

## GENERAL DESCRIPTION

The 840004 is a 4 output LVCMOS/LVTTTL Synthesizer optimized to generate Ethernet reference clock frequencies and is a member of the HiPerClocks™ family of high performance clock solutions from IDT. Using a 26.5625MHz, 18pF parallel resonant crystal, the following frequencies can be generated based on the 2 frequency select pins (F\_SEL1:0): 212.5MHz, 159.375MHz, 156.25MHz, 106.25MHz, and 53.125MHz. The 840004 uses IDT's 3<sup>rd</sup> generation low phase noise VCO technology and can achieve 1ps or lower typical random rms phase jitter, easily meeting Ethernet jitter requirements. The 840004 is packaged in a small 20-pin TSSOP package.

## FEATURES

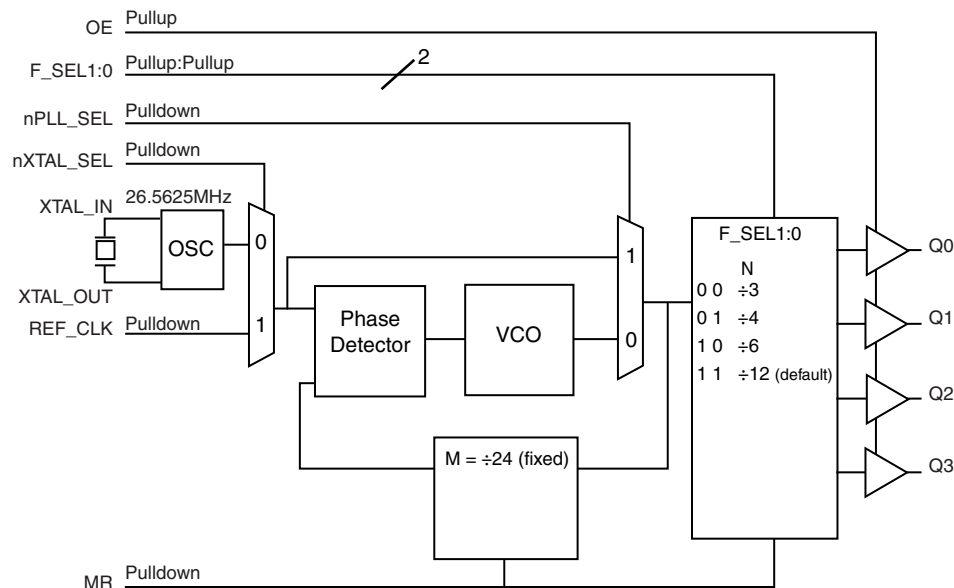
- Four LVCMOS/LVTTTL outputs, 17Ω typical output impedance
- Selectable crystal oscillator interface or LVCMOS single-ended input
- Supports the following input frequencies: 212.5MHz, 159.375MHz, 156.25MHz, 106.25MHz and 53.125MHz
- VCO range: 560MHz - 700MHz
- RMS phase jitter @ 212.5MHz (637kHz - 10MHz): 0.49ps typical,  $V_{DDO} = 3.3V$   
Phase noise:  

Offset	Noise Power
100Hz	-88.8 dBc/Hz
1kHz	-109.0 dBc/Hz
10kHz	-116.1 dBc/Hz
100kHz	-117.5 dBc/Hz
- Full 3.3V or mixed 3.3V core/2.5V output supply mode
- 0°C to 70°C ambient operating temperature
- Available in lead-free (RoHS 6) package

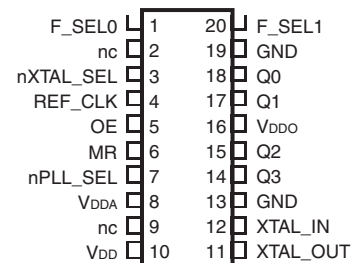
FREQUENCY SELECT FUNCTION TABLE

Input Frequency (MHz)	Inputs					Output Frequency Range (MHz)
	F_SEL1	F_SEL0	M Divider Value	N Divider Value	M/N Ratio Value	
26.5625	0	0	24	3	8	212.5
26.5625	0	1	24	4	6	159.375
26.5625	1	0	24	6	4	106.25
26.5625	1	1	24	12	2	53.125 (default)
26.04166	0	1	24	4	6	156.25

