm)
Storage Temperature, $T_{STG}$	-65°C to 150°C

NOTE: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

**TABLE 4A. POWER SUPPLY DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDOX} = 3.3V \pm 5\%$  OR  $2.5V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{DD}$	Core Supply Voltage		3.135	3.3	3.465	V
$V_{DDA}$	Analog Supply Voltage		3.135	3.3	3.465	V
$V_{DDOX}$	Output Supply Voltage		3.135	3.3	3.465	V
$I_{DD}$	Power Supply Current				185	mA
$I_{DDA}$	Analog Supply Current				15	mA
$I_{DDOA}$	Output Supply Current				20	mA
$I_{DDOB}$	Output Supply Current				20	mA

$V_{DDOX}$  denotes  $V_{DDOA}$ ,  $V_{DDOB}$ .

**TABLE 4B. LVCMOS/LVTTL DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDOX} = 3.3V \pm 5\%$  OR  $2.5V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage	MR, DIV_SELx0, DIV_SELx1, FBDIV_SEL0, FBDIV_SEL1, XTAL_SEL, FB_IN, PLL_SEL	2		$V_{DD} + 0.3$	V
		REF_IN	2		$V_{DD} + 0.3$	V
$V_{IL}$	Input Low Voltage	MR, DIV_SELx0, DIV_SELx1, FBDIV_SEL0, FBDIV_SEL1, XTAL_SEL, FB_IN, PLL_SEL	-0.3		0.8	V
		REF_IN	-0.3		1.3	V
$I_{IH}$	Input High Current	DIV_SELx0, DIV_SELx1, FB-DIV_SEL0, FBDIV_SEL1, MR, FB_IN	$V_{DD} = V_{IN} = 3.465V$		150	$\mu\text{A}$
		XTAL_SEL, PLL_SEL	$V_{DD} = V_{IN} = 3.465V$		5	$\mu\text{A}$
$I_{IL}$	Input Low Current	DIV_SELx0, DIV_SELx1, FB-DIV_SEL0, FBDIV_SEL1, MR, FB_IN	$V_{DD} = 3.465V$ , $V_{IN} = 0V$	-5		$\mu\text{A}$
		XTAL_SEL, PLL_SEL	$V_{DD} = 3.465V$ , $V_{IN} = 0V$	-150		$\mu\text{A}$
$V_{OH}$	Output High Voltage; NOTE 1	$V_{DD} = V_{IN} = 3.465V$	2.6			V
		$V_{DD} = V_{IN} = 2.625V$	1.8			V
$V_{OL}$	Output Low Voltage; NOTE 1				0.5	V

NOTE 1: Outputs terminated with  $50\Omega$  to  $V_{DDOX}/2$ . See Parameter Measurement Information section, "3.3V Output Load Test Circuit".

**TABLE 5. CRYSTAL CHARACTERISTICS**

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency		10		38	MHz
Equivalent Series Resistance (ESR)				50	$\Omega$
Shunt Capacitance			7		pF
Drive Level				1	mW

**TABLE 6. PLL INPUT REFERENCE CHARACTERISTICS,  $V_{DD} = V_{DDA} = V_{DDOX} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{REF}$	Reference Frequency		8.33		41.67	MHz

**TABLE 7A. AC CHARACTERISTICS,  $V_{DD} = V_{DDA} = V_{DDOX} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{MAX}$	Output Frequency				166.67	MHz
$t(\emptyset)$	Static Phase Offset; NOTE 1	$F_{REF} = 25\text{MHz}$	0	160	325	ps
$t_{sk}(b)$	Bank Skew; NOTE 2, 6				60	ps
$t_{sk}(o)$	Output Skew; NOTE 3, 6				250	ps
$t_{jit}(cc)$	Cycle-to-Cycle Jitter; 6				120	ps
$t_{jit}(per)$	Period Jitter, RMS; NOTE 4, 6, 7				20	ps
$t_{sl}(o)$	Slew Rate		1		4	v/ns
$t_L$	PLL Lock Time				10	ms
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	200		700	ps
odc	Output Duty Cycle; NOTE 5		48		52	%

All parameters measured with feedback and output dividers set to DIV by 12 unless otherwise noted.

NOTE 1: Defined as the time difference between the input reference clock and the average feedback input signal when the PLL is locked and the input reference frequency is stable. Measured at  $V_{DD}/2$ .

