

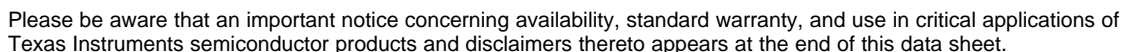
Check for Samples: [LMH2191](#)

DESCRIPTION

- The LMH2191 is a dual-channel clock tree driver that supplies a digital system clock to peripherals in mobile handsets or other applications. It provides a solution to clocking issues such as limited drive capability for fanout or longer traces. It also provides protection of the master clock from varying loads and frequency pulling effects, isolation from noisy modules, and crosstalk isolation. It has very low phase noise which enables it to drive sensitive modules such as Wireless LAN and Bluetooth.

The LMH2191 can be clocked up to 52 MHz and has an independent clock request pin for each clock output which allows the peripheral to control the clock. It features an integrated LDO which provides an ultra low-noise voltage supply with 10 mA external load current which can be used to supply the TCXO or other clock source. The LMH2191 dual clock distributor is offered in a tiny 1.61 mm x 1.063 mm 8-bump DSBGA package. Its small size and low supply current make it ideal for portable applications.

- **Mobile Handsets**
- **Portable Equipment**

[illegible]

Copyright © 2010–2013, Texas Instruments Incorporated



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾⁽²⁾

Supply Voltage	$V_{BAT} - V_{SS}$	-0.3V to 6V
	LVCMOS port IO voltage	-0.3V to ($V_{OUT} + 0.3V$)
ESD Tolerance ⁽³⁾	Human Body Model	2000V
	Machine Model	200V
	Charge Device Model	1000V
Output Short Circuit Duration ⁽⁴⁾	LDO	infinite
	Clock Output	infinite
For Soldering Information see http://www.ti.com/lit/SNOA549		
Storage Temperature Range		-65°C to 150°C
Junction Temperature ⁽⁵⁾		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 specific performance is not specified. For specifications and the test conditions, see the Electrical Characteristics Tables.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (3) Human body model, applicable std. MIL-STD-883, Method 3015.7. Machine model, applicable std. JESD22-A115-A (ESD MM std of JEDEC). Field-Induced Charge-Device Model, applicable std. JESD22-C101-C. (ESD FICDM std. of JEDEC)
- (4) Continuous short circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C.
- (5) The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA} and T_A . The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A)/\theta_{JA}$. All numbers apply for packages soldered directly onto a PC board.

OPERATING RATINGS⁽¹⁾

Supply Voltage ($V_{BAT} - V_{SS}$)		2.5V to 5.5V
Input Clock, SCLK_IN	Frequency	10 MHz to 52 MHz
	Duty Cycle	45% to 55%
Temperature Range		-40°C to +85°C
Package Thermal Resistance θ_{JA} ⁽²⁾		Board specification: 4LCELLPHONE
Package YFX		153 °C/W

- (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 specific performance is not specified. For specifications and the test conditions, see the Electrical Characteristics Tables.
- (2) The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA} and T_A . The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A)/\theta_{JA}$. All numbers apply for packages soldered directly onto a PC board.

3.5 V ELECTRICAL CHARACTERISTICS⁽¹⁾

Unless otherwise specified, all limits are specified at $T_J = 25^\circ\text{C}$, $V_{\text{BAT}} = 3.5\text{V}$, $C_{\text{BAT}} = 1\mu\text{F}$, $C_{\text{OUT}} = 2.2\mu\text{F}$ ⁽²⁾, $f_{\text{SCLK_IN}} = 26\text{ MHz}$, $I_{\text{OUT}} = 1\text{mA}$, **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Condition	Min ⁽³⁾	Typ ⁽⁴⁾	Max ⁽³⁾	Units
Supply Current⁽⁵⁾⁽⁶⁾						
I_{DD}	Supply Current	Active Mode SCLK_IN = 19.2 MHz; both clock outputs toggling; C_{LOAD} CLK1/2 = 0pF; $I_{\text{OUT}} = 0\text{mA}$		1.4	1.65 1.7	mA
		Active Mode SCLK_IN = 19.2 MHz; both clock outputs toggling; C_{LOAD} for CLK1/2 = 33.5pF; $I_{\text{OUT}} = 0\text{mA}$		3.7	4.45 4.50	mA
		Active Mode SCLK_IN = 26 MHz, both clock outputs toggling, C_{LOAD} for CLK1/2 = 0pF, $I_{\text{OUT}}=0\text{mA}$		1.9	2.15 2.25	mA
		Active Mode SCLK_IN = 26 MHz, both clock outputs toggling, C_{LOAD} for CLK1/2 = 33.5 pF, $I_{\text{OUT}}=0\text{mA}$		5	5.80 5.95	mA
		In shutdown. Input clock not active. CLK_REQ1/2=Low		0.1	1	μA
		In shutdown. Input clock toggling. CLK_REQ1/2=Low		0.1	1	μA
C_{PD}	Power Dissipation Capacitance per CLK output	C_{LOAD} for CLK1,2 = 0pF, Defined with respect to $V_{\text{OUT}} = 1.8\text{V}$		20	23.0 24.0	pF
Clock Outputs (CLK1/2) Figure 1, Figure 2						
$t_{\text{PD_LH}}$	Propagation Delay - Low to High	50% to 50%; $C_{\text{LOAD}} = 33\text{ pF}$; measured on CLK1		6.1	10.5	ns
$t_{\text{PD_HL}}$	Propagation Delay - High to Low	50% to 50%; $C_{\text{LOAD}} = 33\text{ pF}$; measured on CLK1		6.1	10.5	
t_{SKEW}	Skew Between Outputs (Either Edge)	CLK1 to CLK2. 50% to 50%		1.5	3.1	
t_{RISE}	Rise Time ⁽⁷⁾	For C_L between 33.5 pF - 50 pF, 20% to 80%; typical value based on 40 pF load	2.1	3.7	5.9	ns
t_{FALL}	Fall Time ⁽⁷⁾	For C_L between 33.5 pF - 50 pF, 20% to 80%; typical value based on 40pF load	2	3.5	5	
CLK_DC	Output Clock Duty Cycle	For C_L between 33.5 pF - 50 pF	42	50	58	%
Jitter _{RMS}	Additive RMS period Jitter	$f_{\text{SCLK_IN}} = 26\text{ MHz}$, BW = 100 Hz to 1MHz	CLK1	95		fs
			CLK2	110		

(1) Electrical Table values apply only for factory testing (ATE) conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No specification of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$.