## BLOCK DIAGRAM



## PIN ASSIGNMENT



**840004**

**20-Lead TSSOP**

6.5mm x 4.4mm x 0.92mm  
package body

**G Package**

Top View

**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1	F_SEL0	Input	Pullup	Frequency select pin. LVCMOS/LVTTL interface levels.
2, 9	nc	Unused		No connect.
3	nXTAL_SEL	Input	Pulldown	Selects between the crystal or REF_CLK inputs as the PLL reference source. When HIGH, selects REF_CLK. When LOW, selects XTAL inputs. LVCMOS/LVTTL interface levels.
4	REF_CLK	Input	Pulldown	Single-ended LVCMOS/LVTTL reference clock input.
5	OE	Input	Pullup	Output enable pin. When HIGH, the outputs are active. When LOW, the outputs are in a high impedance state. LVCMOS/LVTTL interface levels.
6	MR	Input	Pulldown	Active HIGH Master Reset. When logic HIGH, the internal dividers are reset causing the outputs to go low. When logic LOW, the internal dividers and the outputs are enabled. LVCMOS/LVTTL interface levels.
7	nPLL_SEL	Input	Pulldown	PLL Bypass. When LOW, the output is driven from the VCO output. When HIGH, the PLL is bypassed and the output frequency = reference clock frequency/N output divider. LVCMOS/LVTTL interface levels.
8	V <sub>DDA</sub>	Power		Analog supply pin.
10	V <sub>DD</sub>	Power		Core supply pin.
11, 12	XTAL_OUT, XTAL_IN	Input		Crystal oscillator interface. XTAL_OUT is the output. XTAL_IN is the input.
13, 19	GND	Power		Power supply ground.
14, 15 17, 18	Q3, Q2, Q1, Q0	Output		Single-ended clock outputs. LVCMOS/LVTTL interface levels. 17Ω typical output impedance.
16	V <sub>DDO</sub>	Power		Output supply pin.
20	F_SEL1	Input	Pullup	Frequency select pin. LVCMOS/LVTTL 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
C <sub>PD</sub>	Power Dissipation Capacitance			8		pF
R <sub>PULLUP</sub>	Input Pullup Resistor			51		kΩ
R <sub>PULLDOWN</sub>	Input Pulldown Resistor			51		kΩ
R <sub>OUT</sub>	Output Impedance	V <sub>DDO</sub> = 3.3V±5%		17		Ω
		V <sub>DDO</sub> = 2.5V±5%		21		Ω

### 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 $V_{DD} + 0.5V$
Package Thermal Impedance, $\theta_{JA}$	73.2°C/W (0 lfp/m)
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 3A. POWER SUPPLY DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 3.3V \pm 5\%$  OR  $2.5V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  TO  $70^\circ\text{C}$**

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
$V_{DDO}$	Output Supply Voltage		3.135	3.3	3.465	V
			2.375	2.5	2.625	V
$I_{DD}$	Power Supply Current				100	mA
$I_{DDA}$	Analog Supply Current				12	mA
$I_{DDO}$	Output Supply Current				10	mA

**TABLE 3B. LVC MOS/LVTTL DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 3.3V \pm 5\%$  OR  $2.5V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  TO  $70^\circ\text{C}$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage		2		$V_{DD} + 0.3$	V
$V_{IL}$	Input Low Voltage		-0.3		0.8	V
$I_{IH}$	Input High Current	OE, F_SEL0, F_SEL1, nPLL_SEL, MR, nXTAL_ SEL, REF_CLK	$V_{DD} = V_{IN} = 3.465V$		5	$\mu\text{A}$
			$V_{DD} = V_{IN} = 3.465V$		150	$\mu\text{A}$
$I_{IL}$	Input Low Current	OE, F_SEL0, F_SEL1, nPLL_SEL, MR, nXTAL_ SEL, REF_CLK	$V_{DD} = 3.465V, V_{IN} = 0V$	-150		$\mu\text{A}$
			$V_{DD} = 3.465V, V_{IN} = 0V$	-5		$\mu\text{A}$
$V_{OH}$	Output High Voltage; NOTE 1		$V_{DDO} = 3.3V \pm 5\%$	2.6		V
			$V_{DDO} = 2.5V \pm 5\%$	1.8		V
$V_{OL}$	Output Low Voltage; NOTE 1		$V_{DDO} = 3.3V$ or $2.5V \pm 5\%$		0.5	V

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

**TABLE 4. CRYSTAL CHARACTERISTICS**

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency		23.3	26.5625	29.16	MHz
Equivalent Series Resistance (ESR)				50	$\Omega$
Shunt Capacitance				7	pF
Drive Level				1	mW

NOTE: Characterized using an 18pF parallel resonant crystal.

**TABLE 5A. AC CHARACTERISTICS,  $V_{DD} = V_{DDA} = V_{DDO} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{OUT}$	Output Frequency	F_SEL[1:0] = 00	186.67	212.5	226.66	MHz
		F_SEL[1:0] = 01	140	159.375	170	MHz
		F_SEL[1:0] = 10	93.33	156.25	113.33	MHz
		F_SEL[1:0] = 11	46.67	106.25	56.66	MHz
tsk(o)	Output Skew; NOTE 1, 3			60	ps	
$t_{jit}(\emptyset)$	RMS Phase Jitter (Random); NOTE 2	212.5MHz (637kHz - 10MHz)		0.49		ps
		159.375MHz (637kHz - 10MHz)		0.55		ps
		156.25MHz (1.875MHz - 20MHz)		0.56		ps
		106.25MHz (637kHz - 10MHz)		0.79		ps
		53.125MHz (637kHz - 10MHz)		0.65		ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	200		700	ps
odc	Output Duty Cycle	F_SEL[1:0] = 00	41		59	%
		F_SEL[1:0] = 01	43		57	%
		F_SEL[1:0] = 10 or 11	48		52	%

NOTE 1: Defined as skew between outputs at the same supply voltages and with equal load conditions.  
Measured at  $V_{DDO}/2$ .

