2.5 V/3.3 V, Four LVPECL Outputs, SiGe Clock Fanout Buffer

ADCLK944

FEATURES

Operating frequency: 7.0 GHz
Broadband random jitter: 50 fs rms
On-chip input terminations
Power supply (V_{CC} – V_{EE}): 2.5 V to 3.3 V

APPLICATIONS

Low jitter clock distribution
Clock and data signal restoration
Level translation
Wireless communications
Wired communications
Medical and industrial imaging
ATE and high performance instrumentation

FUNCTIONAL BLOCK DIAGRAM

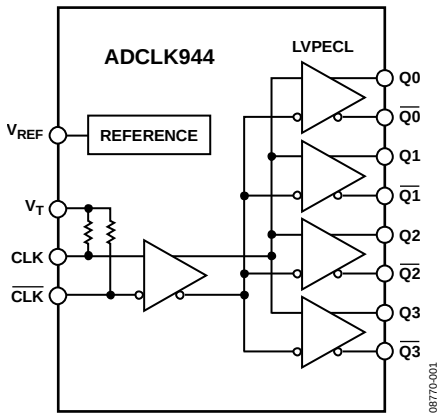

Figure 1.

GENERAL DESCRIPTION

The ADCLK944 is an ultrafast clock fanout buffer fabricated on the Analog Devices, Inc., proprietary XFCB3 silicon germanium (SiGe) bipolar process. This device is designed for high speed applications requiring low jitter.

The device has a differential input equipped with center-tapped, differential, 100 Ω on-chip termination resistors. The input can accept dc-coupled LVPECL, CML, 3.3 V CMOS (single-ended), and ac-coupled 1.8 V CMOS, LVDS, and LVPECL inputs. A V_{REF} pin is available for biasing ac-coupled inputs.

The ADCLK944 features four full-swing emitter-coupled logic (ECL) output drivers. For LVPECL (positive ECL) operation, bias V_{CC} to the positive supply and V_{EE} to ground. For ECL operation, bias V_{CC} to ground and V_{EE} to the negative supply.

The ECL output stages are designed to directly drive 800 mV each side into 50 Ω terminated to V_{CC} – 2 V for a total differential output swing of 1.6 V.

The ADCLK944 is available in a 16-lead LFCSP and is specified for operation over the standard industrial temperature range of −40°C to +85°C.

Rev. 0

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REVISION HISTORY

3/10—Revision 0: Initial Version

SPECIFICATIONS

Typical values are given for $V_{CC} - V_{EE}$ = 3.3 V and T_A = 25°C, unless otherwise noted. Minimum and maximum values are given for the full $V_{CC} - V_{EE}$ = 3.3 V + 10% to 2.5 V − 5% and T_A = −40°C to +85°C variation, unless otherwise noted.

CLOCK INPUTS AND OUTPUTS

Table 1.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
DC INPUT CHARACTERISTICS						
Input Common-Mode Voltage	V_{ICM}	V_{EE} + 1.35		V_{CC} − 0.1	V	
Input Differential Voltage	V_{ID}	0.4		3.4	V p-p	±1.7 V between input pins
Input Capacitance	C_{IN}		0.4		pF	
Input Resistance	R_{IN}					
Single-Ended Mode			50		Ω	
Differential Mode			100		Ω	
Common Mode			50		kΩ	V_T open
Input Bias Current			20		μA	
DC OUTPUT CHARACTERISTICS						
Output Voltage High Level	V_{OH}	V_{CC} − 1.26		V_{CC} − 0.76	V	Load = 50 Ω to (V_{CC} − 2.0 V)
Output Voltage Low Level	V_{OL}	V_{CC} − 1.99		V_{CC} − 1.54	V	Load = 50 Ω to (V_{CC} − 2.0 V)
Output Voltage, Single-Ended	V_O	600		960	mV	$V_{OH} - V_{OL}$, output static
Voltage Reference	V_{REF}					
Output Voltage			(V_{CC} + 1)/2		V	−500 μA to +500 μA
Output Resistance			250		Ω	