(2) C_{BAT} , C_{OUT} : Low-ESR Surface-Mount Ceramic Capacitors (MLCCs) used in setting electrical characteristics.

(3) Limits are 100% production tested at 25°C . Limits over temperature range are specified through correlations using statistical quality control (SQC) method.

(4) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not specified on shipped production material.

(5) Supply current depends on switching frequency and load.

(6) Positive current is current flowing into the device.

(7) This parameter is specified by design and/or characterization and is not tested in production.

3.5 V ELECTRICAL CHARACTERISTICS⁽¹⁾ (continued)

Unless otherwise specified, all limits are specified at $T_J = 25^\circ\text{C}$, $V_{\text{BAT}} = 3.5\text{V}$, $C_{\text{BAT}} = 1\mu\text{F}$, $C_{\text{OUT}} = 2.2\mu\text{F}$ ⁽²⁾, $f_{\text{SCLK_IN}} = 26\text{ MHz}$, $I_{\text{OUT}} = 1\text{mA}$, **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Condition		Min ⁽³⁾	Typ ⁽⁴⁾	Max ⁽³⁾	Units
CLK1 Phase Noise	Additive Phase Noise	All outputs enabled at 26 MHz	f = 100 Hz		-128		dBc/Hz
			f = 1 kHz		-144		
			f = 10 kHz		-150		
			f = 100 kHz		-160		
			f = 1 MHz		-163		
		All outputs enabled at 19.2 MHz	f = 100 Hz		-127		
			f = 1 kHz		-146		
			f = 10 kHz		-153		
			f = 100 kHz		-161		
			f = 1 MHz		-163		
CLK2 Phase Noise	Additive Phase Noise	All outputs enabled at 26 MHz	f = 100 Hz		-127		
			f = 1 kHz		-142		
			f = 10 kHz		-148		
			f = 100 kHz		-160		
			f = 1 MHz		-162		
		All outputs enabled at 19.2 MHz	f = 100 Hz		-129		
			f = 1 kHz		-144		
			f = 10 kHz		-151		
			f = 100 kHz		-163		
			f = 1 MHz		-164		
V _{OH}	CLK1/2 Output Voltage High Level	I _{OH} = -2mA (equivalent output load 800Ω)		1.6			V
V _{OL}	CLK1/2 Output Voltage Low Level	I _{OL} = 2mA				0.2	
R _{OFF}	Ouput Impedance when disabled	with other output enabled (LDO enabled)		grounded			
		Both outputs disabled (LDO disabled)		diode to ground			
System Clock Input (SCLK_IN)							
V _{I-pp}	SCLK_IN peak- to- peak input level ⁽⁷⁾	For duty cycle variation < 1%		0.6	1	1.8	V
I _{IH}	Current into SCLK_IN pin (Input HIGH)	SCLK_IN = 1.8V, CLK_REQ1/2=Low			0	0.1	μA
I _{IL}	Current into SCLK_IN pin (Input LOW)	SCLK_IN = 0V, CLK_REQ1/2=Low		-0.1	0		
C _{IN}	Input Capacitance ⁽⁸⁾	CLK_REQ1/2=High			7.5	13	pF
R _{IN}	Input Resistance ⁽⁸⁾	CLK_REQ1/2=High see Application Note: Input Impedance			14	20	kΩ
Switching Characteristics: System Clock Input							
f _{SCLK_IN}	System Clock			10	26	52	MHz
CLK_DC	Input Clock Duty Cycle			45	50	55	%

(8) This parameter is specified by design and/or characterization and is not tested in production.

3.5 V ELECTRICAL CHARACTERISTICS⁽¹⁾ (continued)

Unless otherwise specified, all limits are specified at $T_J = 25^\circ\text{C}$, $V_{BAT} = 3.5\text{V}$, $C_{BAT} = 1\mu\text{F}$, $C_{OUT} = 2.2\mu\text{F}$ ⁽²⁾, $f_{SCLK_IN} = 26\text{ MHz}$, $I_{OUT} = 1\text{ mA}$, **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Condition	Min ⁽³⁾	Typ ⁽⁴⁾	Max ⁽³⁾	Units
Clock Request Inputs (CLK_REQ1/2)						
t_{SET}	Setup Time from CLK_REQx to SCLK_IN, to enable CLKx (Figure 3)		12	6.2		ns
V_{IH}	CLK_REQ1/2 logic HIGH input level. (clock output = ON) ⁽⁹⁾	$V_{BAT} = 2.5\text{V}$	1.4			V
		$V_{BAT} = 3.5\text{V}$	1.4			
		$V_{BAT} = 5.5\text{V}$	1.4			
V_{IL}	CLK_REQ1/2 logic LOW input level. (clock output = OFF)	$V_{BAT} = 2.5\text{V}$			0.4	V
		$V_{BAT} = 3.5\text{V}$			0.4	
		$V_{BAT} = 5.5\text{V}$			0.4	
I_{IH}	Current into CLK_REQ pin	$V_{IH} = 1.8\text{V}$, 200 k Ω pull down resistor (Input HIGH)		8.5	14	μA
I_{IL}	Current into CLK_REQ pin	$V_{IL} = V_{SS}$, (Input LOW)	-0.2	0		μA
LDO						
V_{OUT}	Output Voltage	$I_{OUT} = 1\text{ mA}$	1.73	1.8	1.88	V
I_{LOAD}	Load Current ⁽¹⁰⁾	$V_{OUT} > 1.7\text{V}$	0		10	mA
V_{DO}	Dropout Voltage ⁽¹¹⁾	$I_{OUT} = 10\text{ mA}$ $V_{out}=1.7\text{V}$		125		mV
I_{SC}	Short Circuit Current Limit			300		mA
PSRR	Power Supply Rejection Ratio	V_{BAT} ripple = 200 mV _{PP} , $I_{OUT} = 10\text{ mA}$	$f = 100\text{ Hz}$		92	dB
			$f = 217.5\text{ Hz}$		90	
			$f = 1\text{ kHz}$		78	
			$f = 10\text{ kHz}$		60	
			$f = 100\text{ kHz}$		50	
			$f = 1\text{ MHz}$		50	
			$f = 3.25\text{ MHz}$		42	
E_N	Output Noise Voltage ⁽¹²⁾	BW = 10 Hz to 100 kHz, CLK_REQ1/2=High, Input clock not active		18		μV_{RMS}
T_{SHTDWN}	Thermal Shutdown	Temperature		160		$^\circ\text{C}$
		Hysteresis		20		
ΔV_{OUT}	Line Transient	$V_{BAT} = 2.8\text{V}$ to 3.4V in $30\mu\text{s}$, $I_{OUT} = 1\text{ mA}$	-1			mV
		$V_{BAT} = 3.4\text{V}$ to 2.8V in $30\mu\text{s}$, $I_{OUT} = 1\text{ mA}$			1	
	Load Transient	$I_{OUT} = 0\text{ mA}$ to 10 mA in $10\mu\text{s}$	-15			mV
		$I_{OUT} = 10\text{ mA}$ to 0 mA in $10\mu\text{s}$			10	
	Overshoot on Startup				20	mV
R_{OUT}	DC Output Resistance			5		Ω
T_{ON}	Turn on Time	From rising edge of CLK_REQ1 to 95% of $V_{OUT(NOM)}$		200	260 350	μs