NOTE 2: Please refer to the Phase Noise Plot.

NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.

**TABLE 5B. AC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 3.3V \pm 5\%$  OR  $2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$** 

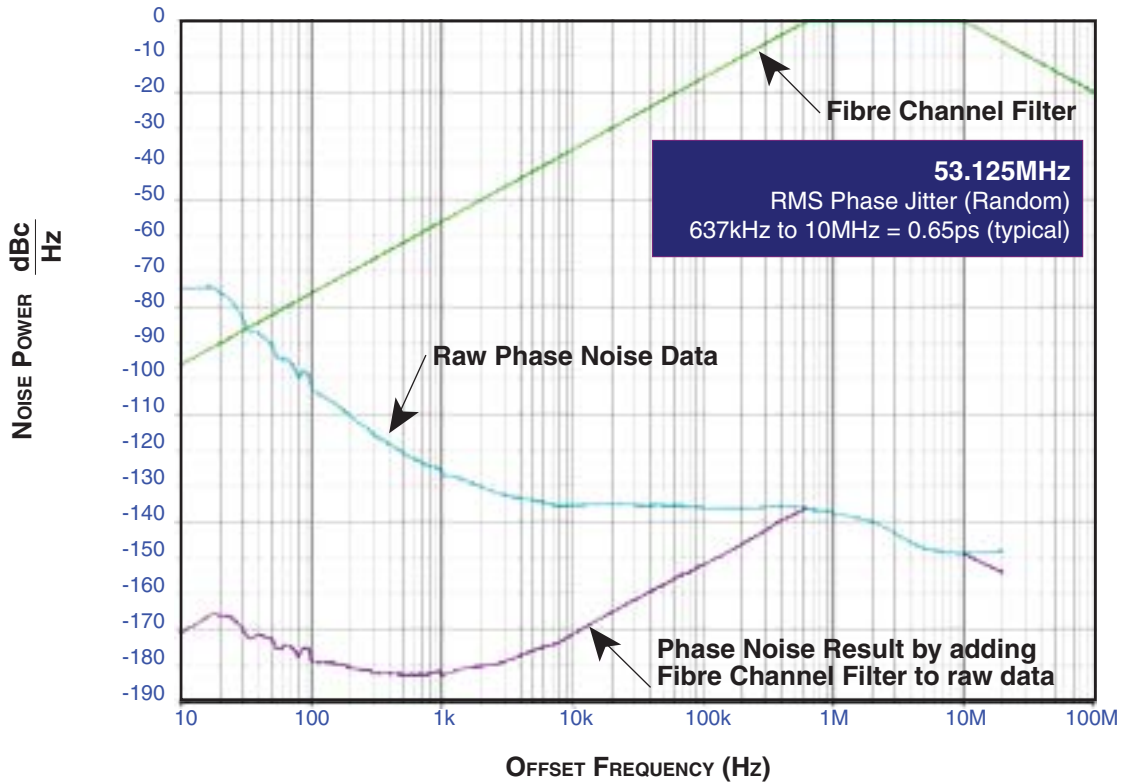
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{OUT}$	Output Frequency	F_SEL[1:0] = 00	186.67	212.5	226.66	MHz
		F_SEL[1:0] = 01	140	159.375	170	MHz
		F_SEL[1:0] = 10	93.33	156.25	113.33	MHz
		F_SEL[1:0] = 11	46.67	106.25	56.66	MHz
tsk(o)	Output Skew; NOTE 1, 3			60	ps	
$t_{jit}(\emptyset)$	RMS Phase Jitter (Random); NOTE 2	212.5MHz (637kHz - 10MHz)		0.46		ps
		159.375MHz (637kHz - 10MHz)		0.54		ps
		156.25MHz (1.875MHz - 20MHz)		0.57		ps
		106.25MHz (637kHz - 10MHz)		0.73		ps
		53.125MHz (637kHz - 10MHz)		0.63		ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	200		700	ps
odc	Output Duty Cycle	F_SEL[1:0] = 00	42		58	%
		F_SEL[1:0] = 01	44		56	%
		F_SEL[1:0] = 10 or 11	48		52	%

NOTE 1: Defined as skew between outputs at the same supply voltages and with equal load conditions.  
Measured at  $V_{DDO}/2$ .