TIMING CHARACTERISTICS

Table 2.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
AC PERFORMANCE						
Maximum Output Frequency		6.2	7.0		GHz	Differential output voltage swing > 0.8 V (see Figure 4)
Output Rise/Fall Time	t_R	35	50	75	ps	20% to 80%, measured differentially
Propagation Delay	t_{PD}	70	100	130	ps	V_{ID} = 1.6 V p-p
Temperature Coefficient			75		fs/°C	
Output-to-Output Skew[1]				15	ps	
Part-to-Part Skew				35	ps	V_{ID} = 1.6 V p-p
Additive Time Jitter						
Integrated Random Jitter			26		fs rms	BW = 12 kHz to 20 MHz, CLK = 1 GHz
Broadband Random Jitter[2]			50		fs rms	V_{ID} = 1.6 V p-p, 8 V/ns, V_{ICM} = 2 V
CLOCK OUTPUT PHASE NOISE						
Absolute Phase Noise						Input slew rate > 1 V/ns (see Figure 11)
f_{IN} = 1 GHz			−118		dBc/Hz	100 Hz offset
			−135		dBc/Hz	1 kHz offset
			−144		dBc/Hz	10 kHz offset
			−150		dBc/Hz	100 kHz offset
			−150		dBc/Hz	>1 MHz offset

[1] The output-to-output skew is the difference between any two similar delay paths while operating at the same voltage and temperature.
[2] Measured at the rising edge of the clock signal; calculated using the SNR of the ADC method.

POWER

Table 3.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
POWER SUPPLY						
Supply Voltage Requirement	$V_{CC} - V_{EE}$	2.375		3.63	V	3.3 V + 10% to 2.5 V − 5%
Power Supply Current						Static
Negative Supply Current	I_{VEE}		35		mA	$V_{CC} - V_{EE}$ = 2.5 V ± 5%
	I_{VEE}		37	49	mA	$V_{CC} - V_{EE}$ = 3.3 V ± 10%
Positive Supply Current	I_{VCC}		139		mA	$V_{CC} - V_{EE}$ = 2.5 V ± 5%
	I_{VCC}		138	165	mA	$V_{CC} - V_{EE}$ = 3.3 V ± 10%
Power Supply Rejection[1]	PSR_{VCC}		−3		ps/V	
Output Swing Supply Rejection[2]	PSR_{VCC}		28		dB	

[1] Change in t_{PD} per change in V_{CC}.
[2] Change in output swing per change in V_{CC}.

ABSOLUTE MAXIMUM RATINGS

Table 4.

Parameter	Rating
Supply Voltage	
$V_{CC} - V_{EE}$	6.0 V
Input Voltage	
CLK, $\overline{CLK}$	V_{EE} − 0.5 V to V_{CC} + 0.5 V
CLK to $\overline{CLK}$	±1.8 V
Input Termination, V_T to CLK, $\overline{CLK}$	±2 V
Input Current, CLK, $\overline{CLK}$ to V_T Pin (CML, LVPECL Termination)	±40 mA
Maximum Voltage on Output Pins	V_{CC} + 0.5 V
Maximum Output Current	35 mA
Voltage Reference (V_{REF})	V_{CC} to V_{EE}
Operating Temperature	
Ambient Range	−40°C to +85°C
Junction	150°C
Storage Temperature Range	−65°C to +150°C

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

DETERMINING JUNCTION TEMPERATURE

To determine the junction temperature on the application printed circuit board (PCB), use the following equation:

$$T_J = T_{CASE} + (\Psi_{JT} \times P_D)$$

where:
T_J is the junction temperature (°C).
T_{CASE} is the case temperature (°C) measured by the customer at the top center of the package.
Ψ_{JT} is as indicated in Table 5.
P_D is the power dissipation.

Values of θ_{JA} are provided for package comparison and PCB design considerations. θ_{JA} can be used for a first-order approximation of T_J using the following equation:

$$T_J = T_A + (\theta_{JA} \times P_D)$$

where T_A is the ambient temperature (°C).

Values of θ_{JB} are provided in Table 5 for package comparison and PCB design considerations.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

THERMAL PERFORMANCE

Table 5.

Parameter	Symbol	Description	Value[1]	Unit
Junction-to-Ambient Thermal Resistance				
Still Air	θ_{JA}	Per JEDEC JESD51-2		
0.0 m/sec Airflow			78	°C/W
Moving Air	θ_{JMA}	Per JEDEC JESD51-6		
1.0 m/sec Airflow			68	°C/W
2.5 m/sec Airflow			61	°C/W
Junction-to-Board Thermal Resistance	θ_{JB}	Per JEDEC JESD51-8		
Moving Air				
1.0 m/sec Airflow			49	°C/W
Junction-to-Case Thermal Resistance (Die-to-Heat Sink)	θ_{JC}	Per MIL-STD-883, Method 1012.1		
Still Air				
0.0 m/sec Airflow			1.5	°C/W
Junction-to-Top-of-Package Characterization Parameter	Ψ_{JT}			
Still Air		Per JEDEC JESD51-2		
0.0 m/sec Airflow			2.0	°C/W