(9) Clock Request Inputs can tolerate logic high input levels up to V_{BAT} .

(10) The device maintains stable, regulated output voltage without a load.

(11) Dropout voltage is the voltage difference between the input and the output at which the output voltage drops to 100 mV below its nominal value.

(12) The noise figure is the noise of the LDO only; harmonics of the output clocks are excluded.

TIMING DIAGRAMS

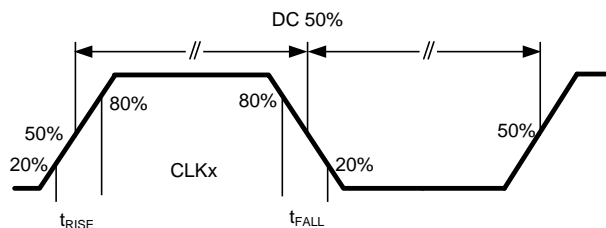


Figure 1. Rise / Fall time and Duty Cycle Waveform for Clock Outputs

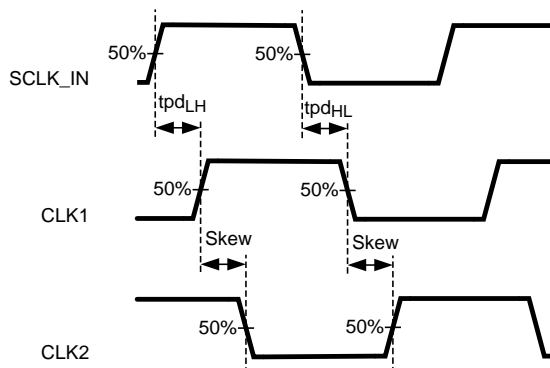


Figure 2. Clock Output Timing Waveforms

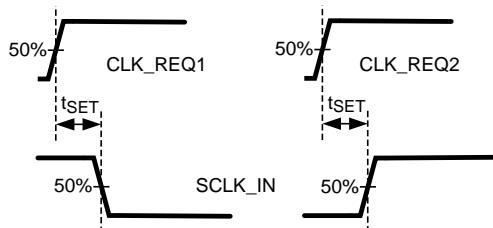


Figure 3. Clock Request Timing Waveforms

Connection Diagram

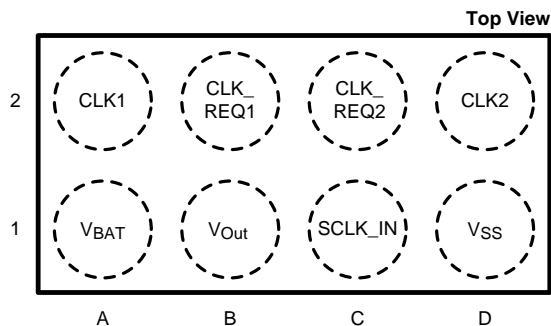


Figure 4. 8-Bump DSBGA
See YFX0008 Package

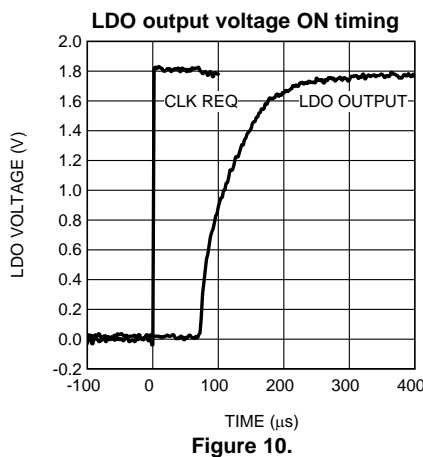
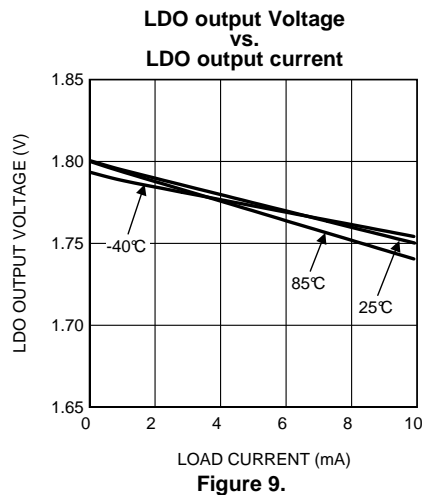
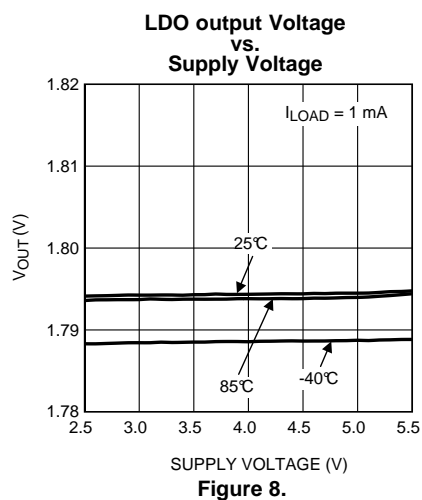
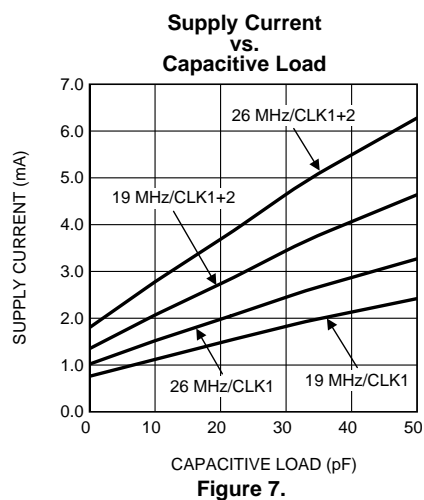
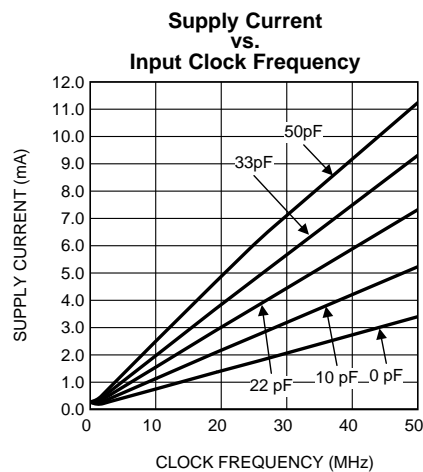
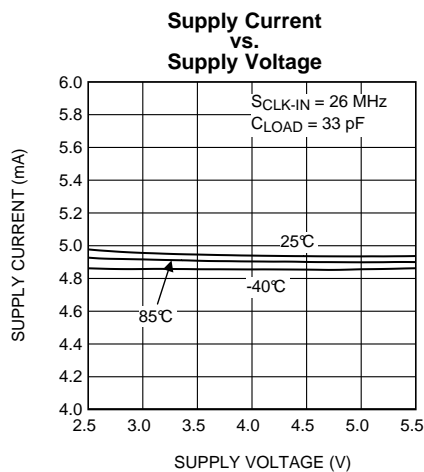
PIN DESCRIPTIONS

Pin	Pin Name	Port / Direction	Type ⁽¹⁾	Description