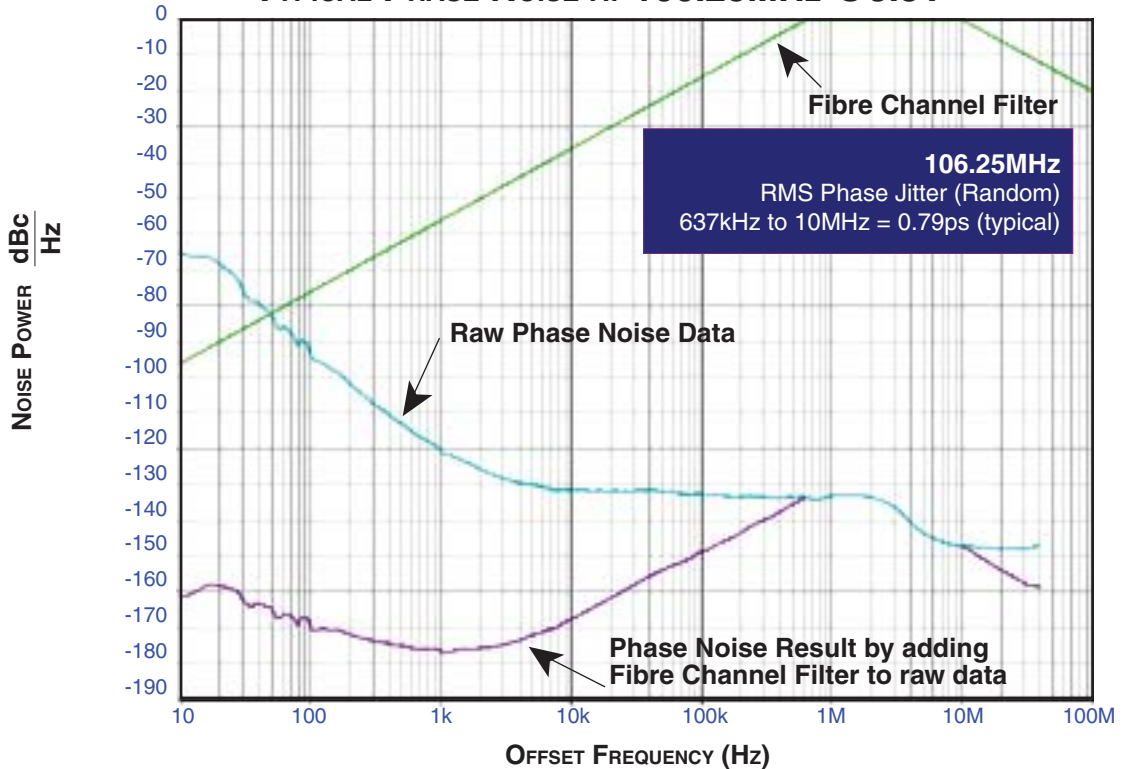
NOTE 2: Please refer to the Phase Noise Plot.

NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.

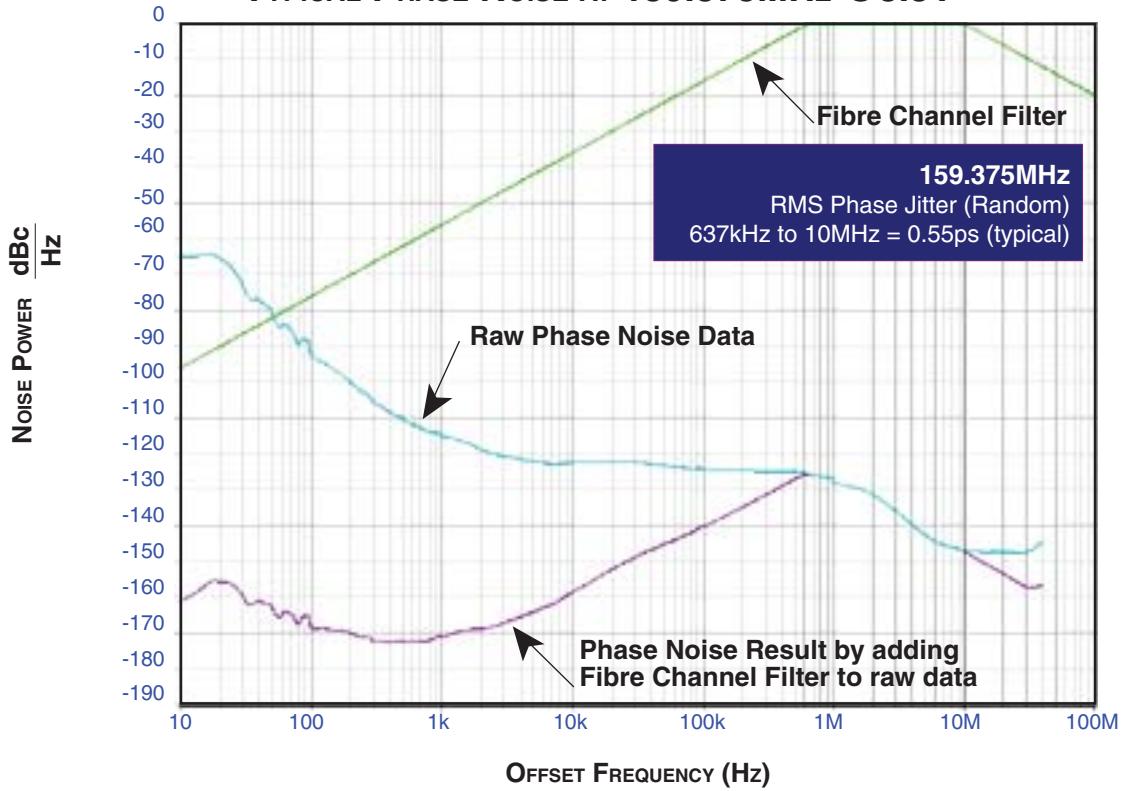
**TYPICAL PHASE NOISE AT 53.125MHz @3.3V**



