

LMK00338 8 输出差动时钟缓冲器/电平转换器

1 特性

- 3: 1 输入多路复用器
 - 两个通用输入工作频率高达 400 MHz，并且接受低电压正射极耦合逻辑 (LVPECL)，低压差分信令 (LVDS)，电流模式逻辑 (CML)，短截线串联端接逻辑 (SSTL)，高速收发器逻辑 (HSTL)，主机时钟信号电平 (HCSL) 或单端时钟
 - 一个晶振输入可接受 10MHz 至 40MHz 的晶振或单端时钟
- 两组差分输出，每组 4 个
 - HCSL 或高阻抗 (Hi-Z) (每组可选)
 - 100MHz 时 PCIe Gen3 的附加相位抖动 (RMS):
 - 30fs RMS (典型值)
- 156.25MHz 时为 -72 dBc
- 具有同步使能驱动的 LVCMOS 输出
- 由引脚控制的配置
- V_{CC} 内核电源: 3.3V ± 5%
- 3 个独立的 V_{CCO} 输出电源: 3.3V/2.5V ± 5%
- 工业温度范围: -40°C 至 +85°C
- 40 接线超薄型四方扁平无引线 (WQFN) 封装 (6mm x 6mm)

2 应用

- 针对模数转换器 (ADC)，数模转换器 (DAC)，多千兆以太网，XAUI，光纤通道，SATA/SAS，SONET/SDH，通用公共无线接口 (CPRI)，高频背板的时钟分配和电平转换
- 交换机、路由器、线路接口卡、定时卡
- 服务器，计算，快速 PCI (PCIe 3.0)
- 射频拉远单元和基站单元

3 说明

LMK00338 是一款 8 路输出 PCIe Gen1/Gen2/Gen3 扇出缓冲器，用于高频、低抖动时钟/数据分配和电平转换。可从两个通用输入或一个晶振输入中选择输入时钟。所选择的输入时钟被分配到两组 HCSL 输出 (每组 4 个) 和 1 个 LVCMOS 输出。LVCMOS 输出具有同步使能输入，在使能或禁用后可实现无短脉冲运行。LMK00338 由一个 3.3V 内核电源和 3 个独立的 3.3V/2.5V 输出电源供电运行。

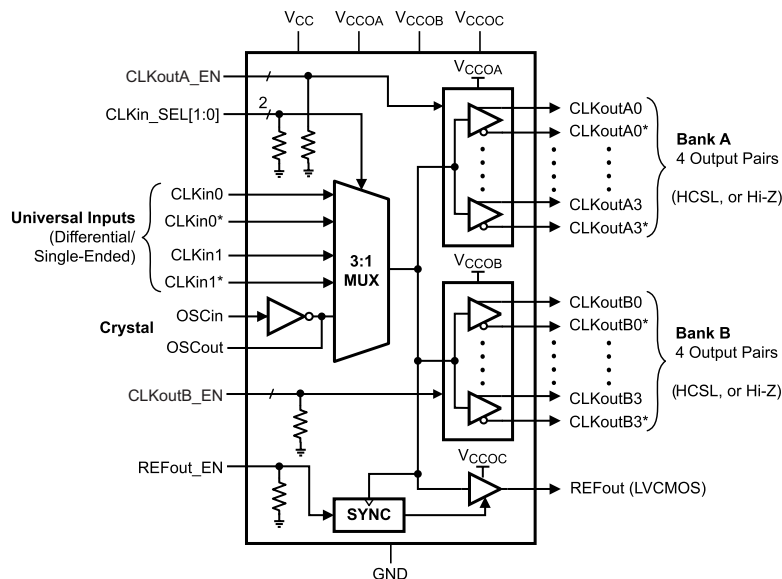
LMK00338 具有高性能、多用途和电源效率特性，这使得它成为替代固定输出缓冲器器件的理想选择，同时还能够增加系统中的时序余裕。

器件信息⁽¹⁾

部件号	封装	封装尺寸 (标称值)
LMK00338	WQFN (40)	6.00mm x 6.00mm

(1) 如需了解所有可用封装，请见数据表末尾的可订购产品附录。

LMK00338 功能方框图



目录

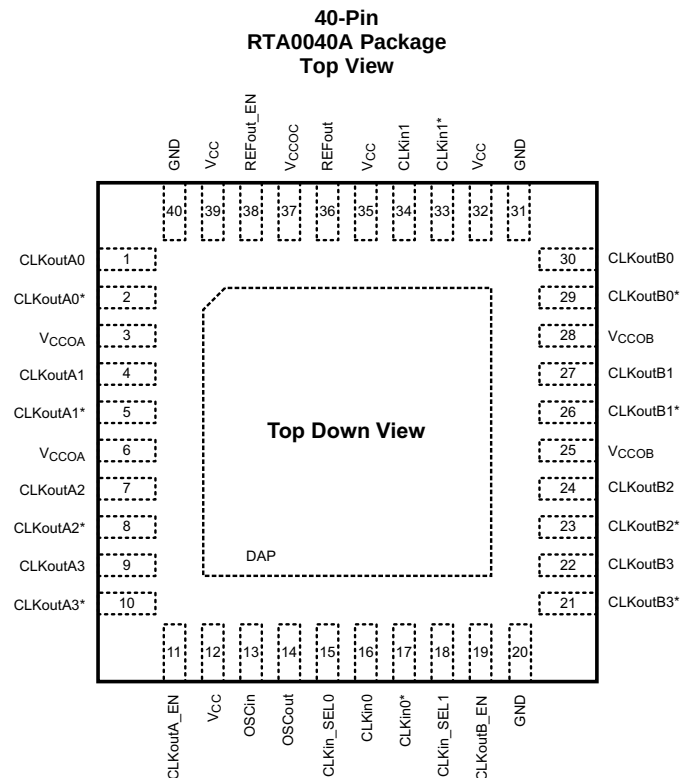
1	特性	1	8.4	Device Functional Modes.....	14
2	应用	1	9	Application and Implementation	15
3	说明	1	9.1	Application Information.....	15
4	修订历史记录	2	9.2	Typical Applications	15
5	Pin Configuration and Functions	3	10	Power Supply Recommendations	20
6	Specifications	5	10.1	Current Consumption and Power Dissipation Calculations.....	20
6.1	Absolute Maximum Ratings	5	10.2	Power Supply Bypassing	21
6.2	Handling Ratings.....	5	11	Layout	23
6.3	Recommended Operating Conditions.....	5	11.1	Layout Guidelines	23
6.4	Thermal Information	5	11.2	Layout Example	23
6.5	Electrical Characteristics.....	6	11.3	Thermal Management.....	24
6.6	Typical Characteristics.....	9	12	器件和文档支持	25
7	Parameter Measurement Information	11	12.1	文档支持.....	25
7.1	Differential Voltage Measurement Terminology.....	11	12.2	商标.....	25
8	Detailed Description	12	12.3	静电放电警告.....	25
8.1	Overview	12	12.4	术语表	25
8.2	Functional Block Diagram	12	13	机械封装和可订购信息	25
8.3	Feature Description.....	12			

4 修订历史记录

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (December 2013) to Revision A	Page
• 已添加、更新或重命名以下部分：器件信息表，应用和实施；电源相关建议；布局；器件和文档支持；机械、封装和订购信息	1
• Changed 1 MHz to 12 kHz	7
• Added Figure 24	23

5 Pin Configuration and Functions



Pin Functions⁽¹⁾

PIN		TYPE	DESCRIPTION
NUMBER	NAME		
DAP	DAP	GND	Die Attach Pad. Connect to the PCB ground plane for heat dissipation.
1, 2	CLKoutA0, CLKoutA0*	O	Differential clock output A0.
3, 6	V _{CCOA}	PWR	Power supply for Bank A Output buffers. V _{CCOA} can operate from 3.3 V or 2.5 V. The V _{CCOA} pins are internally tied together. Bypass with a 0.1 uF low-ESR capacitor placed very close to each Vcco pin. ⁽²⁾
4, 5	CLKoutA1, CLKoutA1*	O	Differential clock output A1.
7, 8	CLKoutA2, CLKoutA2*	O	Differential clock output A2.
9, 10	CLKoutA3, CLKoutA3*	O	Differential clock output A3.
11	CLKoutA_EN	I	Bank A low active output buffer enable ⁽³⁾
12, 32, 35, 39	V _{cc}	PWR	Power supply for Core and Input buffer blocks. The V _{cc} supply operates from 3.3 V. Bypass with a 0.1 uF low-ESR capacitor placed very close to each Vcc pin.
13	OSCin	I	Input for crystal. Can also be driven by a XO, TCXO, or other external single-ended clock.
14	OSCout	O	Output for crystal. Leave OSCout floating if OSCin is driven by a single-ended clock.
15, 18	CLKin_SEL0, CLKin_SEL1	I	Clock input selection pins ⁽³⁾
16, 17	CLKin0, CLKin0*	I	Universal clock input 0 (differential/single-ended)
19	CLKoutB_EN	I	Bank B low active output buffer enable ⁽³⁾

- (1) Any unused output pins should be left floating with minimum copper length (see note in [Clock Outputs](#)), or properly terminated if connected to a transmission line, or disabled/Hi-Z if possible. See [Clock Outputs](#) for output configuration or [Termination and Use of Clock Drivers](#) output interface and termination techniques.
- (2) The output supply voltages/pins (V_{CCOA}, V_{CCOB}, and V_{CCOC}) will be referred to generally as V_{CCO} when no distinction is needed, or when the output supply can be inferred by the output bank/type.
- (3) CMOS control input with internal pull-down resistor.

Pin Functions⁽¹⁾ (continued)

PIN		TYPE	DESCRIPTION
NUMBER	NAME		
20, 31, 40	GND	GND	Ground
21, 22	CLKoutB3*, CLKoutB3	O	Differential clock output B3.
23, 24	CLKoutB2*, CLKoutB2	O	Differential clock output B2.
25, 28	V _{CCOB}	PWR	Power supply for Bank B Output buffers. V _{CCOB} can operate from 3.3 V or 2.5 V. The V _{CCOB} pins are internally tied together. Bypass with a 0.1 uF low-ESR capacitor placed very close to each Vcco pin. ⁽²⁾
26, 27	CLKoutB1*, CLKoutB1	O	Differential clock output B1.
29, 30	CLKoutB0*, CLKoutB0	O	Differential clock output B0.
33, 34	CLKin1*, CLKin1	I	Universal clock input 1 (differential/single-ended)
36	REFout	O	LVC MOS reference output. Enable output by pulling REFout_EN pin high.
37	V _{CCOC}	PWR	Power supply for REFout Output buffer. V _{CCOC} can operate from 3.3 V or 2.5 V. Bypass with a 0.1 uF low-ESR capacitor placed very close to each Vcco pin. ⁽²⁾
38	REFout_EN	I	REFout enable input. Enable signal is internally synchronized to selected clock input. ⁽³⁾

6 Specifications

6.1 Absolute Maximum Ratings⁽¹⁾⁽²⁾

over operating free-air temperature range (unless otherwise noted) ⁽³⁾

		MIN	MAX	UNIT
V _{CC} , V _{CCO}	Supply Voltages	-0.3	3.6	V
V _{IN}	Input Voltage	-0.3	(V _{CC} + 0.3)	V
T _{STG}	Storage Temperature Range			°C
T _L	Lead Temperature (solder 4 s)		+260	°C
T _J	Junction Temperature		+150	°C

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see [Electrical Characteristics](#). The ensured specifications apply only to the test conditions listed.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
- (3) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 Handling Ratings

			MIN	MAX	UNIT
T _{stg}	Storage temperature range		-65	+150	°C
V _(ESD)	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins ⁽¹⁾		2000	V
		Machine model (MM)		150	
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins ⁽²⁾		750	

- (1) JEDEC document JEP155 states that 2000-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 750-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

		MIN	TYP	MAX	UNIT
T _A	Ambient Temperature Range	-40	25	85	°C
T _J	Junction Temperature			125	°C
V _{CC}	Core Supply Voltage Range	3.15	3.3	3.45	V
V _{CCO}	Output Supply Voltage Range ^{(1) (2)}	3.3 – 5% 2.5 – 5%	3.3 2.5	3.3 + 5% 2.5 + 5%	V

- (1) The output supply voltages/pins (V_{CCOA}, V_{CCOB}, and V_{CCOC}) will be referred to generally as V_{CCO} when no distinction is needed, or when the output supply can be inferred by the output bank/type.
- (2) V_{CCO} should be less than or equal to V_{CC} (V_{CCO} ≤ V_{CC}).