C1	SCLK_IN	Host	Input	Source Clock Input
A2	CLK1	Peripheral	Output	Clock Output 1
B2	CLK_REQ1	Peripheral	Input	Clock Request Input 1 Clock1 = ON at high level
D2	CLK2	Peripheral	Output	Clock Output 2
C2	CLK_REQ2	Peripheral	Input	Clock Request Input 2 Clock2 = ON at high level
A1	VBAT	Battery / Input	Power	Power Supply
B1	Vout	LDO / Output	Power	Power Supply to Clock Source and clock outputs
D1	Vss	Ground	Ground	Ground Pin

(1) I = Input, O = Output, I/O = Input / Output

TYPICAL PERFORMANCE CHARACTERISTICS

Unless otherwise specified, $T_A = 25^\circ\text{C}$, $V_{\text{BAT}} = 3.5\text{V}$, $f_{\text{SCLK_IN}} = 26\text{ MHz}$, $C_{\text{OUT}} = 2.2\text{ }\mu\text{F}$



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, $T_A = 25^\circ\text{C}$, $V_{BAT} = 3.5\text{V}$, $f_{SCLK_IN} = 26\text{ MHz}$, $C_{OUT} = 2.2\text{ }\mu\text{F}$

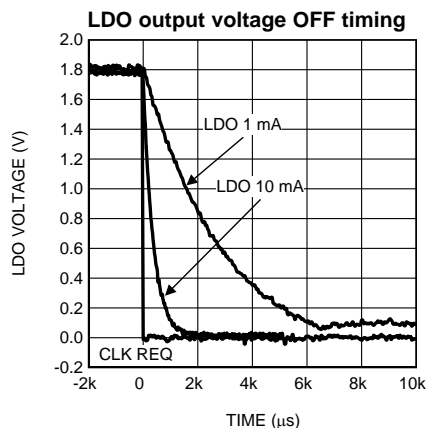


Figure 11.

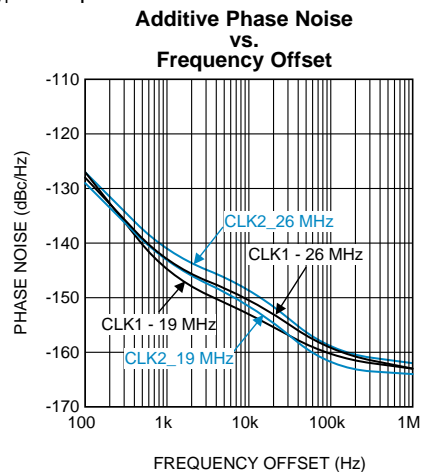


Figure 12.

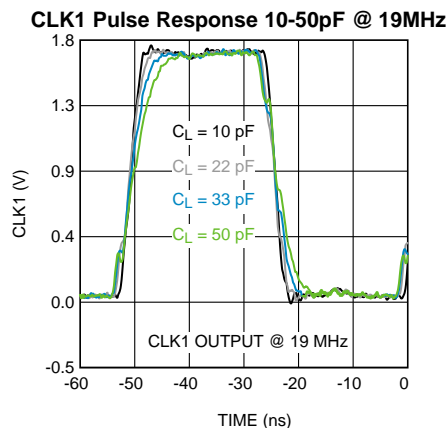


Figure 13.

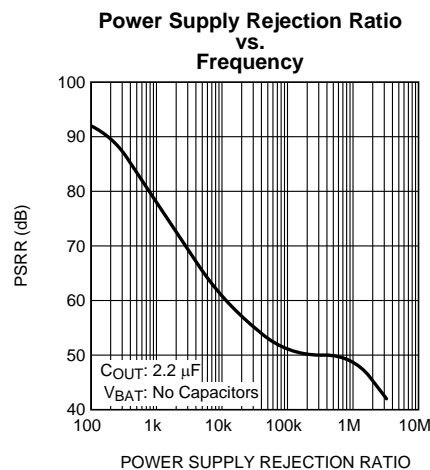


Figure 14.