NOTE 2: Defined as skew within a bank of outputs at the same voltages and with equal load conditions.

NOTE 3: Defined as skew between outputs at the same supply voltage and with equal load conditions.

Measured at  $V_{DDOX}/2$ .

NOTE 4: Jitter performance using LVCMOS inputs.

NOTE 5: Measured using REF\_IN. For XTAL input, refer to Application Note.

NOTE 6: This parameter is defined in accordance with JEDEC Standard 65.

NOTE 7: This parameter is defined as an RMS value.

**TABLE 7B. AC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDOX} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{MAX}$	Output Frequency				166.67	MHz
$t(\emptyset)$	Static Phase Offset; NOTE 1	FREF = 25MHz	-365	-105	160	ps
$t_{sk}(b)$	Bank Skew; NOTE 2, 6				60	ps
$t_{sk}(o)$	Output Skew; NOTE 3, 6				250	ps
$t_{jit}(cc)$	Cycle-to-Cycle Jitter; 6				170	ps
$t_{jit}(per)$	Period Jitter, RMS; NOTE 4, 6, 7				20	ps
$t_{sl}(o)$	Slew Rate		1		4	v/ns
$t_L$	PLL Lock Time				10	ms
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	200		700	ps
odc	Output Duty Cycle; NOTE 5		48		52	%

All parameters measured with feedback and output dividers set to DIV by 12 unless otherwise noted.

NOTE 1: Defined as the time difference between the input reference clock and the average feedback input signal when the PLL is locked and the input reference frequency is stable. Measured at  $V_{DD}/2$ .

NOTE 2: Defined as skew within a bank of outputs at the same voltages and with equal load conditions.

NOTE 3: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at  $V_{DDOX}/2$ .

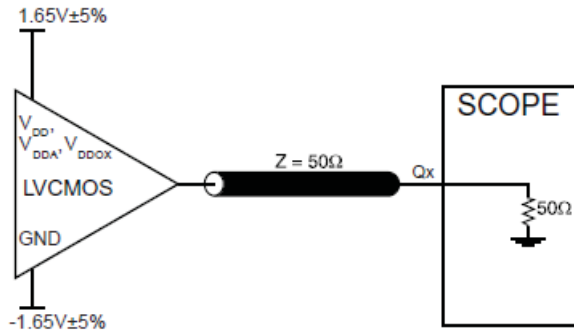
NOTE 4: Jitter performance using LVCMOS inputs.

NOTE 5: Measured using REF\_IN. For XTAL input, refer to Application Note.

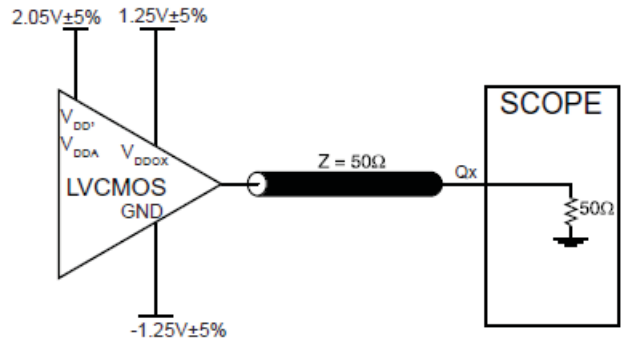
NOTE 6: This parameter is defined in accordance with JEDEC Standard 65.

NOTE 7: This parameter is defined as an RMS value.

## PARAMETER MEASUREMENT INFORMATION



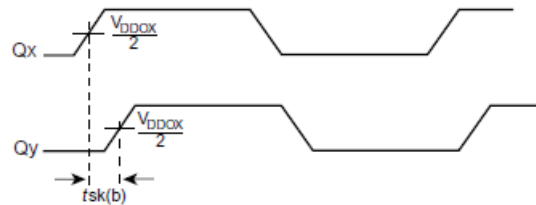
**3.3V OUTPUT LOAD AC TEST CIRCUIT**  
(Where X denotes outputs in the same Bank)