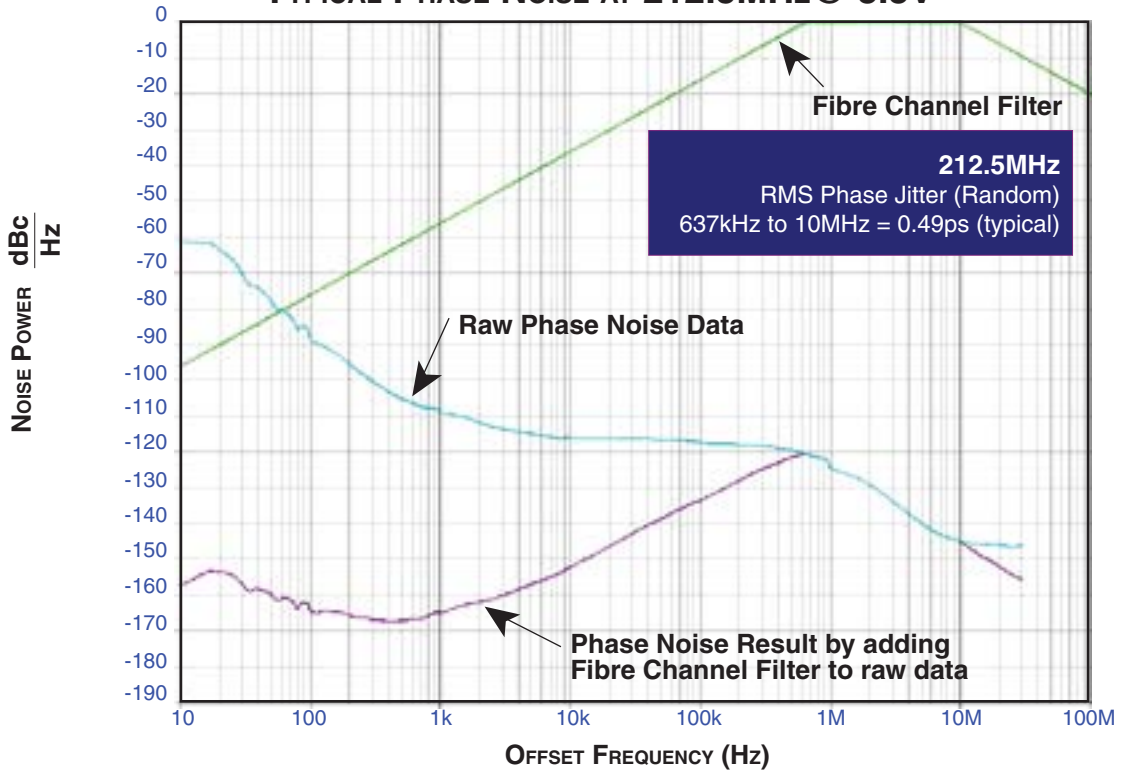
**TYPICAL PHASE NOISE AT 106.25MHz @3.3V**