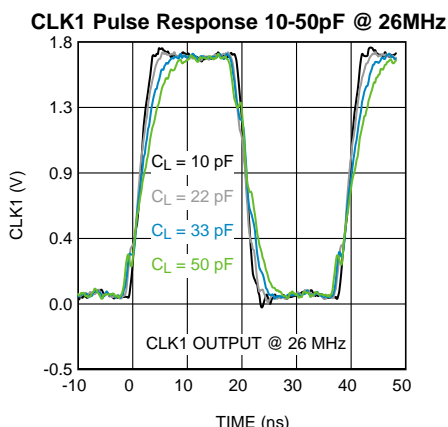


Figure 15.

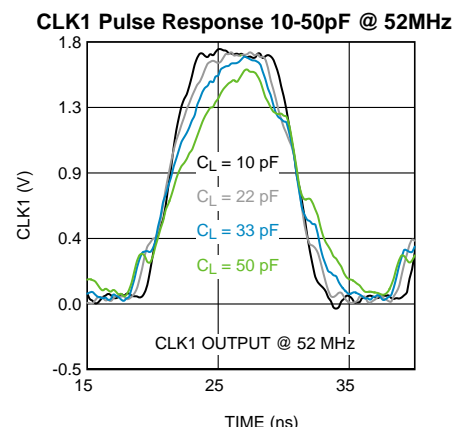


Figure 16.

APPLICATION INFORMATION

The LMH2191 is a complete 52 MHz clocking conditioner and clock tree driver. The LMH2191 is used to supply a common clock to mobile phone peripherals such as Bluetooth, Wireless LAN, and/or Digital Video Broadcast-H (DVB-H). The high isolation between the clock outputs ensures that the peripherals don't disrupt each other. Its excellent phase noise characteristics prevent the clock quality from deteriorating. A typical LMH2191 setup is depicted in [Figure 17](#).

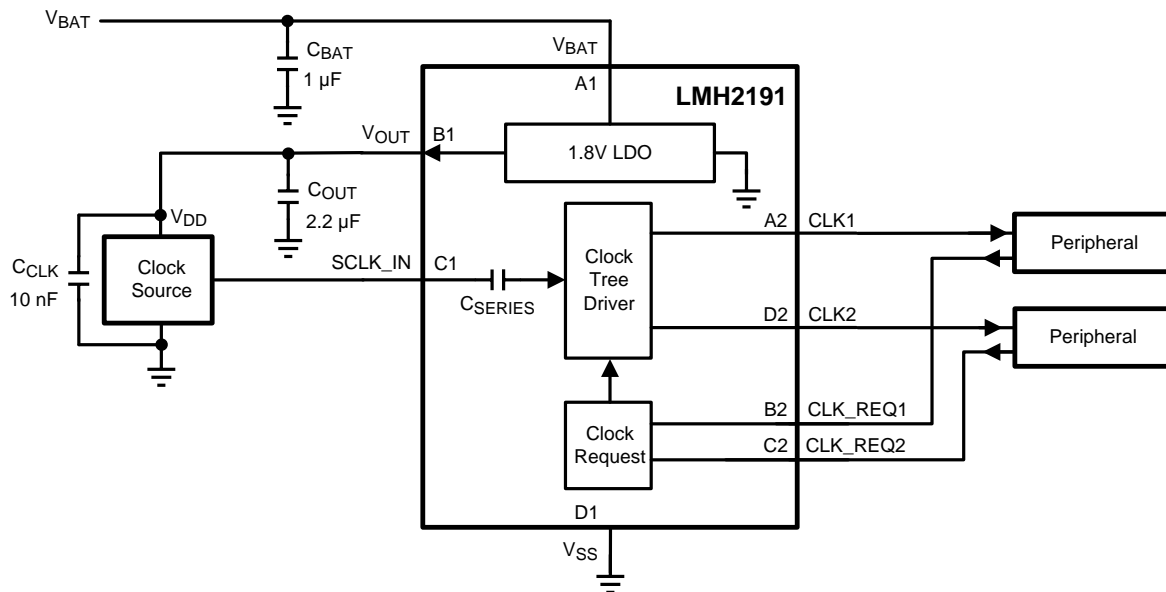


Figure 17. LMH2191 Typical Application Schematic

The internal structure of the LMH2191 is depicted in the block diagram of [Figure 18](#).

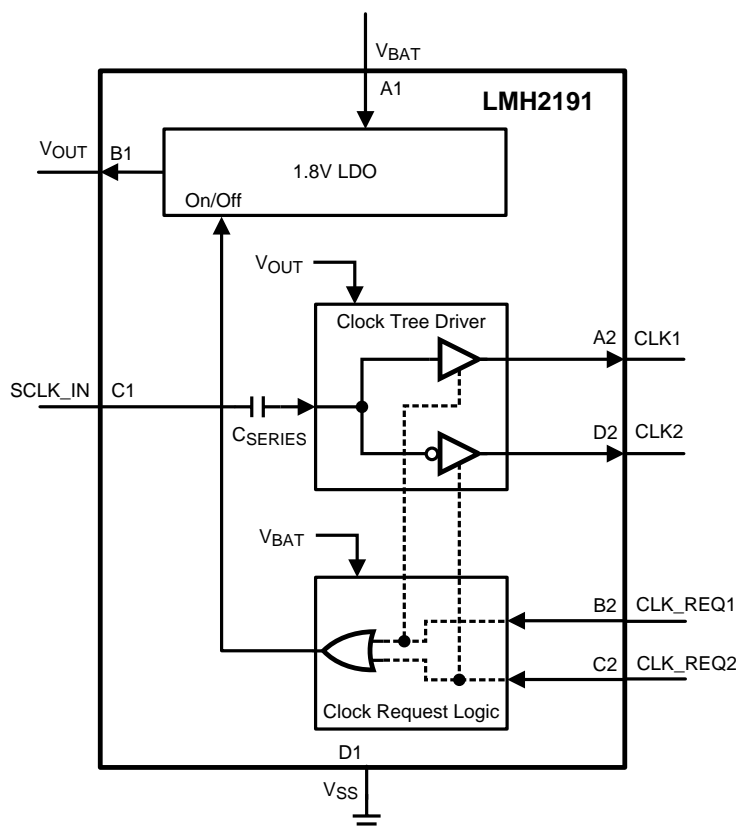


Figure 18. Block Diagram

The LMH2191 clock distribution circuit is comprised of 3 blocks:

- Clock tree driver
- Clock request logic
- Low Dropout Regulator (LDO)

The clock tree driver provides a clean clock to 2 separately connected peripheral devices. Independent clock request inputs allow the peripheral to control when the particular clock should be enabled. Furthermore, both clock request inputs control the LDO output voltage, e.g., when both request inputs are low (no CLK1 and no CLK2 output required), the LDO voltage is disabled. The LDO provides a low-noise, high-PSRR supply voltage that enables low phase noise on the clock outputs, and low quiescent current for portable applications. It can also be used to supply the TCXO. The following sections provide a detailed description of each block.