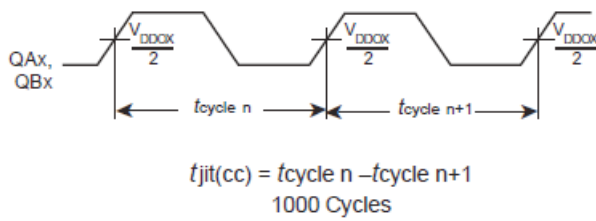
**3.3V/2.5V OUTPUT LOAD AC TEST CIRCUIT**



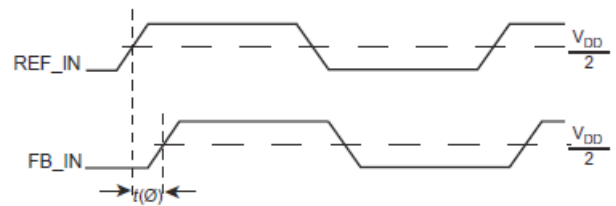
**OUTPUT SKEW**



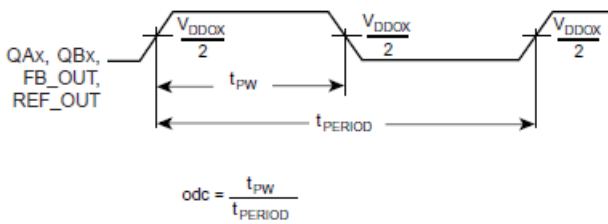
**BANK SKEW**



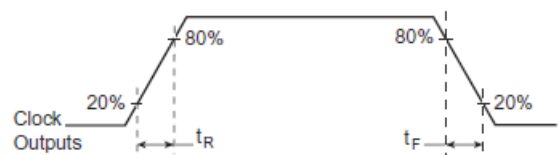
**CYCLE-TO-CYCLE JITTER**



**STATIC PHASE OFFSET**



**OUTPUT PULSE WIDTH/PULSE WIDTH PERIOD**



**OUTPUT RISE/FALL TIME**



## APPLICATION INFORMATION

### POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The 87608I provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DD}$ ,  $V_{DDA}$ , and  $V_{DDOX}$  should be individually connected to the power supply plane through vias, and bypass capacitors should be used for each pin. To achieve optimum jitter performance, power supply isolation is required. *Figure 1* illustrates how a  $10\Omega$  resistor along with a  $10\mu\text{F}$  and a  $.01\mu\text{F}$  bypass capacitor should be connected to each  $V_{DDA}$ .

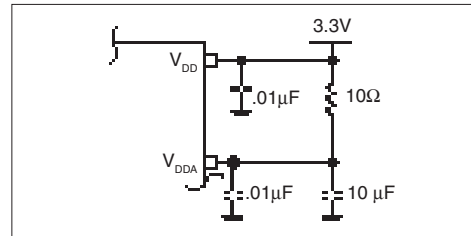


FIGURE 1. POWER SUPPLY FILTERING

### RECOMMENDATIONS FOR UNUSED INPUT AND OUTPUT PINS

#### INPUTS:

##### LVC MOS CONTROL PINS:

All control pins have internal pull-ups or pull-downs; additional resistance is not required but can be added for additional protection. A  $1\text{k}\Omega$  resistor can be used.

#### OUTPUTS:

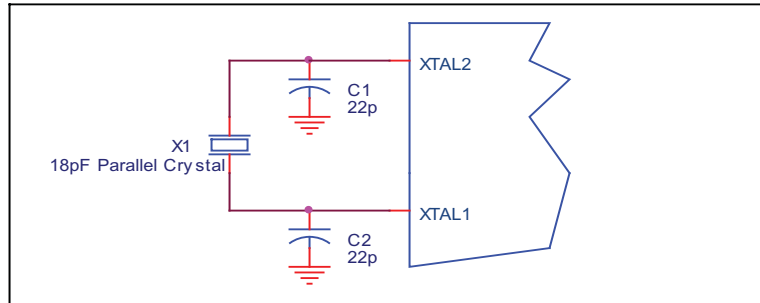
##### LVC MOS OUTPUT:

All unused LVC MOS output can be left floating. We recommend that there is no trace attached.

**CRYSTAL INPUT INTERFACE**

The 87608I has been characterized with 18pF parallel resonant crystals. The capacitor values, C1 and C2, shown in Figure 2 below were determined using a 25MHz, 18pF parallel

resonant crystal and were chosen to minimize the frequency ppm error. The optimum C1 and C2 values can be slightly adjusted for optimum frequency accuracy.