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		LMK00338	UNIT
		RTA0040A	
		40 PINS ⁽²⁾	
R _{θJA}	Junction-to-ambient thermal resistance	31.4	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	7.2 (DAP)	

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).
- (2) Specification assumes 9 thermal vias connect the die attach pad (DAP) to the embedded copper plane on the 4-layer JEDEC board. These vias play a key role in improving the thermal performance of the package. It is recommended that the maximum number of vias be used in the board layout.

6.5 Electrical Characteristics

Unless otherwise specified: $V_{CC} = 3.3 \text{ V} \pm 5\%$, $V_{CCO} = 3.3 \text{ V} \pm 5\%$, $2.5 \text{ V} \pm 5\%$, $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$, CLKin driven differentially, input slew rate $\geq 3 \text{ V/ns}$. Typical values represent most likely parametric norms at $V_{CC} = 3.3 \text{ V}$, $V_{CCO} = 3.3 \text{ V}$, $T_A = 25^\circ\text{C}$, and at the Recommended Operation Conditions at the time of product characterization and are not ensured. ⁽¹⁾⁽²⁾

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
CURRENT CONSUMPTION ⁽³⁾							
ICC_CORE	Core Supply Current, All Outputs Disabled	CLKinX selected		8.5	10.5		mA
		OSCin selected		10	13.5		mA
ICC_HCSL				31	38.5		mA
ICC_CMOS				3.5	5.5		mA
ICCO_HCSL	Additive Output Supply Current, HCSL Banks Enabled	Includes Output Bank Bias and Load Currents for both banks, RT = 50 Ω on all outputs in bank		68	84		mA
ICCO_CMOS	Additive Output Supply Current, LVCMOS Output Enabled	200 MHz, CL = 5 pF	Vcco = 3.3 V ±5%	9	10		mA
			Vcco = 2.5V ± 5%	7	8		mA
POWER SUPPLY RIPPLE REJECTION (PSRR)							
PSRRHCSL	Ripple-Induced Phase Spur Level ⁽⁴⁾ Differential HCSL Output		156.25 MHz	-72			dBc
			312.5 MHz	-63			
CMOS CONTROL INPUTS (CLKin_SELn, CLKout_TYPEn, REFout_EN)							
VIH	High-Level Input Voltage			1.6		Vcc	V
VIL	Low-Level Input Voltage			GND		0.4	V
IIH	High-Level Input Current	VIH = Vcc, Internal pull-down resistor				50	µA
IIL	Low-Level Input Current	VIL = 0 V, Internal pull-down resistor		-5	0.1		µA
CLOCK INPUTS (CLKin0/CLKin0*, CLKin1/CLKin1*)							
fCLKin	Input Frequency Range ⁽⁵⁾	Functional up to 400 MHz Output frequency range and timing specified per output type (refer to HCSL, LVCMOS output specifications)		DC		400	MHz
VIHD	Differential Input High Voltage					Vcc	V
VILD	Differential Input Low Voltage	CLKin driven differentially		GND			V
VID	Differential Input Voltage Swing ⁽⁶⁾			0.15		1.3	V
VCMD	Differential Input CMD Common Mode Voltage	VID = 150 mV		0.25		Vcc - 1.2	V
		VID = 350 mV		0.25		Vcc - 1.1	
		VID = 800 mV		0.25		Vcc - 0.9	
VIH	Single-Ended Input IH High Voltage					VCC	V
VIL	Single-Ended Input IL Low Voltage			GND			V
VI_SE	Single-Ended Input Voltage Swing ⁽⁷⁾	CLKinX driven single-ended (AC or DC coupled), CLKinX* AC coupled to GND or externally biased within VCM range		0.3		2	Vpp
VCM	Single-Ended Input CM Common Mode Voltage			0.25		VCC - 1.2	V

- (1) The output supply voltages/pins (V_{CCOA}, V_{CCOB}, and V_{CCOC}) will be referred to generally as V_{CCO} when no distinction is needed, or when the output supply can be inferred by the output bank/type.
- (2) The Electrical Characteristics tables list ensured specifications under the listed Recommended Operating Conditions except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not ensured.
- (3) See [Power Supply Recommendations](#) for more information on current consumption and power dissipation calculations.
- (4) Power supply ripple rejection, or PSRR, is defined as the single-sideband phase spur level (in dBc) modulated onto the clock output when a single-tone sinusoidal signal (ripple) is injected onto the V_{CCO} supply. Assuming no amplitude modulation effects and small index modulation, the peak-to-peak deterministic jitter (DJ) can be calculated using the measured single-sideband phase spur level (PSRR) as follows: $DJ (\text{ps pk-pk}) = [(2 * 10^{(PSRR / 20)}) / (\pi * f_{CLK})] * 1E12$
- (5) Specification is ensured by characterization and is not tested in production.
- (6) See [Differential Voltage Measurement Terminology](#) for definition of V_{ID} and V_{OD} voltages.
- (7) Parameter is specified by design, not tested in production.

Electrical Characteristics (continued)

Unless otherwise specified: $V_{CC} = 3.3\text{ V} \pm 5\%$, $V_{CCO} = 3.3\text{ V} \pm 5\%$, $2.5\text{ V} \pm 5\%$, $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, CLKIn driven differentially, input slew rate $\geq 3\text{ V/ns}$. Typical values represent most likely parametric norms at $V_{CC} = 3.3\text{ V}$, $V_{CCO} = 3.3\text{ V}$, $T_A = 25\text{ }^{\circ}\text{C}$, and at the Recommended Operation Conditions at the time of product characterization and are not ensured.⁽¹⁾⁽²⁾

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
ISO _{MUX}	Mux Isolation, CLKin0 to CLKin1	f _{OFFSET} > 50 kHz, P _{CLKinX} = 0 dBm	f _{CLKin0} = 100 MHz	-84		dBc	
			f _{CLKin0} = 200 MHz	-82			
			f _{CLKin0} = 500 MHz	-71			
			f _{CLKin0} = 1000 MHz	-65			
CRYSTAL INTERFACE (OSCin, OSCout)							
F _{CLK}	External Clock Frequency Range ⁽⁵⁾	OSCin driven single-ended, OSCout floating			250		MHz
F _{XTAL}	Crystal Frequency Range	Fundamental mode crystal ESR ≤ 200 Ω (10 to 30 MHz) ESR ≤ 125 Ω (30 to 40 MHz) ⁽⁸⁾		10	40		MHz
C _{IN}	OSCin Input Capacitance			1			pF
HCSL OUTPUTS (CLKoutAn/CLKoutAn*, CLKoutBn/CLKoutBn*)							
f _{CLKout}	Output Frequency Range ⁽⁵⁾	R _L = 50 Ω to GND, C _L ≤ 5 pF		DC	400		MHz
Jitter _{ADD_PClE}	Additive RMS Phase Jitter for PCIe 3.0 ⁽⁵⁾	PCle Gen 3, PLL BW = 2–5 MHz, CDR = 10 MHz	CLKin: 100 MHz, Slew rate ≥ 0.6 V/ns	0.03	0.15		ps
Jitter _{ADD}	Additive RMS Jitter Integration Bandwidth to 20 MHz ⁽⁹⁾⁽¹⁰⁾	V _{CCO} = 3.3 V, RT = 50 Ω to GND	CLKin: 100 MHz, Slew rate ≥ 3 V/ns	77		fs	
			CLKin: 156.25 MHz, Slew rate ≥ 2.7 V/ns	86			
Noise Floor	Noise Floor f _{OFFSET} ≥ 10 MHz ⁽⁹⁾⁽¹⁰⁾	V _{CCO} = 3.3 V, RT = 50 Ω to GND	CLKin: 100 MHz, Slew rate ≥ 3 V/ns	-161.3		dBc/Hz	
			CLKin: 156.25 MHz, Slew rate ≥ 2.7 V/ns	-156.3			
DUTY	Duty Cycle ⁽⁵⁾	50% input clock duty cycle		45%	55%		
V _{OH}	Output High Voltage	T _A = 25 °C, DC Measurement, R _T = 50 Ω to GND		520	810	920	mV
V _{OL}	Output Low Voltage			-150	0.5	150	mV
V _{CROSS}	Absolute Crossing Voltage ⁽⁵⁾⁽¹¹⁾	R _L = 50 Ω to GND, C _L ≤ 5 pF		160	350	460	mV
ΔV _{CROSS}	Total Variation of V _{CROSS}			140		mV	
t _R	Output Rise Time 20% to 80% ⁽¹¹⁾⁽⁷⁾	250 MHz, Uniform transmission line up to 10 in. with 50-Ω characteristic impedance, RL = 50 Ω to GND, C _L ≤ 5 pF		300	500		ps
t _F	Output Fall Time 80% to 20% ⁽¹¹⁾⁽⁷⁾			300	500	ps	

- (8) The ESR requirements stated must be met to ensure that the oscillator circuitry has no startup issues. However, lower ESR values for the crystal may be necessary to stay below the maximum power dissipation (drive level) specification of the crystal. Refer to [Crystal Interface](#) for crystal drive level considerations.
- (9) The noise floor of the output buffer is measured as the far-out phase noise of the buffer. Typically this offset is $\geq 10\text{ MHz}$, but for lower frequencies this measurement offset can be as low as 5 MHz due to measurement equipment limitations.
- (10) Phase noise floor will degrade as the clock input slew rate is reduced. Compared to a single-ended clock, a differential clock input (LVPECL, LVDS) will be less susceptible to degradation in noise floor at lower slew rates due to its common mode noise rejection. However, it is recommended to use the highest possible input slew rate for differential clocks to achieve optimal noise floor performance at the device outputs.
- (11) AC timing parameters for HCSL or CMOS are dependent on output capacitive loading.