CLOCK TREE DRIVER

The clock tree driver consists of one input that drives 2 outputs. It is supplied by a high-precision voltage regulator of 1.8V, the LDO. The Clock outputs are enabled when the appropriate Clock Request inputs are logic high.

Clock Tree Driver Input

The source clock input (SCLK_IN) is the input for the clock tree driver. This input has an internally connected coupling capacitor (C_{SERIES}) with a value of 33pF. In shutdown mode (when both CLK_REQ inputs are low), the input stage is completely switched off to prevent unnecessary power consumption when the source clock is still present.

Due to the internal coupling capacitor, the clock signal is DC biased, since the coupling capacitor prevents the internal biasing of the input circuitry to be affected by the external DC voltage. Because of the coupling capacitor, the minimum clock frequency is 10 MHz. It is assumed that the input signal is a sine wave or a typical TCXO waveform (the signal from a TCXO has slow edges), enabling the control loop to adjust to a duty cycle of 50% if the input signal differs slightly from 50% duty cycle. The duty cycle is an important timing parameter for the peripheral equipment. The circuit that adjust the duty cycle is shown in [Figure 19](#).

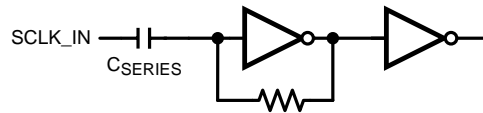


Figure 19. Clock Duty Cycle Regulation

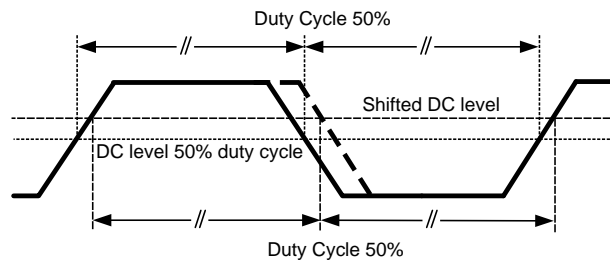


Figure 20. Duty Cycle adjust levels

In order to achieve a duty cycle of 50%, the edges of the incoming clock signal (SCLK_IN) are used to move the switching point to the level that is needed to create the 50% duty cycle. The simplified input circuit consists of an inverter and a feedback resistor. Together with the input series capacitor of about 30 pF, the circuit creates a DC level depending on the duty cycle of the incoming clock signal. When the duty cycle is exactly 50%, the DC level is in the middle of the upper and lower pulse level. When the duty cycle differs from 50%, the DC level shifts slightly to maintain the duty cycle level at 50%. (See Duty Cycle adjust levels of [Figure 20](#).) As explained above, the slow edges of the SCLK_IN signal are important to make the control loop work.

Input Impedance

The input impedance can be split up into two parts: the DC input resistance and the AC input impedance. Due to the used series capacitor in the input signal path the DC resistance is infinite. The AC input impedance is formed by the circuit drawn in [Figure 19](#). This circuit consists of an inverter and a feedback resistor. A signal fed to the input pin is connected to the inverter input which has a high input impedance and is in parallel to the feedback resistor of 30 kΩ. The other pin of the feedback resistor is connected to the output of the inverter which means that the input current is higher than it would be if it were connected to a decoupled supply connection. For this reason the AC input resistance can be much lower than the connected feedback resistor of 30 kΩ. The input resistance is dependant on the amplitude of the input signal. When an input amplitude of 1.8V is used (the same amplitude as the output of the inverter), the input impedance is theoretical half the value of the feedback resistor. When the amplitude of the input signal lowers, the input resistance becomes lower too. With an input signal of 1V_{PP}, the input impedance will be about 10 kΩ.

Clock Tree Driver Outputs

The LMH2191's clock tree driver outputs have a drive strength that make each output capable of driving a capacitive load up to 50 pF, together with a minimum of EMI. Further reduction of EMI is achieved by the inversion of the CLK2 output. (See [Figure 21](#).) Both the drive strength and the capacitive load make the edges of the output pulse relative slow which is favorable for EMI reduction.

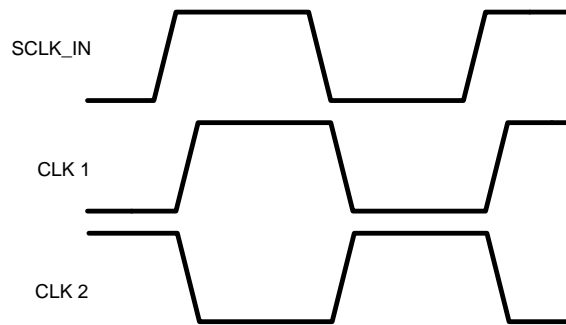


Figure 21. Clock Outputs

CLOCK REQUEST LOGIC

A clock request input is provided for each clock output. This allows the peripheral device to control when it wants to receive a clock. In case the application does not have clock request functionality, the CLKx_REQ can be hard wired to a logic high level to enable the clock output continuously. The clock request inputs have logic levels compatible with 1.8V logic, but can tolerate logic high levels up to V_{BAT} .

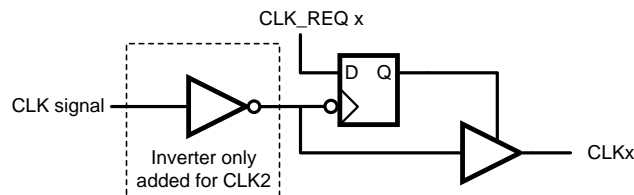


Figure 22. Enabling the output

The clock request logic enables an independent control of the clock tree driver outputs, CLK1 and CLK2, as well as an LDO disable when both request inputs are low.