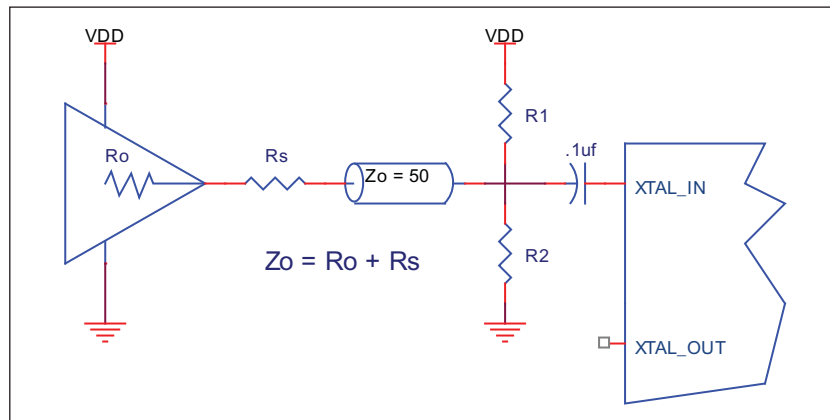


**Figure 2. CRYSTAL INPUT INTERFACE**

**LVC MOS TO XTAL INTERFACE**

The XTAL\_IN input can accept a single-ended LVC MOS signal through an AC coupling capacitor. A general interface diagram is shown in Figure 3. The XTAL\_OUT pin can be left floating. The input edge rate can be as slow as 10ns. For LVC MOS inputs, it is recommended that the amplitude be reduced from full swing to half swing in order to prevent signal interference with the power rail and to reduce noise. This configuration requires

that the output impedance of the driver ( $R_o$ ) plus the series resistance ( $R_s$ ) equals the transmission line impedance. In addition, matched termination at the crystal input will attenuate the signal in half. This can be done in one of two ways. First,  $R_1$  and  $R_2$  in parallel should equal the transmission line impedance. For most 50Ω applications,  $R_1$  and  $R_2$  can be 100Ω. This can also be accomplished by removing  $R_1$  and making  $R_2$  50Ω.



**FIGURE 3. GENERAL DIAGRAM FOR LVC MOS DRIVER TO XTAL INPUT INTERFACE**

## RELIABILITY INFORMATION

TABLE 8.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 32 LEAD LQFP

$\theta_{JA}$ by Velocity (Linear Feet per Minute)			
	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	67.8°C/W	55.9°C/W	50.1°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	47.9°C/W	42.1°C/W	39.4°C/W