Electrical Characteristics (continued)

Unless otherwise specified: $V_{CC} = 3.3 \text{ V} \pm 5\%$, $V_{CCO} = 3.3 \text{ V} \pm 5\%$, $2.5 \text{ V} \pm 5\%$, $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$, CLKin driven differentially, input slew rate $\geq 3 \text{ V/ns}$. Typical values represent most likely parametric norms at $V_{CC} = 3.3 \text{ V}$, $V_{CCO} = 3.3 \text{ V}$, $T_A = 25^\circ\text{C}$, and at the Recommended Operation Conditions at the time of product characterization and are not ensured.⁽¹⁾⁽²⁾

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
LVCMOS OUTPUT (REFout)							
f _{CLKout}	Output Frequency Range ⁽⁵⁾	CL ≤ 5 pF		DC	250		MHz
Jitter _{ADD}	Additive RMS Jitter Integration Bandwidth 1 MHz to 20 MHz ⁽¹²⁾	V _{CCO} = 3.3 V, CL ≤ 5 pF	100 MHz, Input Slew rate ≥ 3 V/ns	95			fs
Noise Floor	Noise Floor f _{OFFSET} ≥ 10 MHz ⁽⁹⁾⁽¹⁰⁾	V _{CCO} = 3.3 V, CL ≤ 5 pF	100 MHz, Input Slew rate ≥ 3 V/ns	-159.3			dBc/Hz
DUTY	Duty Cycle ⁽⁵⁾	50% input clock duty cycle		45%	55%		
V _{OH}	Output High Voltage	1 mA load		V _{CCO} - 0.1			V
V _{OL}	Output Low Voltage			0.1			V
I _{OH}	Output High Current (Source)	Vo = V _{CCO} / 2	V _{CCO} = 3.3 V	28		mA	
			V _{CCO} = 2.5 V	20			
			V _{CCO} = 3.3 V	28		mA	
I _{OL}	Output Low Current (Sink)		V _{CCO} = 2.5 V	20			
t _R	Output Rise Time 20% to 80% ⁽¹¹⁾⁽⁷⁾	250 MHz, Uniform transmission line up to 10 in. with 50-Ω characteristic impedance, RL = 50 Ω to GND, CL ≤ 5 pF		225	400		ps
t _F	Output Fall Time 80% to 20% ⁽¹¹⁾⁽⁷⁾			225	400		ps
t _{EN}	Output Enable Time ⁽¹³⁾	CL ≤ 5 pF		3			cycles
t _{DIS}	Output Disable Time ⁽¹³⁾			3			cycles
PROPAGATION DELAY and OUTPUT SKEW							
t _{PD_HCSL}	Propagation Delay CLKin-to-HCSL ⁽¹¹⁾⁽⁷⁾	RT = 50 Ω to GND, CL ≤ 5 pF		295	590	885	ps
t _{PD_CMOS}	Propagation Delay CLKin-to-LVCMOS ⁽¹¹⁾⁽⁷⁾	CL ≤ 5 pF	V _{CCO} = 3.3 V	900	1475	2300	ps
			V _{CCO} = 2.5 V	1000	1550	2700	
t _{SK(O)}	Output Skew ⁽⁵⁾⁽¹¹⁾⁽¹⁴⁾	Skew specified between any two CLKouts. Load conditions are the same as propagation delay specifications.		30	50		ps
t _{SK(PP)}	Part-to-Part Output Skew LVPECL/LVDS/HCSL ⁽¹¹⁾⁽⁷⁾⁽¹⁴⁾			80	120		ps

(12) For the 100 MHz and 156.25 MHz clock input conditions, Additive RMS Jitter (J_{ADD}) is calculated using Method #1: $J_{ADD} = \sqrt{J_{OUT}^2 - J_{SOURCE}^2}$, where J_{OUT} is the total RMS jitter measured at the output driver and J_{SOURCE} is the RMS jitter of the clock source applied to CLKin. For the 625 MHz clock input condition, Additive RMS Jitter is approximated using Method #2: $J_{ADD} = \sqrt{2 \cdot 10^{dBc/10} / (2 \cdot \pi \cdot f_{CLK})}$, where dBc is the phase noise power of the Output Noise Floor integrated from 1 to 20 MHz bandwidth. The phase noise power can be calculated as: dBc = Noise Floor + $10 \cdot \log_{10}(20 \text{ MHz} - 1 \text{ MHz})$. The additive RMS jitter was approximated for 625 MHz using Method #2 because the RMS jitter of the clock source was not sufficiently low enough to allow practical use of Method #1. Refer to the "Noise Floor vs. CLKin Slew Rate" and "RMS Jitter vs. CLKin Slew Rate" plots in [Typical Characteristics](#).

(13) Output Enable Time is the number of input clock cycles it takes for the output to be enabled after REFout_EN is pulled high. Similarly, Output Disable Time is the number of input clock cycles it takes for the output to be disabled after REFout_EN is pulled low. The REFout_EN signal should have an edge transition much faster than that of the input clock period for accurate measurement.

(14) Output skew is the propagation delay difference between any two outputs with identical output buffer type and equal loading while operating at the same supply voltage and temperature conditions.

6.6 Typical Characteristics

Unless otherwise specified: $V_{CC} = 3.3\text{ V}$, $V_{CCO} = 3.3\text{ V}$, $T_A = 25\text{ }^{\circ}\text{C}$, CLKIn driven differentially, input slew rate $\geq 3\text{ V/ns}$.

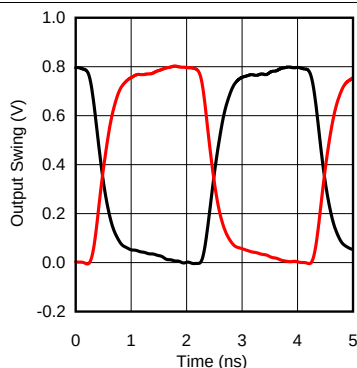


Figure 1. HCSL Output Swing @ 250 MHz

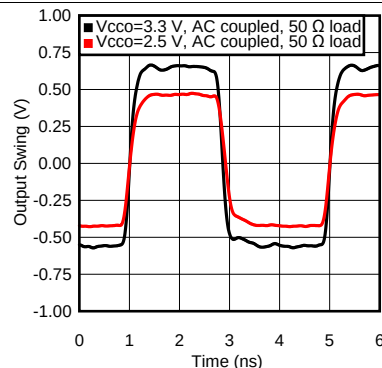


Figure 2. LVC MOS Output Swing @ 250 MHz

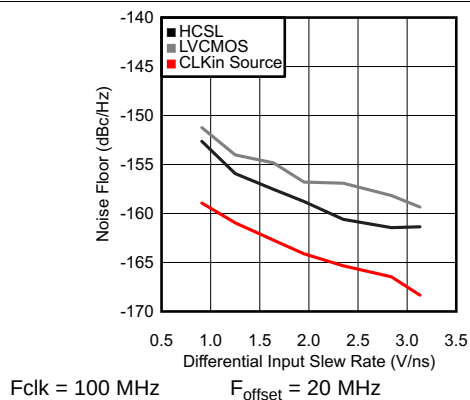


Figure 3. Noise Floor vs. CLKIn Slew Rate @ 100 MHz

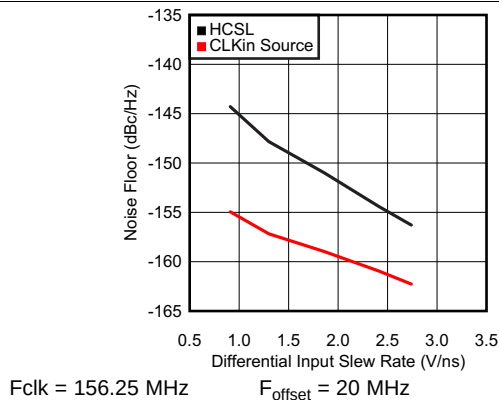


Figure 4. Noise Floor vs. CLKIn Slew Rate @ 156.25 MHz

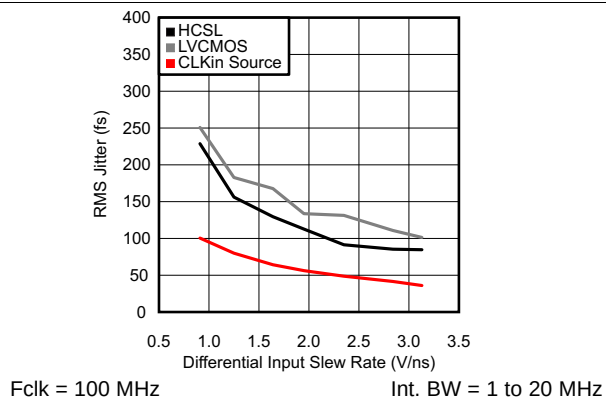


Figure 5. RMS Jitter vs. CLKIn Slew Rate @ 100 MHz

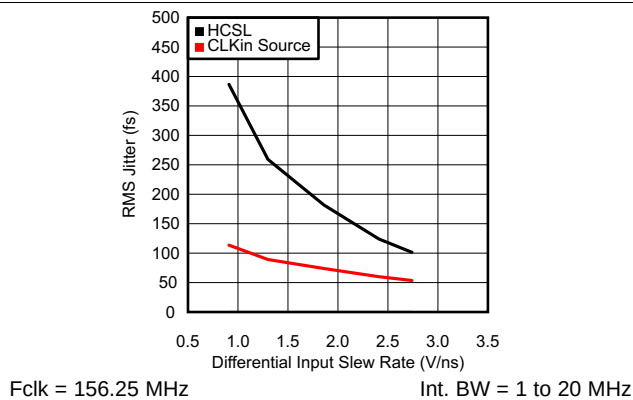
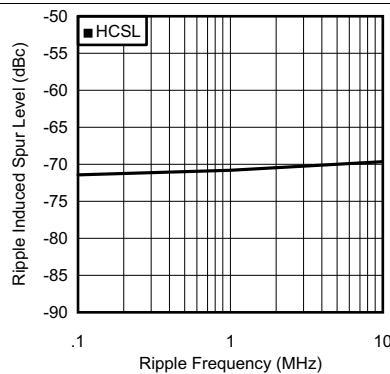


Figure 6. RMS Jitter vs. CLKIn Slew Rate @ 156.25 MHz

Typical Characteristics (continued)

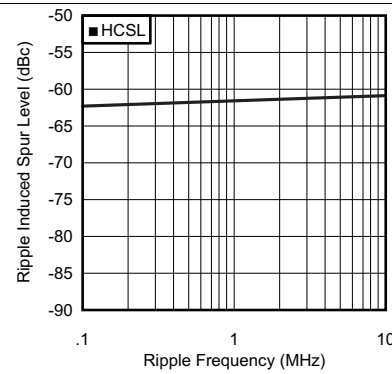
Unless otherwise specified: $V_{CC} = 3.3\text{ V}$, $V_{CCO} = 3.3\text{ V}$, $T_A = 25\text{ }^{\circ}\text{C}$, CLKin driven differentially, input slew rate $\geq 3\text{ V/ns}$.