[1] Results are from simulations. The PCB is a JEDEC multilayer type. Thermal performance for actual applications requires careful inspection of the conditions in the application to determine whether they are similar to those assumed in these calculations.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

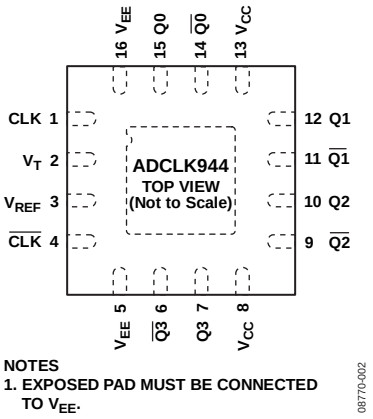

Figure 2. Pin Configuration

Table 6. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	CLK	Differential Input (Positive).
2	V_T	Center Tap. This pin provides the center tap of a 100 Ω input resistor for the CLK and $\overline{CLK}$ inputs.
3	V_{REF}	Reference Voltage. This pin provides the reference voltage for biasing ac-coupled CLK and $\overline{CLK}$ inputs.
4	$\overline{CLK}$	Differential Input (Negative).
5, 16	V_{EE}	Negative Supply Pin.
6, 7	$\overline{Q3}$, Q3	Differential LVPECL Outputs.
8, 13	V_{CC}	Positive Supply Pin.
9, 10	$\overline{Q2}$, Q2	Differential LVPECL Outputs.
11, 12	$\overline{Q1}$, Q1	Differential LVPECL Outputs.
14, 15	$\overline{Q0}$, Q0	Differential LVPECL Outputs.
	EPAD	The exposed pad must be connected to V_{EE}.

TYPICAL PERFORMANCE CHARACTERISTICS

V_{CC} = 3.3 V, V_{EE} = 0.0 V, V_{ICM} = V_{REF}, T_A = 25°C, clock outputs terminated at 50 Ω to V_{CC} − 2 V, unless otherwise noted.