The on and off switching of the clock output drivers is done synchronously with the clock input in order to prevent glitches at the clock output. For this the clock request signal is connected to the D input of a latch. The Q output of this latch enables the clock output driver (see Figure 22). For the CLK1 output the CLK input signal is connected via an inverter to the clock input of the latch. In this way the latch enables and disables the CLK1 output buffer on the falling edge of the clock signal. For the CLK2 output an extra inverter is inserted prior to the latch circuit, and the CLK2 output buffer is enabled and disabled on the rising edge of the clock input signal (equal to the falling edge of the CLK2 output signal).

LOW DROPOUT REGULATOR

The linear and Low-Dropout regulator (LDO) is used to regulate the input voltage, V_{BAT} , thus generating a well-defined ultra low noise 1.8V supply voltage. This allows the LMH2191 to suppress V_{BAT} supply voltage ripple and noise for the TCXO and the internal Clock Path. Voltage ripple and noise would distort clock edges causing extra phase noise on the distributed clock signal.

The LDO is powered up whenever a Clock Request is active; it supports overheating detection and will switch off in case overheating occurs. The recommended sequence for powering up the LDO is to raise a clock request to a high level with the supply already powered up. Thus the LDO stays in shutdown mode with sub μA current consumption until an output clock is actually needed. The LDO will power up within the turn-on time of about 200 μs (as specified in the data sheet tables). Alternatively, the clock request input can be hard wired to V_{BAT} which powers up the LDO simultaneously with V_{BAT} . A drawback is that the LDO and clock path (and if connected, the TCXO) will always draw current when V_{BAT} is powered up. Also, in this setup, care should be taken with supplies with an excessive long startup time of more than about 25 ms. Under this condition the LDO could exhibit excessive long turn-on delay (order of seconds.)

LAYOUT RECOMMENDATIONS

As with any other device, careful attention must be paid to the board layout. If the board isn't properly designed, the performance of the device can be less than desired. Care should be taken that the SCLK_IN input trace and the output traces of CLK1 and CLK2 are as short as possible to reduce extra capacitive load observed by the clock outputs. Also proper de-coupling close to the device is necessary. [Table 1](#) depicts the advised component values. TI suggests to use the evaluation board, available from the Texas Instruments web site www.ti.com, as a guide for layout and as an aid in device testing and characterization.

Table 1. Recommended Component Values

Symbol	Parameter	Min	Typ	Max	Units
C _{BAT} ⁽¹⁾	Capacitor on V _{BAT}	0.47	1		μF
C _{OUT} ⁽¹⁾	Capacitor on V _{OUT}	1	2.2		
ESR	Equivalent Series Resistance	5		500	mΩ

(1) C_{BAT}, C_{OUT}: Low-ESR Surface-Mount Ceramic Capacitors (MLCC's) used in setting electrical characteristics.

REVISION HISTORY

Changes from Revision C (April 2013) to Revision D

Page

- Changed layout of National Data Sheet to TI format [14](#)

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LMH2191TME/NOPB	Active	Production	DSBGA (YFX) 8	250 SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	5
LMH2191TME/NOPB.A	Active	Production	DSBGA (YFX) 8	250 SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	5
LMH2191TMX/NOPB	Active	Production	DSBGA (YFX) 8	3000 LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	5
LMH2191TMX/NOPB.A	Active	Production	DSBGA (YFX) 8	3000 LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	5

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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
LMH2191TME/NOPB	DSBGA	YFX	8	250	178.0	8.4	1.24	1.7	0.76	4.0	8.0	Q1
LMH2191TMX/NOPB	DSBGA	YFX	8	3000	178.0	8.4	1.24	1.7	0.76	4.0	8.0	Q1

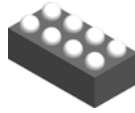
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMH2191TME/NOPB	DSBGA	YFX	8	250	208.0	191.0	35.0
LMH2191TMX/NOPB	DSBGA	YFX	8	3000	208.0	191.0	35.0