F_{clk} = 156.25 MHz

V_{cco} Ripple = 100

Figure 7. PSRR vs. Ripple Frequency @ 156.25 MHz



F_{clk} = 312.5 MHz

V_{cco} Ripple = 100 mVpp

Figure 8. PSRR vs. Ripple Frequency @ 312.5 MHz

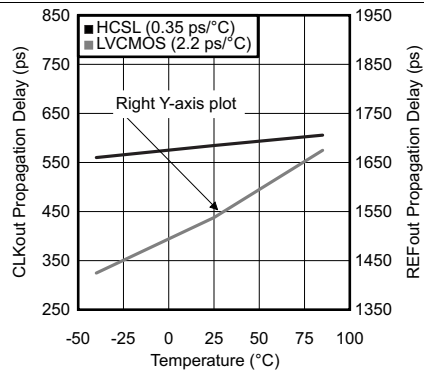


Figure 9. Propagation Delay vs. Temperature

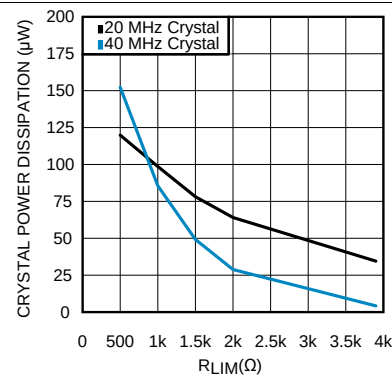


Figure 10. Crystal Power Dissipation vs. R_{LIM}

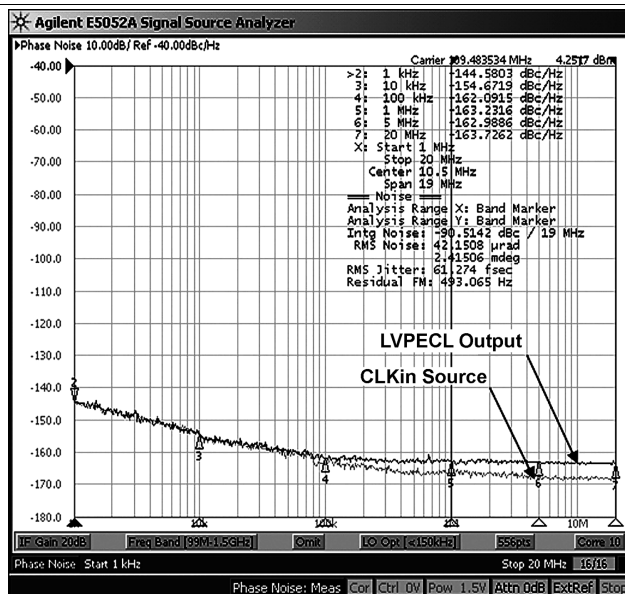


Figure 11. LVPECL Phase Noise @ 100 MHz

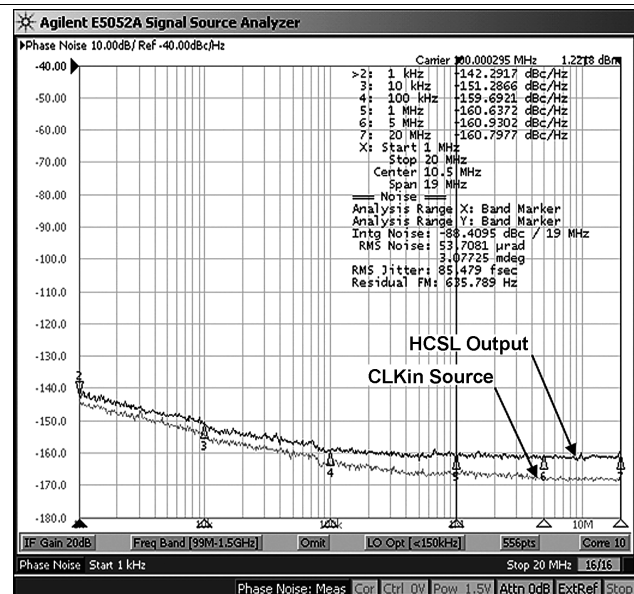


Figure 12. HCSL Phase Noise @ 100 MHz

7 Parameter Measurement Information

7.1 Differential Voltage Measurement Terminology

The differential voltage of a differential signal can be described by two different definitions causing confusion when reading datasheets or communicating with other engineers. This section will address the measurement and description of a differential signal so that the reader will be able to understand and discern between the two different definitions when used.

The first definition used to describe a differential signal is the absolute value of the voltage potential between the inverting and non-inverting signal. The symbol for this first measurement is typically V_{ID} or V_{OD} depending on if an input or output voltage is being described.

The second definition used to describe a differential signal is to measure the potential of the non-inverting signal with respect to the inverting signal. The symbol for this second measurement is V_{SS} and is a calculated parameter. Nowhere in the IC does this signal exist with respect to ground; it only exists in reference to its differential pair. V_{SS} can be measured directly by oscilloscopes with floating references, otherwise this value can be calculated as twice the value of V_{OD} as described above.

Figure 13 illustrates the two different definitions side-by-side for inputs and Figure 14 illustrates the two different definitions side-by-side for outputs. The V_{ID} (or V_{OD}) definition shows the DC levels, V_{IH} and V_{OL} (or V_{OH} and V_{OL}), that the non-inverting and inverting signals toggle between with respect to ground. V_{SS} input and output definitions show that if the inverting signal is considered the voltage potential reference, the non-inverting signal voltage potential is now increasing and decreasing above and below the non-inverting reference. Thus the peak-to-peak voltage of the differential signal can be measured.

V_{ID} and V_{OD} are often defined as volts (V) and V_{SS} is often defined as volts peak-to-peak (V_{PP}).

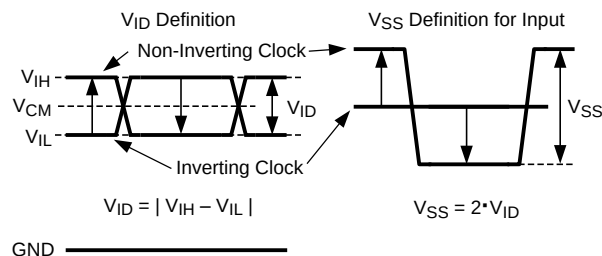


Figure 13. Two Different Definitions for Differential Input Signals

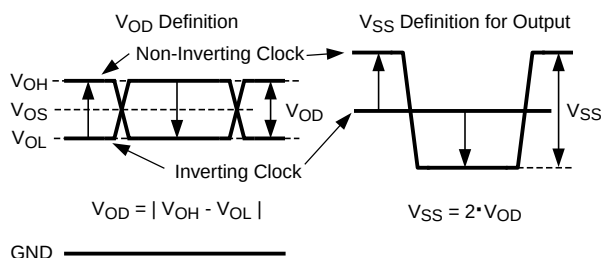


Figure 14. Two Different Definitions for Differential Output Signals

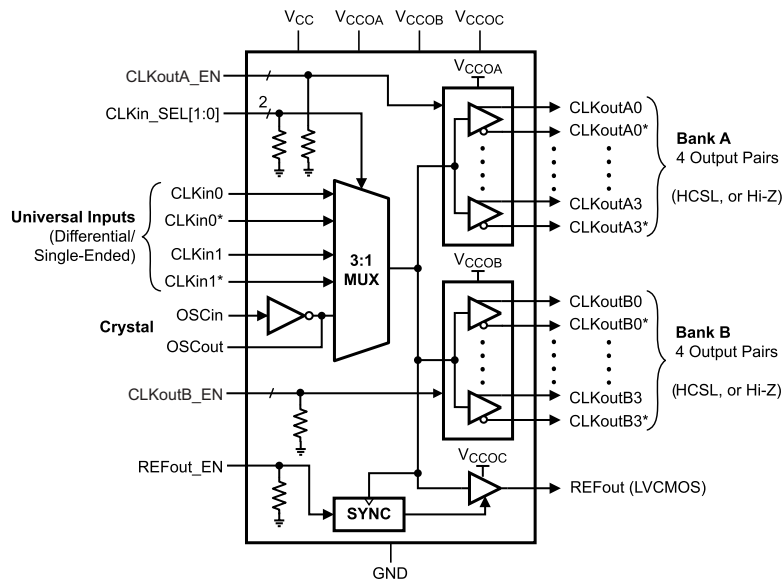
Refer to "Common Data Transmission Parameters and their Definitions", Application Note AN-912 ([SNLA036](#)), for more information.

8 Detailed Description

8.1 Overview

The LMK00338 is an 8-output PCIe Gen1/Gen2/Gen3 clock fanout buffer with low additive jitter that can operate up to 400 MHz. It features a 3:1 input multiplexer with an optional crystal oscillator input, two banks of 4 HCSL outputs, one LVCMOS output, and 3 independent output buffer supplies. The input selection and output buffer modes are controlled via pin strapping. The device is offered in a 40-pin WQFN package and leverages much of the high-speed, low-noise circuit design employed in the LMK04800 family of clock conditioners.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Crystal Power Dissipation vs. R_{LIM}

For [Figure 10](#), the following applies:

- The typical RMS jitter values in the plots show the total output RMS jitter (J_{OUT}) for each output buffer type and the source clock RMS jitter (J_{SOURCE}). From these values, the Additive RMS Jitter can be calculated as:

$$J_{ADD} = \text{SQRT}(J_{OUT}^2 - J_{SOURCE}^2)$$
- 20 MHz crystal characteristics: Abracon ABL series, AT cut, $C_L = 18$ pF, $C_0 = 4.4$ pF measured (7 pF max), ESR = 8.5 Ω measured (40 Ω max), and Drive Level = 1 mW max (100 μ W typical).
- 40 MHz crystal characteristics: Abracon ABLS2 series, AT cut, $C_L = 18$ pF, $C_0 = 5$ pF measured (7 pF max), ESR = 5 Ω measured (40 Ω max), and Drive Level = 1 mW max (100 μ W typical).

Feature Description (continued)

8.3.2 Clock Inputs

The input clock can be selected from CLKIn0/CLKIn0*, CLKIn1/CLKIn1*, or OSCIn. Clock input selection is controlled using the CLKIn_SEL[1:0] inputs as shown in [Table 1](#). Refer to [Driving the Clock Inputs](#) for clock input requirements. When CLKIn0 or CLKIn1 is selected, the crystal circuit is powered down. When OSCIn is selected, the crystal oscillator circuit will start-up and its clock will be distributed to all outputs. Refer to [Crystal Interface](#) for more information. Alternatively, OSCIn may be driven by a single-ended clock (up to 250 MHz) instead of a crystal.

Table 1. Input Selection

CLKIn_SEL1	CLKIn_SEL0	SELECTED INPUT
0	0	CLKIn0, CLKIn0*
0	1	CLKIn1, CLKIn1*
1	X	OSCIn

[Table 2](#) shows the output logic state vs. input state when either CLKIn0/CLKIn0* or CLKIn1/CLKIn1* is selected. When OSCIn is selected, the output state will be an inverted copy of the OSCIn input state.

Table 2. CLKIn Input vs. Output States

STATE of SELECTED CLKIn	STATE of ENABLED OUTPUTS
CLKInX and CLKInX* inputs floating	Logic low
CLKInX and CLKInX* inputs shorted together	Logic low
CLKIn logic low	Logic low
CLKIn logic high	Logic high

8.3.3 Clock Outputs

The HCSL output buffer for Bank A and Bank B outputs can be separately disabled to Hi-Z using the CLKoutA_EN and CLKoutB_EN inputs, respectively, as shown in [Table 3](#). For applications where all differential outputs are not needed, any unused output pin should be left floating with a minimum copper length (see note below) to minimize capacitance and potential coupling and reduce power consumption. If an entire output bank will not be used, it is recommended to disable/Hi-Z the bank to reduce power. Refer to [Termination and Use of Clock Drivers](#) for more information on output interface and termination techniques.

NOTE

For best soldering practices, the minimum trace length for any unused output pin should extend to include the pin solder mask. This way during reflow, the solder has the same copper area as connected pins. This allows for good, uniform fillet solder joints helping to keep the IC level during reflow.

Table 3. Differential Output Buffer Type Selection

CLKoutX_EN	CLKoutX BUFFER TYPE (BANK A or B)
0	HCSL
1	Disabled (Hi-Z)

8.3.3.1 Reference Output

The reference output (REFout) provides a LVCMOS copy of the selected input clock. The LVCMOS output high level is referenced to the Vcco voltage. REFout can be enabled or disabled using the enable input pin, REFout_EN, as shown in [Table 4](#).

Table 4. Reference Output Enable

REFout_EN	REFout STATE
0	Disabled (Hi-Z)
1	Enabled

The REFout_EN input is internally synchronized with the selected input clock by the SYNC block. This synchronizing function prevents glitches and runt pulses from occurring on the REFout clock when enabled or disabled. REFout will be enabled within 3 cycles (t_{EN}) of the input clock after REFout_EN is toggled high. REFout will be disabled within 3 cycles (t_{DIS}) of the input clock after REFout_EN is toggled low.

When REFout is disabled, the use of a resistive loading can be used to set the output to a predetermined level. For example, if REFout is configured with a 1 k Ω load to ground, then the output will be pulled to low when disabled.

8.4 Device Functional Modes

8.4.1 V_{CC} and V_{CCO} Power Supplies

The LMK00338 has a 3.3 V core power supply (V_{CC}) and 3 independent 3.3 V/2.5 V output power supplies (V_{CCOA}, V_{CCOB}, V_{CCOC}). Output supply operation at 2.5 V enables lower power consumption and output-level compatibility with 2.5 V receiver devices. The output levels for HCSL are relatively constant over the specified Vcco range. Refer to [Power Supply Recommendations](#) for additional supply related considerations, such as power dissipation, power supply bypassing, and power supply ripple rejection (PSRR).