**NOTE:** Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs.

### TRANSISTOR COUNT

The transistor count for 87608I is: 5495

PACKAGE OUTLINE - Y SUFFIX FOR 32 LEAD LQFP

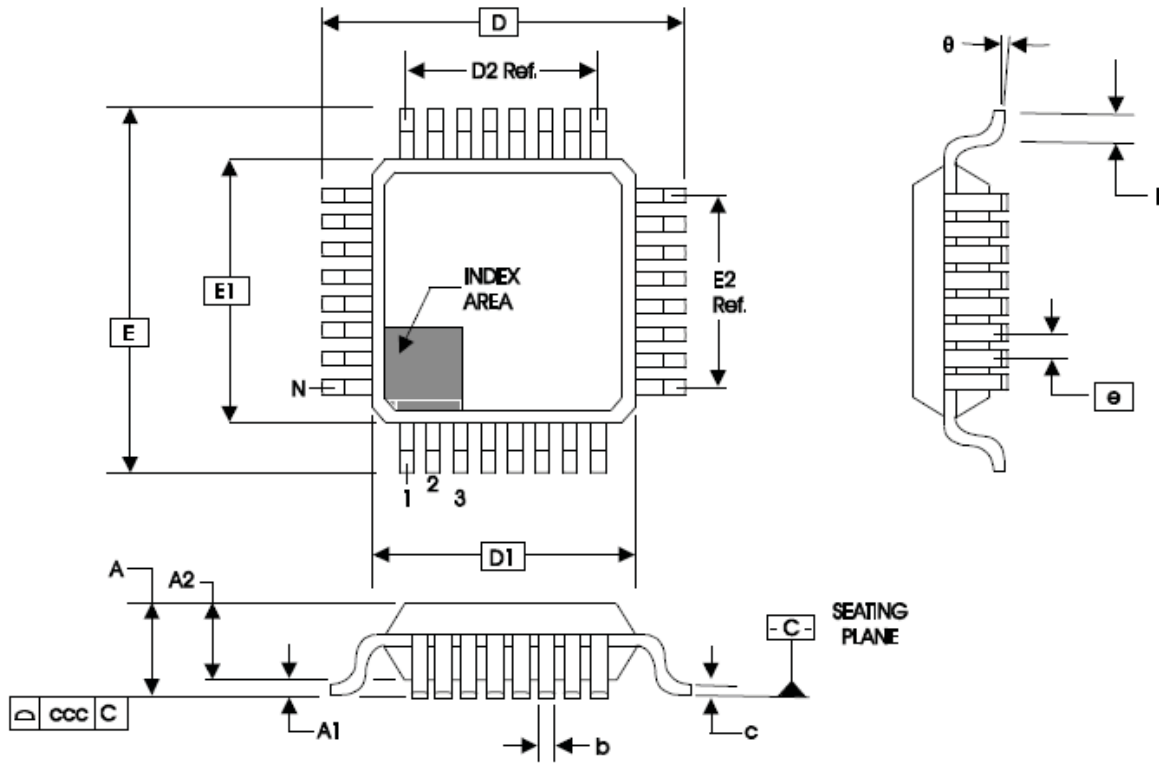


TABLE 9. PACKAGE DIMENSIONS

JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS			
SYMBOL	BBA		
	MINIMUM	NOMINAL	MAXIMUM
N	32		
A	--	--	1.60
A1	0.05	--	0.15
A2	1.35	1.40	1.45
b	0.30	0.37	0.45
c	0.09	--	0.20
D	9.00 BASIC		
D1	7.00 BASIC		
D2	5.60 Ref.		
E	9.00 BASIC		
E1	7.00 BASIC		
E2	5.60 Ref.		
e	0.80 BASIC		
L	0.45	0.60	0.75
θ	0°	--	7°
ccc	--	--	0.10

Reference Document: JEDEC Publication 95, MS-026

**TABLE 10. ORDERING INFORMATION**

<b>Part/Order Number</b>	<b>Marking</b>	<b>Package</b>	<b>Shipping Packaging</b>	<b>Temperature</b>
87608AYILF	ICS87608AILF	32 lead "Lead Free" LQFP	Tray	-40°C to +85°C
87608AYILFT	ICS87608AILF	32 lead "Lead Free" LQFP	Tape and Reel	-40°C to +85°C

REVISION HISTORY SHEET				
Rev	Table	Page	Description of Change	Date
A		2	Corrected MR in the Block Diagram.	4/6/04
A		7	Parameter Measurement Information - for 3.3V Outpt Load AC Test Circuit diagram corrected GND from "-1.165V±5%" to "-1.65V±5%".	4/23/04
A	T10	11	Ordering Information Table - added Lead-Free part number.	10/11/04
B	T7B	6	AC Characteristics Table - changed tjit(cc) from 120ps max to 170ps max.	1/28/05
B		1	Feature section, Cycle-to-Cycle Jitter note - added "@ 3.3V".	3/11/05
C	T2	3	Pin Characteristics Table - corrected R <sub>PULLUP/DOWN</sub> values from 51Ω max. to 51kΩ typical. Crystal Characterisitics Table - Added Drive Level parameter. Added <i>Recommendations for Unused Input and Output Pins</i> . Ordering Information Table - added lead-free note.	11/11/05
	T5	6		
	T10	9 12		
C	T10	10	Added <i>LVC MOS to XTAL Interface</i> .	4/28/06
		12	Ordering Information Table - corrected lead-free marking.	
C	T10	13	Updated datasheet's header/footer with IDT from ICS.	10/13/10
		15	Removed ICS prefix from Part/Order Number column. Added Contact Page.	
C	T10	1	Removed ICS from part number where needed.	1/25/16
		13	Features section - removed reference to leaded packages. Ordering Information - removed quantity from tape and reel. Deleted LF note below table. Updated header and footer.	



## IMPORTANT NOTICE AND DISCLAIMER

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