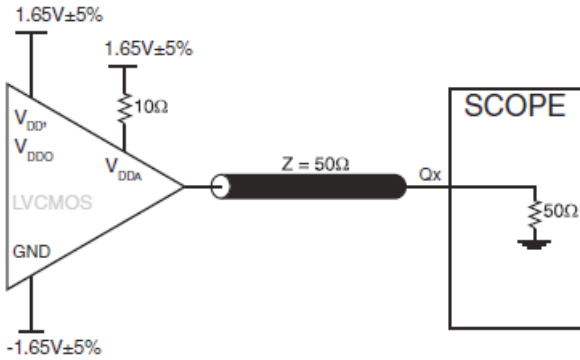
TYPICAL PHASE NOISE AT 159.375MHz @3.3V



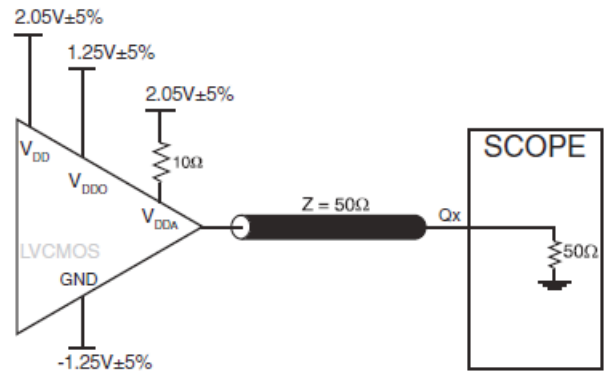
TYPICAL PHASE NOISE AT 212.5MHz @ 3.3V



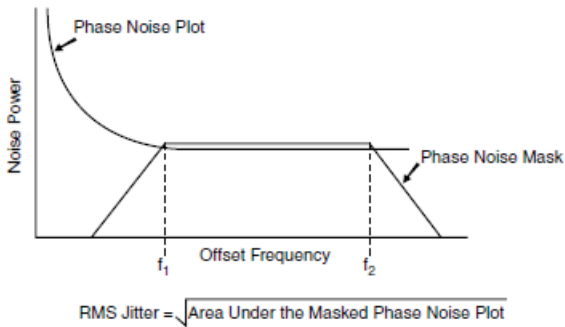
## PARAMETER MEASUREMENT INFORMATION



3.3V CORE/3.3V OUTPUT LOAD AC TEST CIRCUIT



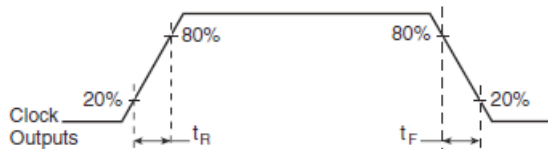
3.3V CORE/2.5V OUTPUT LOAD AC TEST CIRCUIT



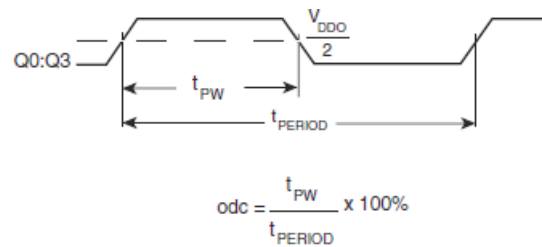
RMS PHASE JITTER



OUTPUT SKEW



OUTPUT RISE/FALL TIME



OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD

## APPLICATION INFORMATION

### POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The 840004 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DD}$ ,  $V_{DDA}$ , and  $V_{DDO}$  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  $V_{DDA}$ .

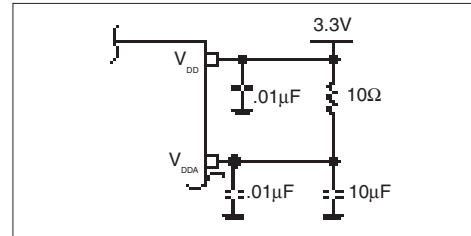


FIGURE 1. POWER SUPPLY FILTERING

### CRYSTAL INPUT INTERFACE

The 840004 has been characterized with 18pF parallel resonant crystals. The capacitor values shown in *Figure 2* below were

determined using a 26.5625MHz, 18pF parallel resonant crystal and were chosen to minimize the ppm error.

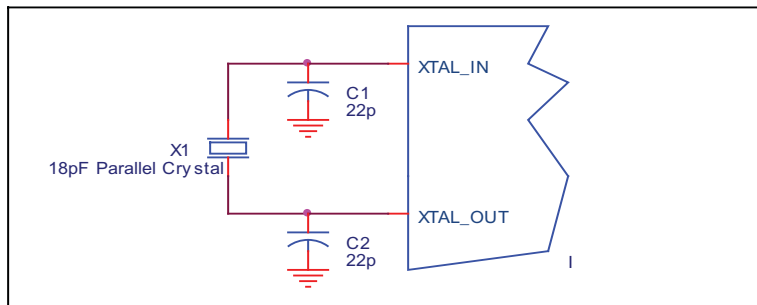


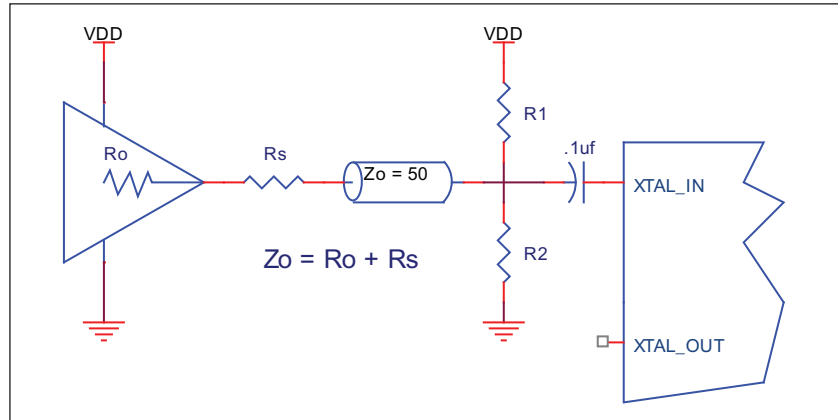
Figure 2. CRYSTAL INPUT INTERFACE



**LVC MOS TO XTAL INTERFACE**

The XTAL\_IN input can accept a single-ended LVC MOS signal through an AC couple 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  $50\Omega$  applications,  $R_1$  and  $R_2$  can be  $100\Omega$ . This can also be accomplished by removing  $R_1$  and making  $R_2$   $50\Omega$ .