NOTE

Care should be taken to ensure the Vcco voltages do not exceed the Vcc voltage to prevent turning-on the internal ESD protection circuitry.

9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

A common PCIe application, such as a server card, consists of several building blocks, which all need a reference clock. In the mostly used Common RefClk architecture, the clock is distributed from a single source to both RX and TX. This requires either a Clock generator with high output count or a buffer like the LMK00338. The buffer simplifies the clocking tree and provides a cost and space optimized solution. While using a buffer to distribute the clock, the additive jitter needs to be considered. The LMK00338 is an ultra-low additive jitter PCIe clock buffer suitable for all current and future PCIe Generations.

9.2 Typical Applications

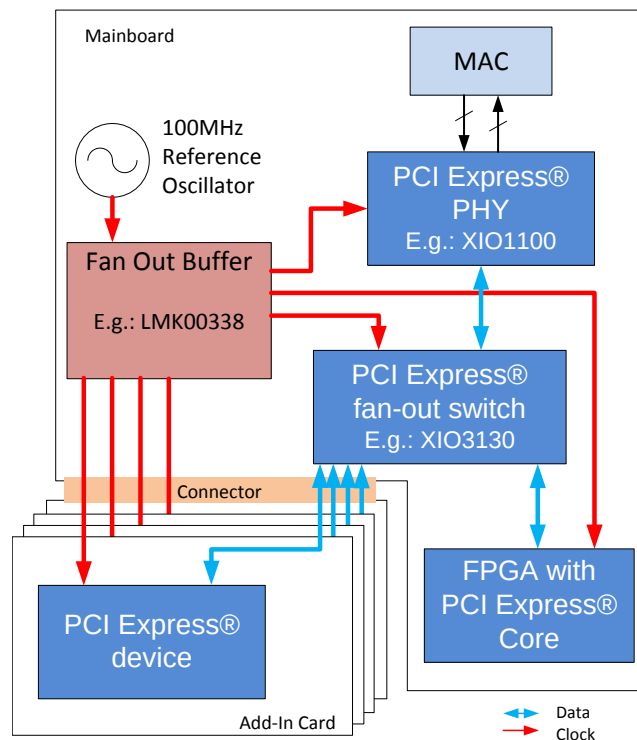


Figure 15. Example PCI Express Application Diagram

9.2.1 Design Requirements

9.2.1.1 Driving the Clock Inputs

The LMK00338 has two universal inputs (CLKin0/CLKin0* and CLKin1/CLKin1*) that can accept AC- or DC-coupled 3.3V/2.5V LVPECL, LVDS, CML, SSTL, and other differential and single-ended signals that meet the input requirements specified in the [Electrical Characteristics](#). The device can accept a wide range of signals due to its wide input common mode voltage range (V_{CM}) and input voltage swing (V_{ID}) / dynamic range. For 50% duty cycle and DC-balanced signals, AC coupling may also be employed to shift the input signal to within the V_{CM} range. Refer to [Termination and Use of Clock Drivers](#) for signal interfacing and termination techniques.

Typical Applications (continued)

To achieve the best possible phase noise and jitter performance, it is mandatory for the input to have high slew rate of 3 V/ns (differential) or higher. Driving the input with a lower slew rate will degrade the noise floor and jitter. For this reason, a differential signal input is recommended over single-ended because it typically provides higher slew rate and common-mode-rejection. Refer to the Noise Floor vs. CLKIn Slew Rate and RMS Jitter vs. CLKIn Slew Rate plots in [Typical Characteristics](#).

While it is recommended to drive the CLKIn/CLKIn* pair with a differential signal input, it is possible to drive it with a single-ended clock provided it conforms to the Single-Ended Input specifications for CLKIn pins listed in the [Electrical Characteristics](#). For large single-ended input signals, such as 3.3V or 2.5V LVCMOS, a 50-Ω load resistor should be placed near the input for signal attenuation to prevent input overdrive as well as for line termination to minimize reflections. Again, the single-ended input slew rate should be as high as possible to minimize performance degradation. The CLKIn input has an internal bias voltage of about 1.4 V, so the input can be AC coupled as shown in [Figure 16](#). The output impedance of the LVCMOS driver plus R_S should be close to 50 Ω to match the characteristic impedance of the transmission line and load termination.

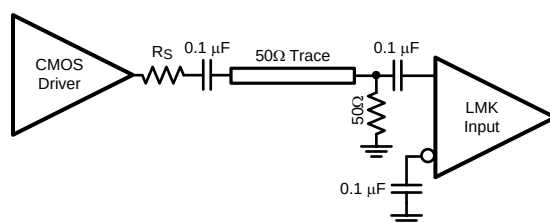


Figure 16. Single-Ended LVCMOS Input, AC Coupling

A single-ended clock may also be DC coupled to CLKInX as shown in [Figure 17](#). A 50-Ω load resistor should be placed near the CLKInX input for signal attenuation and line termination. Because half of the single-ended swing of the driver ($V_{O,PP} / 2$) drives CLKInX, CLKInX* should be externally biased to the midpoint voltage of the attenuated input swing ($(V_{O,PP} / 2) \times 0.5$). The external bias voltage should be within the specified input common voltage (V_{CM}) range. This can be achieved using external biasing resistors in the kΩ range (R_{B1} and R_{B2}) or another low-noise voltage reference. This will ensure the input swing crosses the threshold voltage at a point where the input slew rate is the highest.

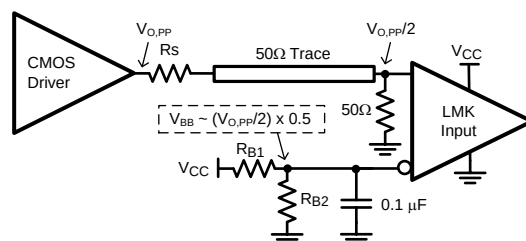


Figure 17. Single-Ended LVCMOS Input, DC Coupling with Common Mode Biasing

Typical Applications (continued)

If the crystal oscillator circuit is not used, it is possible to drive the OSCin input with an single-ended external clock as shown in Figure 18. The input clock should be AC coupled to the OSCin pin, which has an internally-generated input bias voltage, and the OSCout pin should be left floating. While OSCin provides an alternative input to multiplex an external clock, it is recommended to use either differential input (CLKinX) since it offers higher operating frequency, better common mode and power supply noise rejection, and greater performance over supply voltage and temperature variations.

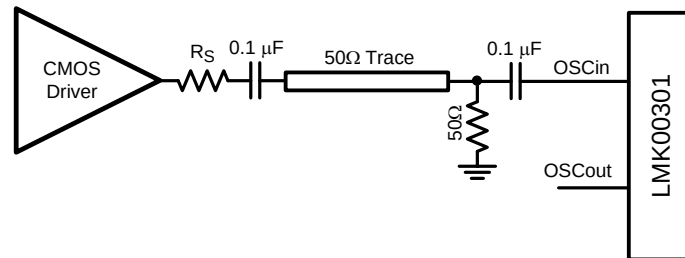


Figure 18. Driving OSCin with a Single-Ended Input

9.2.1.2 Crystal Interface

The LMK00338 has an integrated crystal oscillator circuit that supports a fundamental mode, AT-cut crystal. The crystal interface is shown in Figure 19.

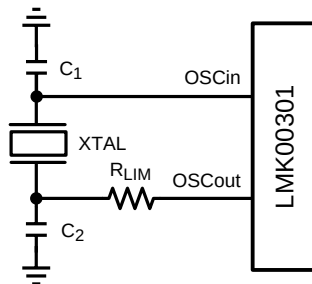


Figure 19. Crystal Interface

The load capacitance (C_L) is specific to the crystal, but usually on the order of 18 - 20 pF. While C_L is specified for the crystal, the OSCin input capacitance ($C_{IN} = 1$ pF typical) of the device and PCB stray capacitance ($C_{STRAY} \sim 1\text{--}3$ pF) can affect the discrete load capacitor values, C_1 and C_2 .

For the parallel resonant circuit, the discrete capacitor values can be calculated as follows:

$$C_L = (C_1 * C_2) / (C_1 + C_2) + C_{IN} + C_{STRAY} \quad (1)$$

Typically, $C_1 = C_2$ for optimum symmetry, so Equation 1 can be rewritten in terms of C_1 only:

$$C_L = C_1^2 / (2 * C_1) + C_{IN} + C_{STRAY} \quad (2)$$

Finally, solve for C_1 :

$$C_1 = (C_L - C_{IN} - C_{STRAY}) * 2 \quad (3)$$

Typical Applications (continued)

[Electrical Characteristics](#) provides crystal interface specifications with conditions that ensure start-up of the crystal, but it does not specify crystal power dissipation. The designer will need to ensure the crystal power dissipation does not exceed the maximum drive level specified by the crystal manufacturer. Overdriving the crystal can cause premature aging, frequency shift, and eventual failure. Drive level should be held at a sufficient level necessary to start-up and maintain steady-state operation.

The power dissipated in the crystal, P_{XTAL} , can be computed by:

$$P_{XTAL} = I_{RMS}^2 * R_{ESR} * (1 + C_0/C_L)^2$$

where

- I_{RMS} is the RMS current through the crystal.
 - R_{ESR} is the max. equivalent series resistance specified for the crystal
 - C_L is the load capacitance specified for the crystal
 - C_0 is the min. shunt capacitance specified for the crystal
- (4)

I_{RMS} can be measured using a current probe (for example, Tektronix CT-6 or equivalent) placed on the leg of the crystal connected to OSCout with the oscillation circuit active.

As shown in [Figure 19](#), an external resistor, R_{LIM} , can be used to limit the crystal drive level, if necessary. If the power dissipated in the selected crystal is higher than the drive level specified for the crystal with R_{LIM} shorted, then a larger resistor value is mandatory to avoid overdriving the crystal. However, if the power dissipated in the crystal is less than the drive level with R_{LIM} shorted, then a zero value for R_{LIM} can be used. As a starting point, a suggested value for R_{LIM} is 1.5 k Ω .

9.2.2 Detailed Design Procedure

9.2.2.1 Termination and Use of Clock Drivers

When terminating clock drivers keep in mind these guidelines for optimum phase noise and jitter performance:

- Transmission line theory should be followed for good impedance matching to prevent reflections.
- Clock drivers should be presented with the proper loads.
 - HCSL drivers are switched current outputs and require a DC path to ground via 50 Ω termination.
- Receivers should be presented with a signal biased to their specified DC bias level (common mode voltage) for proper operation. Some receivers have self-biasing inputs that automatically bias to the proper voltage level; in this case, the signal should normally be AC coupled.

9.2.2.2 Termination for DC Coupled Differential Operation

For DC coupled operation of an HCSL driver, terminate with 50 Ω to ground near the driver output as shown in [Figure 20](#). Series resistors, R_s , may be used to limit overshoot due to the fast transient current. Because HCSL drivers require a DC path to ground, AC coupling is not allowed between the output drivers and the 50 Ω termination resistors.

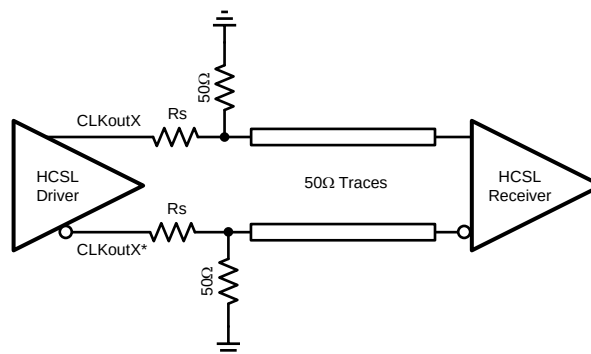


Figure 20. HCSL Operation, DC Coupling

Typical Applications (continued)

9.2.2.3 Termination for AC Coupled Differential Operation

AC coupling allows for shifting the DC bias level (common mode voltage) when driving different receiver standards. Since AC coupling prevents the driver from providing a DC bias voltage at the receiver, it is important to ensure the receiver is biased to its ideal DC level.