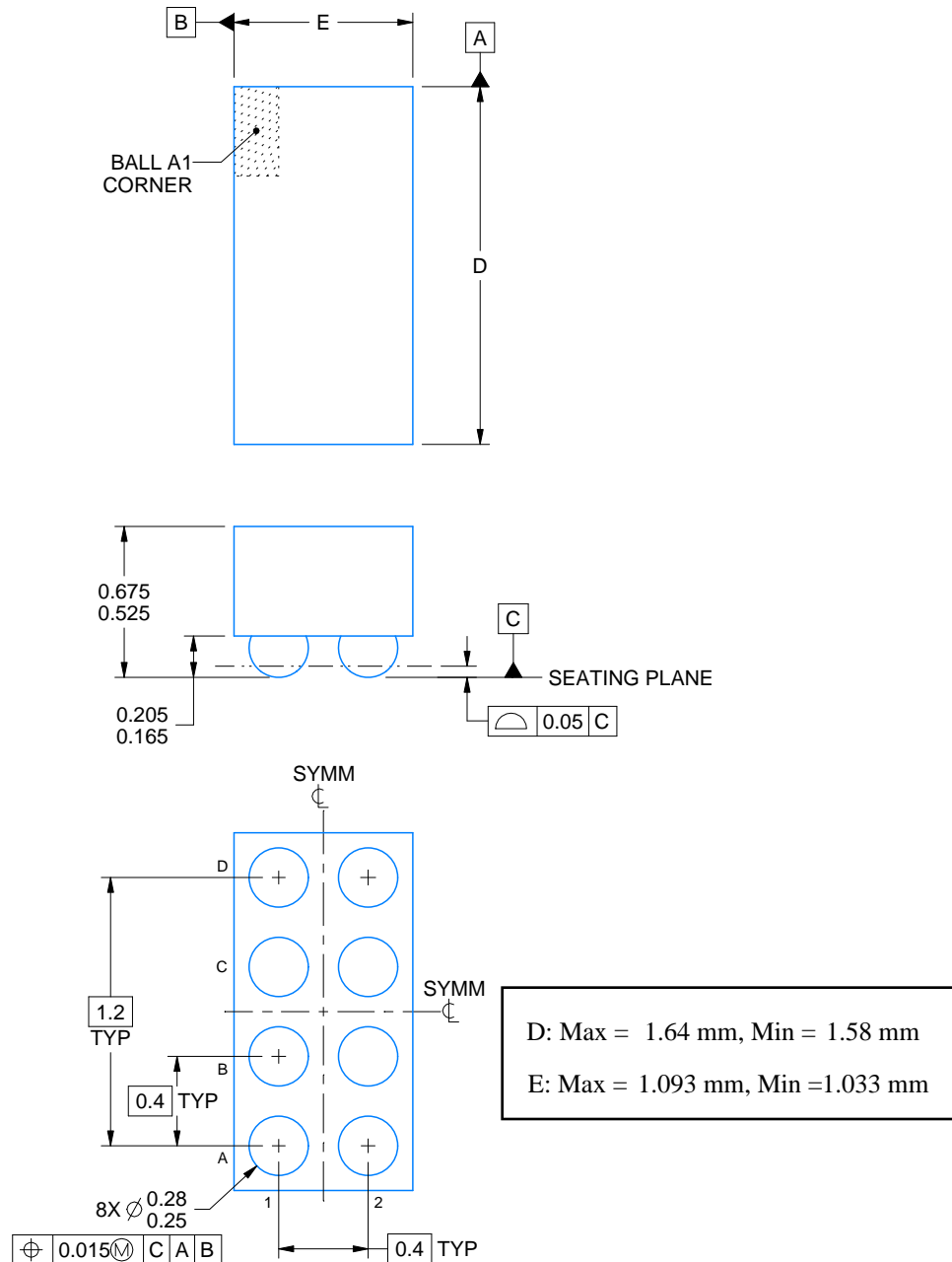
YFX0008



PACKAGE OUTLINE

DSBGA - 0.675 mm max height

DIE SIZE BALL GRID ARRAY



4215093/B 04/2022

NOTES:

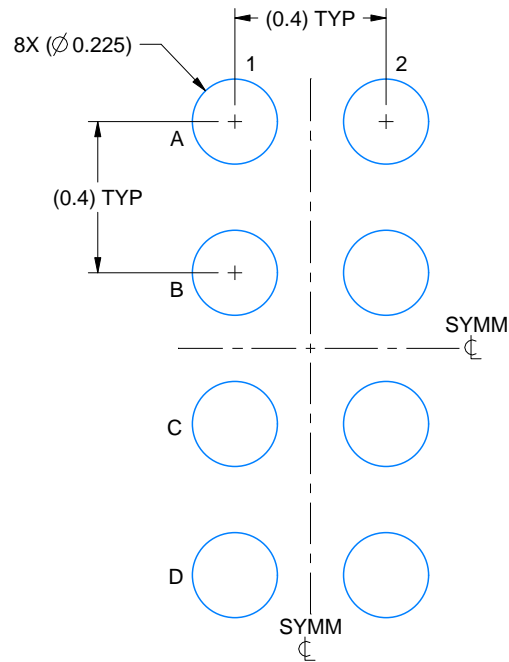
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

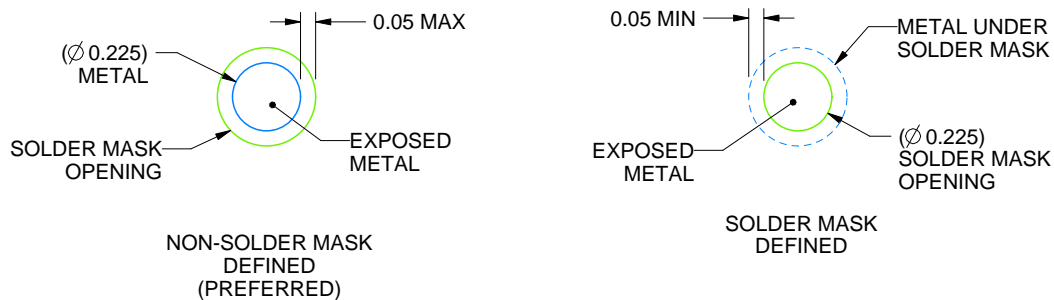
YFX0008

DSBGA - 0.675 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 50X



SOLDER MASK DETAILS
NOT TO SCALE

4215093/B 04/2022

NOTES: (continued)

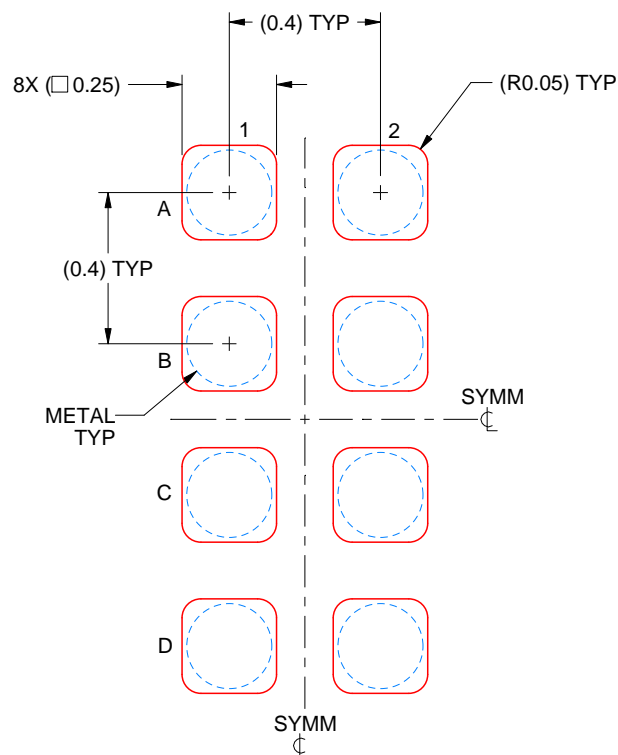
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).

EXAMPLE STENCIL DESIGN

YFX0008

DSBGA - 0.675 mm max height

DIE SIZE BALL GRID ARRAY



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 50X

4215093/B 04/2022

NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL 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 AND 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 skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2025, Texas Instruments Incorporated

Last updated 10/2025