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

**RECOMMENDATIONS FOR UNUSED INPUT AND OUTPUT PINS**

**INPUTS:**

**CRYSTAL INPUT:**

For applications not requiring the use of the crystal oscillator input, both XTAL\_IN and XTAL\_OUT can be left floating. Though not required, but for additional protection, a  $1k\Omega$  resistor can be tied from XTAL\_IN to ground.

**REF\_CLK INPUT:**

For applications not requiring the use of the reference clock, it can be left floating. Though not required, but for additional protection, a  $1k\Omega$  resistor can be tied from the REF\_CLK to ground.

**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  $1k\Omega$  resistor can be used.

**OUTPUTS:**

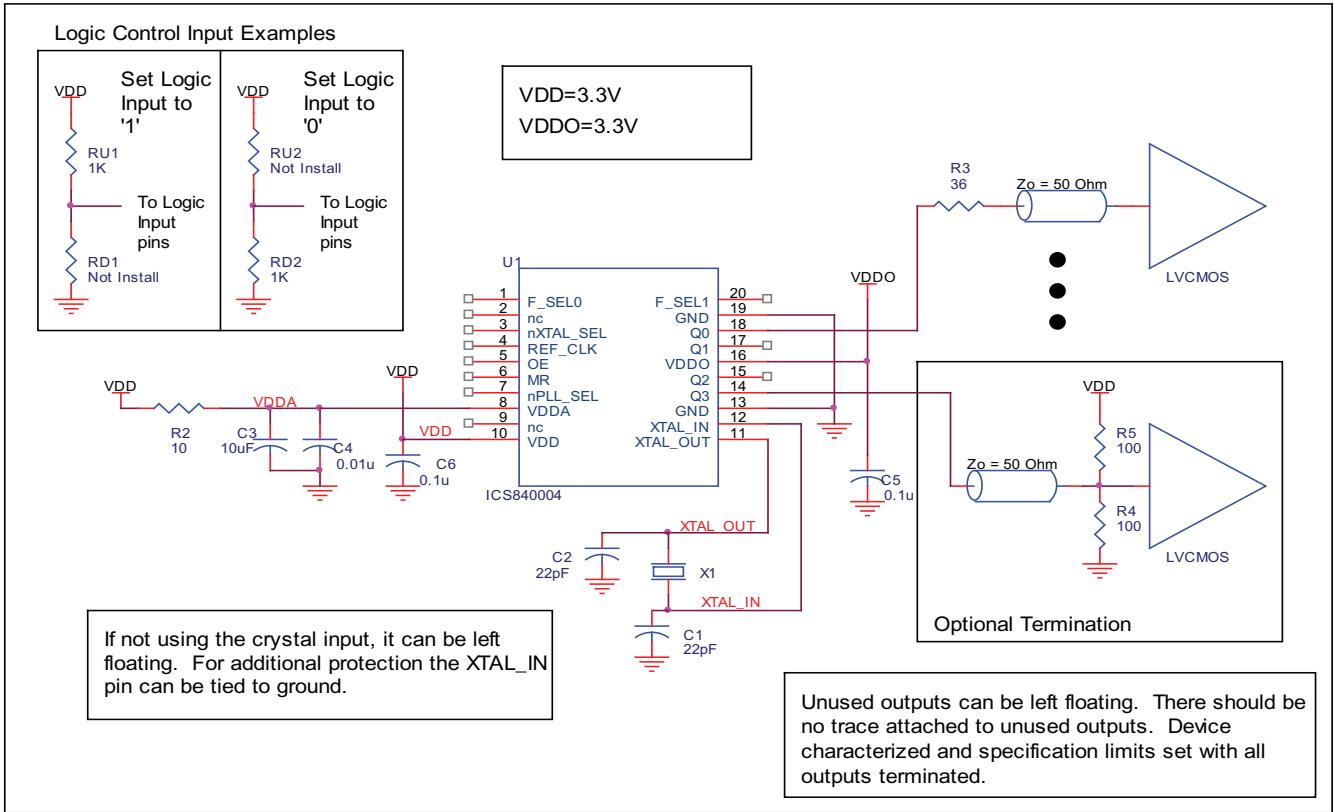
**LVC MOS OUTPUT:**

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

**LAYOUT GUIDELINE**

Figure 4 shows a schematic example of the 840004. An example of LVCMOS termination is shown in this schematic. Additional LVCMOS termination approaches are shown in the LVCMOS Termination Application Note. In this example, an 18pF parallel resonant 26.5625MHz crystal is used. The C1=22pF and C2=22pF

are recommended for frequency accuracy. For different board layout, the C1 and C2 may be slightly adjusted for optimizing frequency accuracy. 1kΩ pullup or pulldown resistors can be used for the logic control input pins.