9.2.3 Application Curves

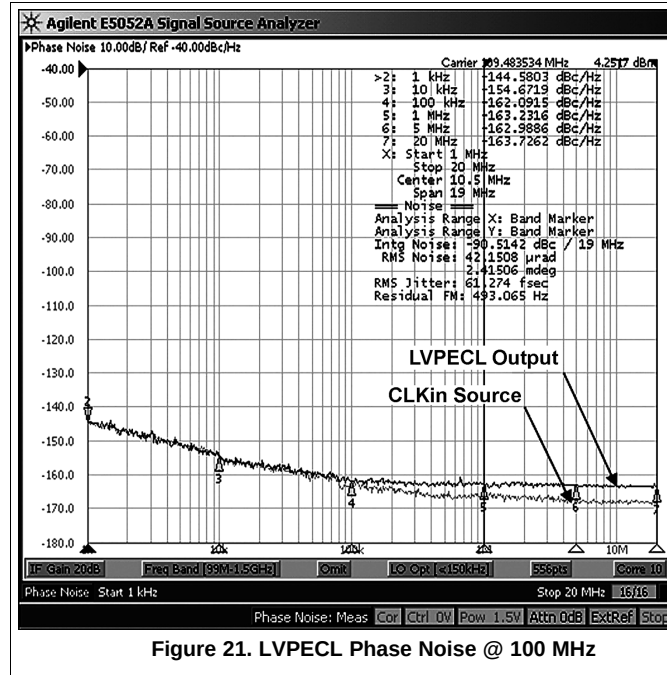


Figure 21. LVPECL Phase Noise @ 100 MHz

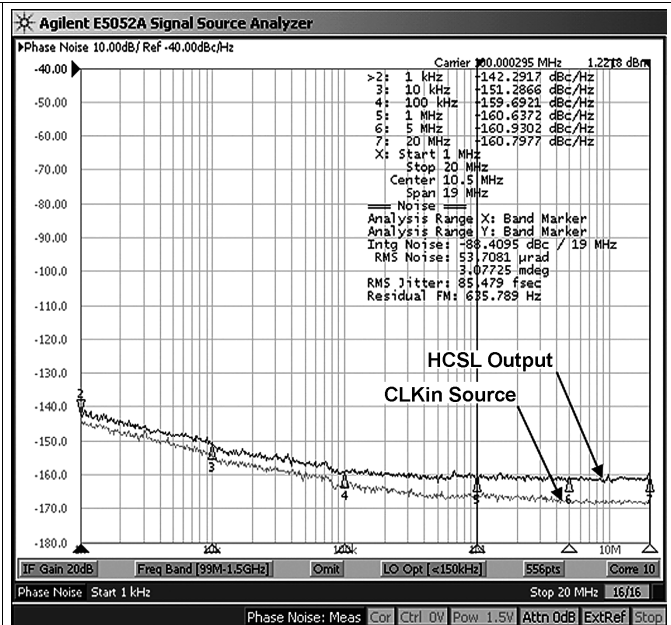


Figure 22. HCSL Phase Noise @ 100 MHz

10 Power Supply Recommendations

10.1 Current Consumption and Power Dissipation Calculations

The current consumption values specified in [Electrical Characteristics](#) can be used to calculate the total power dissipation and IC power dissipation for any device configuration. The total V_{CC} core supply current (I_{CC_TOTAL}) can be calculated using [Equation 5](#):

$$I_{CC_TOTAL} = I_{CC_CORE} + I_{CC_BANK_A} + I_{CC_BANK_B} + I_{CC_CMOS}$$

where

- I_{CC_CORE} is the current for core logic and input blocks and depends on selected input (CLKinX or OSCin).
- $I_{CC_BANK_A}$ is the current for Bank A.
- $I_{CC_BANK_B}$ is the current for Bank B.
- I_{CC_CMOS} is the current for the LVC MOS output (or 0 mA if REFout is disabled).

Since the output supplies (V_{CCOA} , V_{CCOB} , V_{CCOC}) can be powered from 3 independent voltages, the respective output supply currents ($I_{CCO_BANK_A}$, $I_{CCO_BANK_B}$, and I_{CCO_CMOS}) should be calculated separately. I_{CCO_BANK} for either Bank A or B can be directly taken from the corresponding output supply current spec (I_{CCO_HCSL}) **provided the output loading matches the specified conditions**. Otherwise, I_{CCO_BANK} should be calculated as follows:

$$I_{CCO_BANK} = I_{BANK_BIAS} + (N * I_{OUT_LOAD})$$

where

- I_{BANK_BIAS} is the output bank bias current (fixed value).
- I_{OUT_LOAD} is the DC load current per loaded output pair.
- N is the number of loaded output pairs per bank (N = 0 to 4).

[Table 5](#) shows the typical I_{BANK_BIAS} values and I_{OUT_LOAD} expressions for HCSL.

Table 5. Typical Output Bank Bias and Load Currents

CURRENT PARAMETER	HCSL
I_{BANK_BIAS}	4.8 mA
I_{OUT_LOAD}	V_{OH}/R_T

Once the current consumption is calculated for each supply, the total power dissipation (P_{TOTAL}) can be calculated as:

$$P_{TOTAL} = (V_{CC} * I_{CC_TOTAL}) + (V_{CCOA} * I_{CCO_BANK_A}) + (V_{CCOB} * I_{CCO_BANK_B}) + (V_{CCOC} * I_{CCO_CMOS}) \quad (7)$$

If the device configuration is configured with HCSL outputs, then it is also necessary to calculate the power dissipated in any termination resistors (P_{RT_HCSL}). The external power dissipation values can be calculated as follows:

$$P_{RT_HCSL} \text{ (per HCSL pair)} = V_{OH}^2 / R_T \quad (8)$$

Finally, the IC power dissipation (P_{DEVICE}) can be computed by subtracting the external power dissipation values from P_{TOTAL} as follows:

$$P_{DEVICE} = P_{TOTAL} - N_2 * P_{RT_HCSL}$$

where

- N_2 is the number of HCSL output pairs with termination resistors to GND.

10.1.1 Power Dissipation Example: Worst-Case Dissipation

This example shows how to calculate IC power dissipation for a configuration to estimate worst-case power dissipation. In this case, the maximum supply voltage and supply current values specified in [Electrical Characteristics](#) are used.

- $V_{CC} = V_{CCO} = 3.465$ V. Max I_{CC} and I_{CCO} values.
- CLKin0/CLKin0* input is selected.
- Banks A and B are enabled: all outputs terminated with 50 Ω to GND.
- REFout is enabled with 5 pF load.
- $T_A = 85$ °C

Using the power calculations from the previous section and *maximum* supply current specifications, we can compute P_{TOTAL} and P_{DEVICE} .

- From Equation 5: $I_{CC_TOTAL} = 10.5\text{ mA} + 38.5\text{ mA} + 38.5\text{ mA} + 5.5\text{ mA} = 93\text{ mA}$
- From I_{CCO_HCSL} max spec: $I_{CCO_BANK_A} = I_{CCO_BANK_B} = 84\text{ mA}$
- From Equation 7: $P_{TOTAL} = 3.465\text{ V} * (93\text{ mA} + 84\text{ mA} + 84\text{ mA} + 10\text{ mA}) = 939\text{ mW}$
- From Equation 8: $P_{RT_HCSL} = (0.92\text{V})^2/50\Omega = 16.9\text{ mW}$ (per output pair)
- From Equation 9: $P_{DEVICE} = 939\text{ mW} - (8 * 16.9\text{ mW}) = 803.8\text{ mW}$

In this worst-case example, the IC device will dissipate about 803.8 mW or 85.6% of the total power (939 mW), while the remaining 14.4% will be dissipated in the termination resistors (135.2 mW for 8 pairs). Based on θ_{JA} of 31.4 °C/W, the estimated die junction temperature would be about 25.2 °C above ambient, or 110.2 °C when $T_A = 85\text{ °C}$.

10.2 Power Supply Bypassing

The Vcc and Vcco power supplies should have a high-frequency bypass capacitor, such as 0.1 uF or 0.01 uF, placed very close to each supply pin. 1 uF to 10 uF decoupling capacitors should also be placed nearby the device between the supply and ground planes. All bypass and decoupling capacitors should have short connections to the supply and ground plane through a short trace or via to minimize series inductance.

10.2.1 Power Supply Ripple Rejection

In practical system applications, power supply noise (ripple) can be generated from switching power supplies, digital ASICs or FPGAs, and so on. While power supply bypassing will help filter out some of this noise, it is important to understand the effect of power supply ripple on the device performance. When a single-tone sinusoidal signal is applied to the power supply of a clock distribution device, such as LMK00338, it can produce narrow-band phase modulation as well as amplitude modulation on the clock output (carrier). In the single-side band phase noise spectrum, the ripple-induced phase modulation appears as a phase spur level relative to the carrier (measured in dBc).

For the LMK00338, power supply ripple rejection, or PSRR, was measured as the single-sideband phase spur level (in dBc) modulated onto the clock output when a ripple signal was injected onto the Vcco supply. The PSRR test setup is shown in Figure 23.

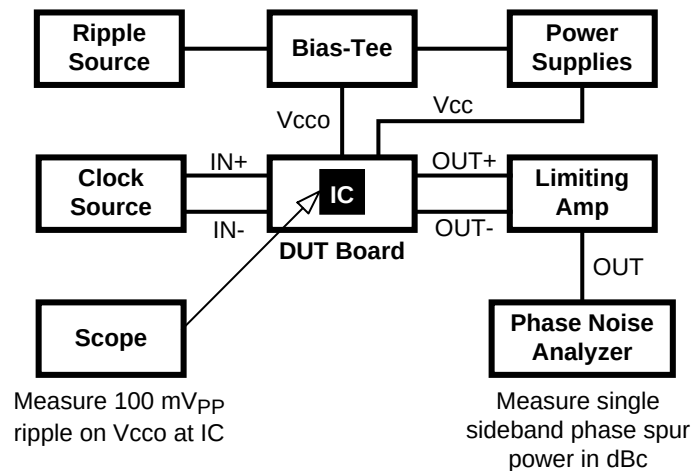


Figure 23. PSRR Test Setup

A signal generator was used to inject a sinusoidal signal onto the Vcco supply of the DUT board, and the peak-to-peak ripple amplitude was measured at the Vcco pins of the device. A limiting amplifier was used to remove amplitude modulation on the differential output clock and convert it to a single-ended signal for the phase noise analyzer. The phase spur level measurements were taken for clock frequencies of 156.25 MHz and 312.5 MHz under the following power supply ripple conditions:

- Ripple amplitude: 100 mVpp on Vcco = 2.5 V
- Ripple frequencies: 100 kHz, 1 MHz, and 10 MHz

Power Supply Bypassing (continued)

Assuming no amplitude modulation effects and small index modulation, the peak-to-peak deterministic jitter (DJ) can be calculated using the measured single-sideband phase spur level (PSRR) as follows:

$$DJ \text{ (ps pk-pk)} = [(2 \cdot 10^{(PSRR / 20)}) / (\pi \cdot f_{CLK})] \cdot 10^{12} \quad (10)$$

The PSRR vs. Ripple Frequency plots in [Typical Characteristics](#) show the ripple-induced phase spur levels at 156.25 MHz and 312.5 MHz. The LMK00338 exhibits very good and well-behaved PSRR characteristics across the ripple frequency range. The phase spur levels for HCSL are below -72 dBc at 156.25 MHz and below -63 dBc at 312.5 MHz. Using [Equation 10](#), these phase spur levels translate to Deterministic Jitter values of 1.02 ps pk-pk at 156.25 MHz and 1.44 ps pk-pk at 312.5 MHz. Testing has shown that the PSRR performance of the device improves for $V_{CCO} = 3.3 \text{ V}$ under the same ripple amplitude and frequency conditions.