**FIGURE 4. 840004 SCHEMATIC EXAMPLE**

## RELIABILITY INFORMATION

TABLE 6.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 20 LEAD TSSOP

	$\theta_{JA}$ by Velocity (Linear Feet per Minute)		
	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	114.5°C/W	98.0°C/W	88.0°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	73.2°C/W	66.6°C/W	63.5°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 840004 is: 3796

PACKAGE OUTLINE - G SUFFIX FOR 20 LEAD TSSOP

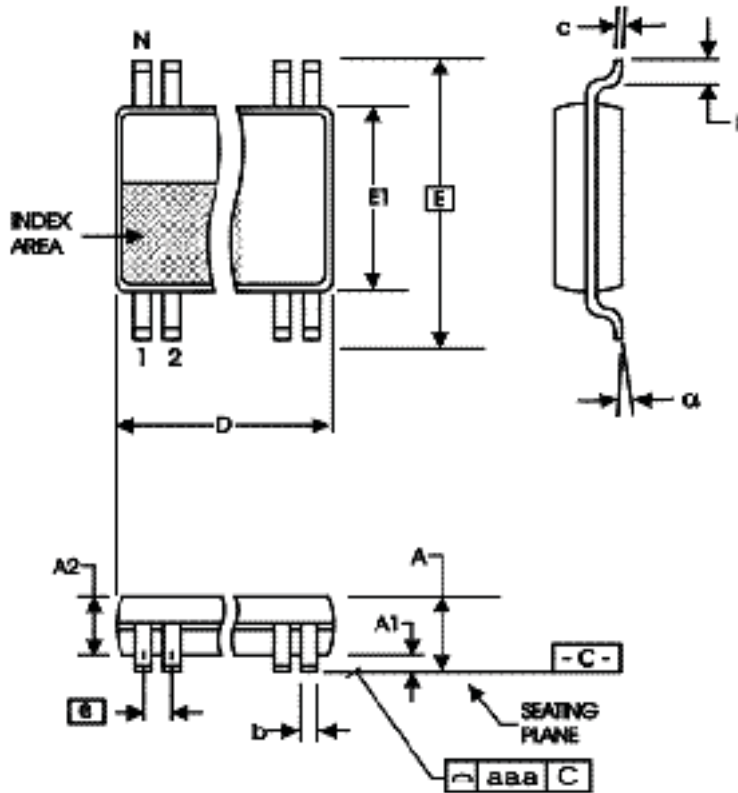


TABLE 7. PACKAGE DIMENSIONS

SYMBOL	Millimeters	
	MIN	MAX
N	20	
A	--	1.20
A1	0.05	0.15
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	6.40	6.60
E	6.40 BASIC	
E1	4.30	4.50
e	0.65 BASIC	
L	0.45	0.75
α	0°	8°
aaa	--	0.10

Reference Document: JEDEC Publication 95, MO-153

**TABLE 8. ORDERING INFORMATION**

<b>Part/Order Number</b>	<b>Marking</b>	<b>Package</b>	<b>Shipping Packaging</b>	<b>Temperature</b>
ICS840004AGLF	ICS840004AGL	20 Lead "Lead-Free" TSSOP	tube	0°C to 70°C
ICS840004AGLFT	ICS840004AGL	20 Lead "Lead-Free" TSSOP	tape & reel	0°C to 70°C

NOTE: Parts that are ordered with an "LF" suffix to the part number are the Pb-Free configuration and are RoHS compliant.

**REVISION HISTORY SHEET**

<b>Rev</b>	<b>Table</b>	<b>Page</b>	<b>Description of Change</b>	<b>Date</b>
B	T4	3	Crystal Table - added Frequency min/max values.	8/16/06
B	T8	13	Ordering Information - removed leaded devices. Updated data sheet format.	4/2/15



## IMPORTANT NOTICE AND DISCLAIMER

RENESAS ELECTRONICS CORPORATION AND ITS SUBSIDIARIES (“RENESAS”) PROVIDES TECHNICAL SPECIFICATIONS AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT OF THIRD-PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for developers who are designing with Renesas products. You are solely responsible for (1) selecting the appropriate products for your application, (2) designing, validating, and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. Renesas grants you permission to use these resources only to develop an application that uses Renesas products. Other reproduction or use of these resources is strictly prohibited. No license is granted to any other Renesas intellectual property or to any third-party intellectual property. Renesas disclaims responsibility for, and you will fully indemnify Renesas and its representatives against, any claims, damages, costs, losses, or liabilities arising from your use of these resources. Renesas' products are provided only subject to Renesas' Terms and Conditions of Sale or other applicable terms agreed to in writing. No use of any Renesas resources expands or otherwise alters any applicable warranties or warranty disclaimers for these products.

(Disclaimer Rev.1.01 Jan 2024)

### Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,  
Koto-ku, Tokyo 135-0061, Japan  
[www.renesas.com](http://www.renesas.com)

### Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

### Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit [www.renesas.com/contact-us/](http://www.renesas.com/contact-us/).