11 Layout

11.1 Layout Guidelines

- For DC coupled operation of an HCSL driver, terminate with $50\ \Omega$ to ground near the driver output as shown in [Figure 24](#).
- Keep the connections between the bypass capacitors and the power supply on the device as short as possible
- Ground the other side of the capacitor using a low impedance connection to the ground plane
- If the capacitors are mounted on the back side, 0402 components can be employed; however, soldering to the Thermal Dissipation Pad can be difficult
- For component side mounting, use 0201 body size capacitors to facilitate signal routing

11.2 Layout Example

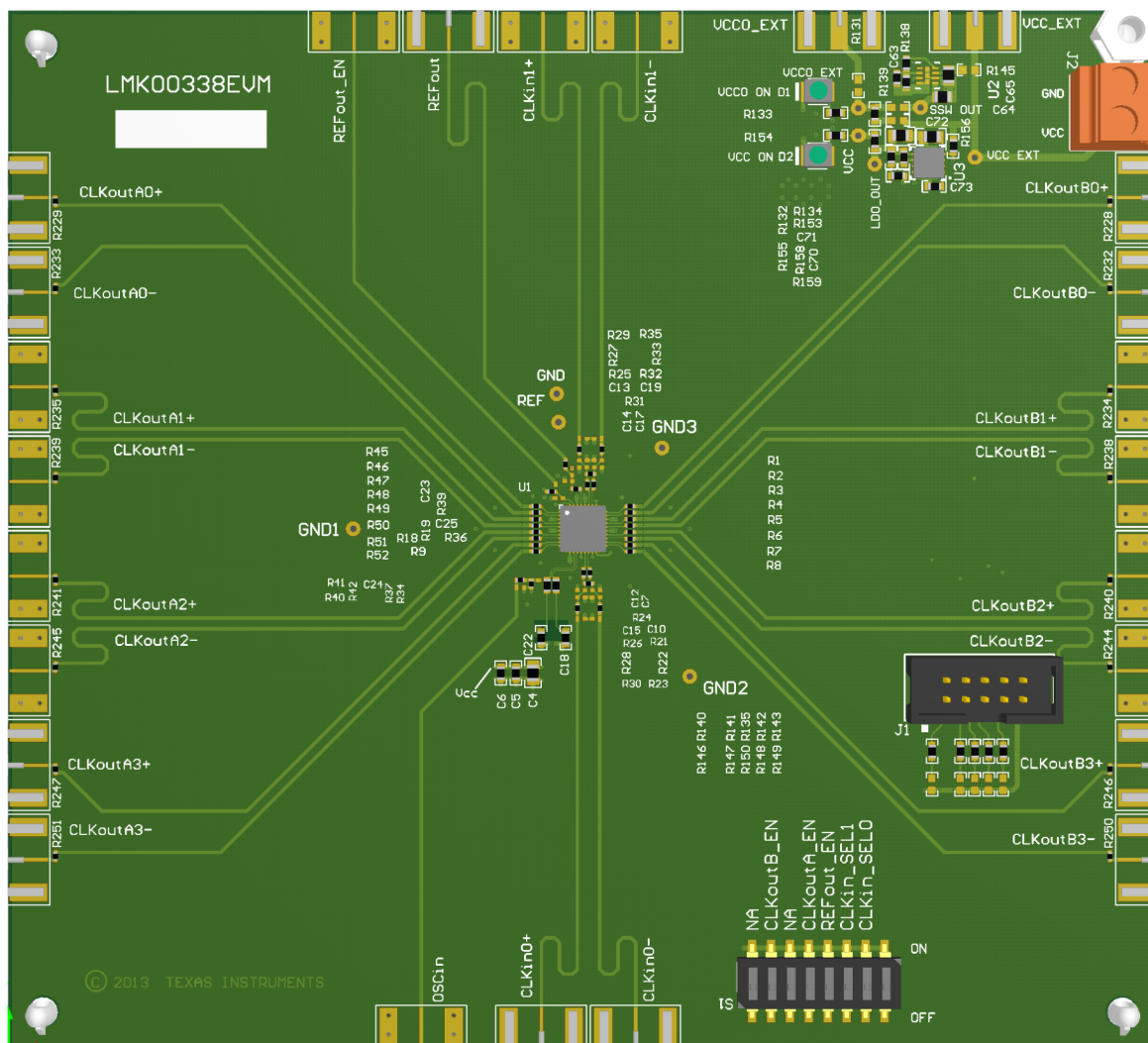


Figure 24. LMK00338 Layout Example

11.3 Thermal Management

Power dissipation in the LMK00338 device can be high enough to require attention to thermal management. For reliability and performance reasons the die temperature should be limited to a maximum of 125 °C. That is, as an estimate, T_A (ambient temperature) plus device power dissipation times $R_{\theta JA}$ should not exceed 125 °C.

The package of the device has an exposed pad that provides the primary heat removal path as well as excellent electrical grounding to the printed circuit board. To maximize the removal of heat from the package a thermal land pattern including multiple vias to a ground plane must be incorporated on the PCB within the footprint of the package. The exposed pad must be soldered down to ensure adequate heat conduction out of the package.

A recommended land and via pattern is shown in Figure 25. More information on soldering WQFN packages can be obtained at: <http://www.ti.com/packaging>.

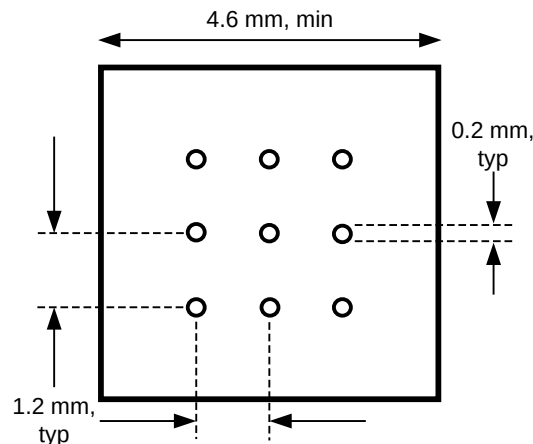


Figure 25. Recommended Land and Via Pattern

To minimize junction temperature it is recommended that a simple heat sink be built into the PCB (if the ground plane layer is not exposed). This is done by including a copper area of about 2 square inches on the opposite side of the PCB from the device. This copper area may be plated or solder coated to prevent corrosion but should not have conformal coating (if possible), which could provide thermal insulation. The vias shown in Figure 25 should connect these top and bottom copper layers and to the ground layer. These vias act as “heat pipes” to carry the thermal energy away from the device side of the board to where it can be more effectively dissipated.

12 器件和文档支持

12.1 文档支持

12.1.1 相关文档

如需相关文档，请参见以下内容：

- 《焊接相关的最大绝对额定值》([SNOA549](#))。
- 应用手册 AN-912《通用数据传输参数及其定义》([SNLA036](#))
- “[如何优化 PCIe 应用中的时钟分配](#)”，德州仪器 (TI) E2E 社区论坛。
- 《LMK00338EVM 用户指南》([SNAU155](#))。
- 《半导体和 IC 封装热指标》([SPRA953](#))。

12.2 商标

All trademarks are the property of their respective owners.

12.3 静电放电警告



这些装置包含有限的内置 ESD 保护。存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

12.4 术语表

[SLYZ022](#) — TI 术语表。

这份术语表列出并解释术语、首字母缩略词和定义。

13 机械封装和可订购信息

以下页中包括机械封装和可订购信息。 这些信息是针对指定器件可提供的最新数据。 这些数据会在无通知且不对本文档进行修订的情况下发生改变。 欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

重要声明

德州仪器(TI) 及其下属子公司有权根据 JESD46 最新标准, 对所提供的产品和服务进行更正、修改、增强、改进或其它更改, 并有权根据 JESD48 最新标准中止提供任何产品和服务。客户在下订单前应获取最新的相关信息, 并验证这些信息是否完整且是最新的。所有产品的销售都遵循在订单确认时所提供的TI 销售条款与条件。

TI 保证其所销售的组件的性能符合产品销售时 TI 半导体产品销售条件与条款的适用规范。仅在 TI 保证的范围内, 且 TI 认为 有必要时才会使用测试或其它质量控制技术。除非适用法律做出了硬性规定, 否则没有必要对每种组件的所有参数进行测试。

TI 对应用帮助或客户产品设计不承担任何义务。客户应对其使用 TI 组件的产品和应用自行负责。为尽量减小与客户产品和应用相关的风险, 客户应提供充分的设计与操作安全措施。

TI 不对任何 TI 专利权、版权、屏蔽作品权或其它与使用了 TI 组件或服务的组合设备、机器或流程相关的 TI 知识产权中授予 的直接或隐含权限作出任何保证或解释。TI 所发布的与第三方产品或服务有关的信息, 不能构成从 TI 获得使用这些产品或服务 的许可、授权、或认可。使用此类信息可能需要获得第三方的专利权或其它知识产权方面的许可, 或是 TI 的专利权或其它 知识产权方面的许可。

对于 TI 的产品手册或数据表中 TI 信息的重要部分, 仅在没有对内容进行任何篡改且带有相关授权、条件、限制和声明的情况 下才允许进行复制。TI 对此类篡改过的文件不承担任何责任或义务。复制第三方的信息可能需要服从额外的限制条件。

在转售 TI 组件或服务时, 如果对该组件或服务参数的陈述与 TI 标明的参数相比存在差异或虚假成分, 则会失去相关 TI 组件 或服务的所有明示或暗示授权, 且这是不正当的、欺诈性商业行为。TI 对任何此类虚假陈述均不承担任何责任或义务。

客户认可并同意, 尽管任何应用相关信息或支持仍可能由 TI 提供, 但他们将独力负责满足与其产品及其应用中使用的 TI 产品 相关的所有法律、法规和安全相关要求。客户声明并同意, 他们具备制定与实施安全措施所需的全部专业技术和知识, 可预见 故障的危险后果、监测故障及其后果、降低有可能造成人身伤害的故障的发生机率并采取适当的补救措施。客户将全额赔偿因 在此类安全关键应用中使用任何 TI 组件而对 TI 及其代理造成的任何损失。

在某些场合中, 为了推进安全相关应用有可能对 TI 组件进行特别的促销。TI 的目标是利用此类组件帮助客户设计和创立其特 有的可满足适用的功能安全性标准和要求的终端产品解决方案。尽管如此, 此类组件仍然服从这些条款。

TI 组件未获得用于 FDA Class III (或类似的生命攸关医疗设备) 的授权许可, 除非各方授权官员已经达成了专门管控此类使 用的特别协议。

只有那些 TI 特别注明属于军用等级或“增强型塑料”的 TI 组件才是设计或专门用于军事/航空应用或环境的。购买者认可并同 意, 对并非指定面向军事或航空航天用途的 TI 组件进行军事或航空航天方面的应用, 其风险由客户单独承担, 并且由客户独 力负责满足与此类使用相关的所有法律和法规要求。

TI 已明确指定符合 ISO/TS16949 要求的产品, 这些产品主要用于汽车。在任何情况下, 因使用非指定产品而无法达到 ISO/TS16949 要求, TI 不承担任何责任。

	产品		应用
数字音频	www.ti.com.cn/audio	通信与电信	www.ti.com.cn/telecom
放大器和线性器件	www.ti.com.cn/amplifiers	计算机及周边	www.ti.com.cn/computer
数据转换器	www.ti.com.cn/dataconverters	消费电子	www.ti.com.cn/consumer-apps
DLP® 产品	www.dlp.com	能源	www.ti.com.cn/energy
DSP - 数字信号处理器	www.ti.com.cn/dsp	工业应用	www.ti.com.cn/industrial
时钟和计时器	www.ti.com.cn/clockandtimers	医疗电子	www.ti.com.cn/medical
接口	www.ti.com.cn/interface	安防应用	www.ti.com.cn/security
逻辑	www.ti.com.cn/logic	汽车电子	www.ti.com.cn/automotive
电源管理	www.ti.com.cn/power	视频和影像	www.ti.com.cn/video
微控制器 (MCU)	www.ti.com.cn/microcontrollers		
RFID 系统	www.ti.com.cn/rfidsys		
OMAP应用处理器	www.ti.com.cn/omap		
无线连通性	www.ti.com.cn/wirelessconnectivity	德州仪器在线技术支持社区	www.deyisupport.com

邮寄地址: 上海市浦东新区世纪大道1568号, 中建大厦32楼邮政编码: 200122
Copyright © 2014, 德州仪器半导体技术(上海)有限公司

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LMK00338RTAR	ACTIVE	WQFN	RTA	40	1000	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR	-40 to 85	K00338	Samples
LMK00338RTAT	ACTIVE	WQFN	RTA	40	250	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR	-40 to 85	K00338	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

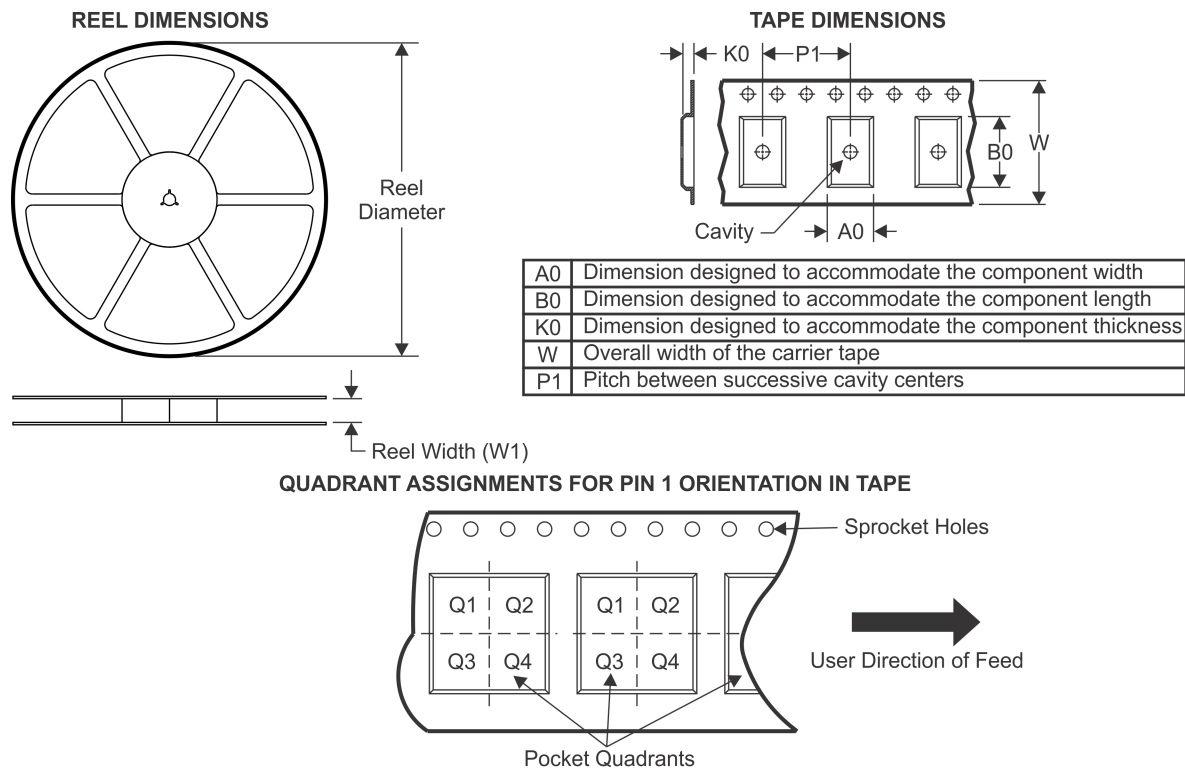
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

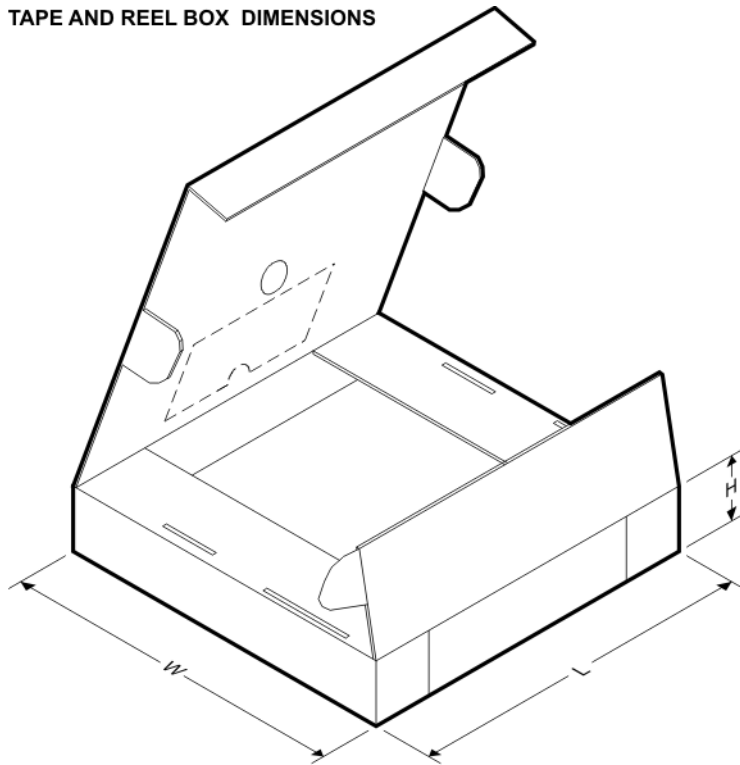
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LMK00338RTAR	WQFN	RTA	40	1000	330.0	16.4	6.3	6.3	1.5	12.0	16.0	Q1
LMK00338RTAT	WQFN	RTA	40	250	178.0	16.4	6.3	6.3	1.5	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS

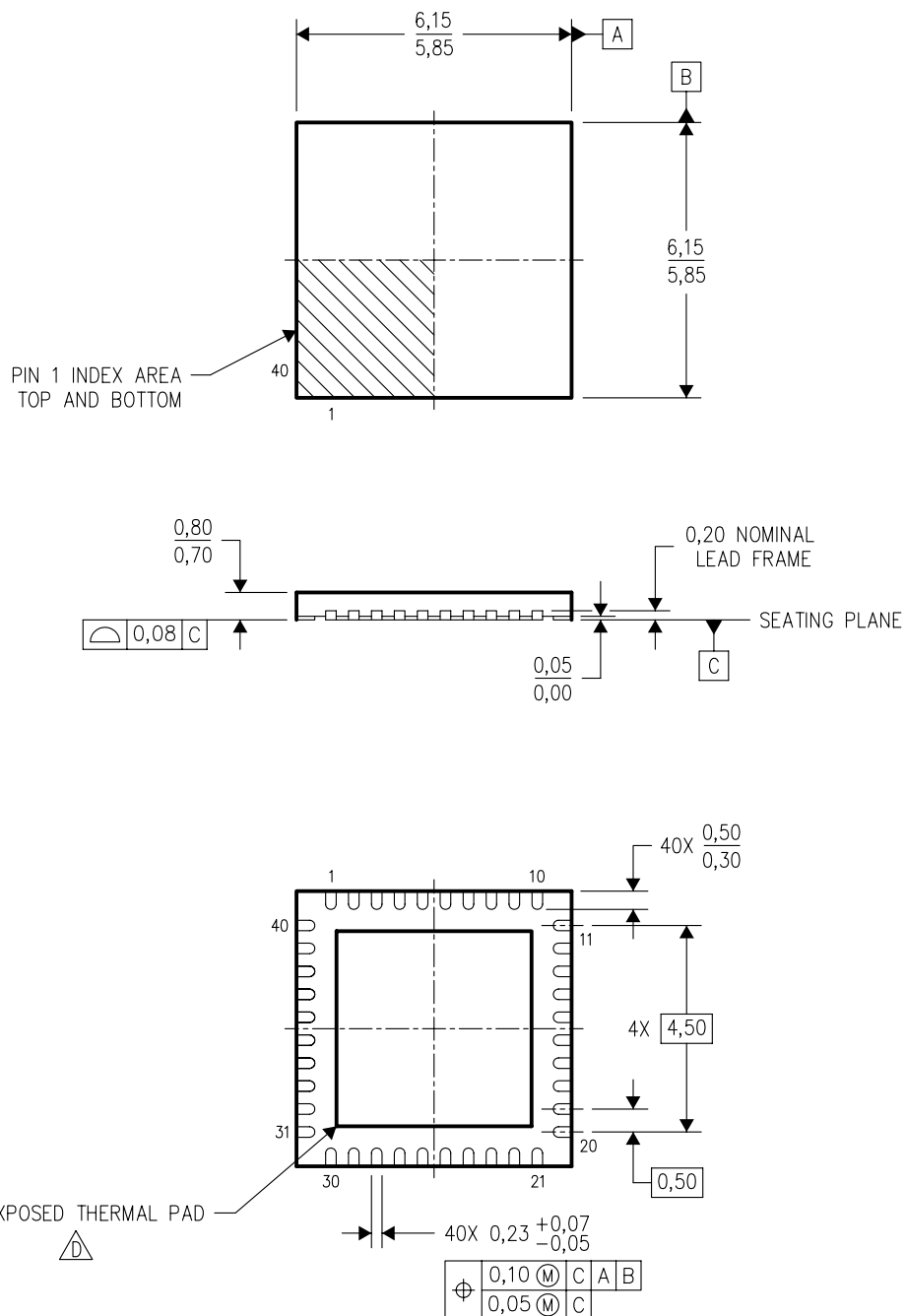


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMK00338RTAR	WQFN	RTA	40	1000	367.0	367.0	38.0
LMK00338RTAT	WQFN	RTA	40	250	210.0	185.0	35.0

RTA (S-PQFP-N40)

PLASTIC QUAD FLATPACK



4204422/B 11/04

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. QFN (Quad Flatpack No-Lead) Package configuration.
-  The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.

重要声明和免责声明

TI 均以“原样”提供技术性 & 可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证其中不含任何瑕疵，且不做任何明示或暗示的担保，包括但不限于对适销性、适合某特定用途或不侵犯任何第三方知识产权的暗示担保。

所述资源可供专业开发人员应用 TI 产品进行设计使用。您将对以下行为独自承担全部责任：(1) 针对您的应用选择合适的 TI 产品；(2) 设计、验证并测试您的应用；(3) 确保您的应用满足相应标准以及任何其他安全、安保或其他要求。所述资源如有变更，恕不另行通知。TI 对您使用所述资源的授权仅限于开发资源所涉及 TI 产品的相关应用。除此之外不得复制或展示所述资源，也不提供其它 TI 或任何第三方的知识产权授权许可。如因使用所述资源而产生任何索赔、赔偿、成本、损失及债务等，TI 对此概不负责，并且您须赔偿由此对 TI 及其代表造成的损害。

TI 所提供产品均受 TI 的销售条款 (<http://www.ti.com.cn/zh-cn/legal/termsofsale.html>) 以及 [ti.com.cn](http://www.ti.com.cn) 上或随附 TI 产品提供的其他可适用条款的约束。TI 提供所述资源并不扩展或以其他方式更改 TI 针对 TI 产品所发布的可适用的担保范围或担保免责声明。

邮寄地址：上海市浦东新区世纪大道 1568 号中建大厦 32 楼，邮政编码：200122
Copyright © 2019 德州仪器半导体技术（上海）有限公司