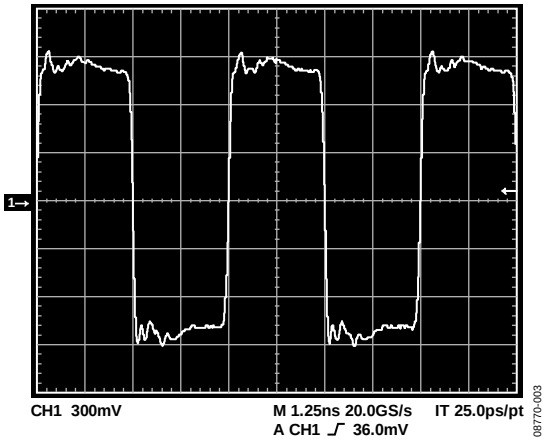

Figure 3. LVPECL Differential Output Waveform at 200 MHz

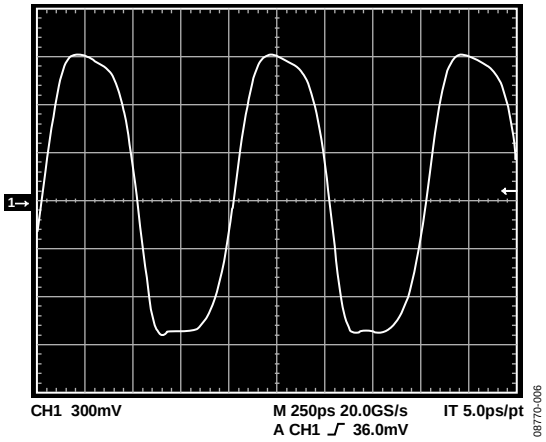

Figure 6. LVPECL Differential Output Waveform at 1000 MHz

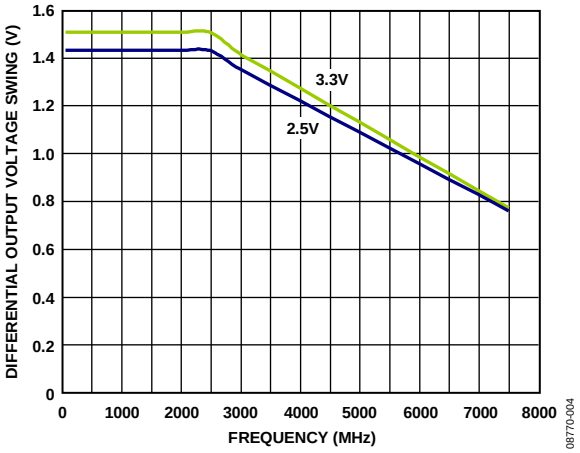

Figure 4. Differential Output Voltage Swing vs. Frequency

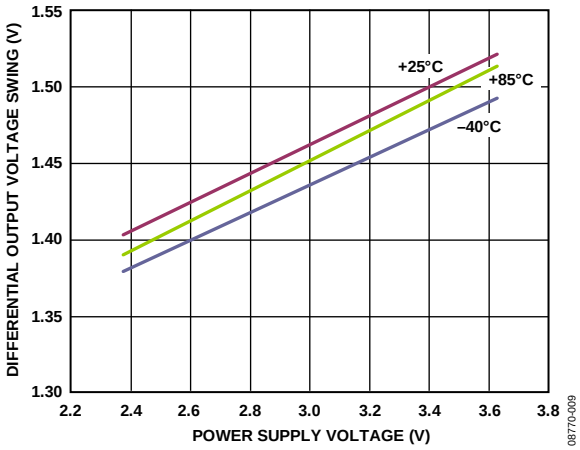

Figure 7. Differential Output Voltage Swing vs. Power Supply Voltage and Temperature, V_{ID} = 1.6 V p-p

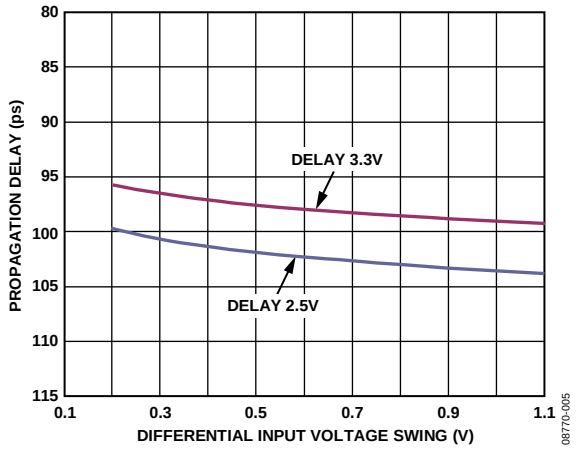

Figure 5. Propagation Delay vs. Differential Input Voltage Swing

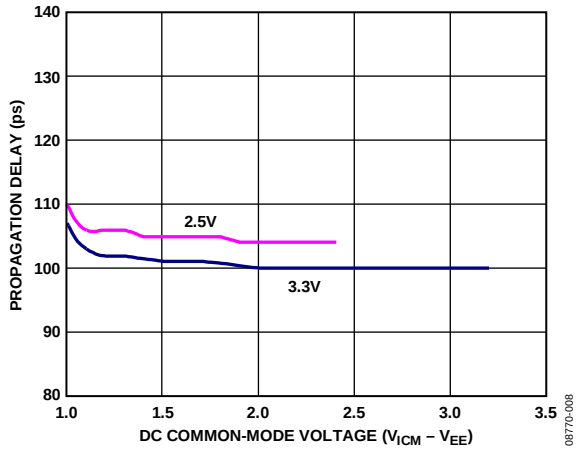

Figure 8. Propagation Delay vs. DC Common-Mode Voltage

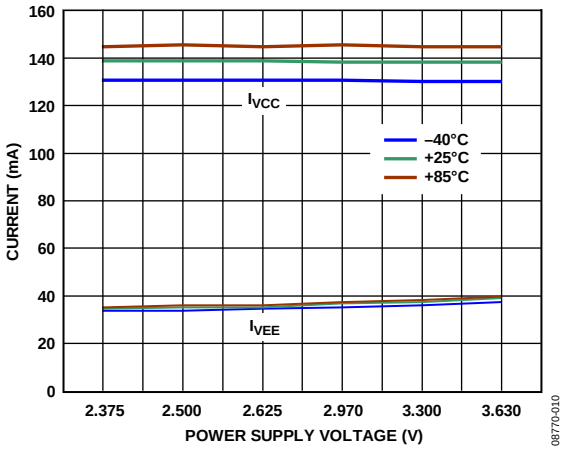

Figure 9. Power Supply Current vs. Power Supply Voltage and Temperature, All Outputs Loaded (50 Ω to V_{CC} – 2 V)

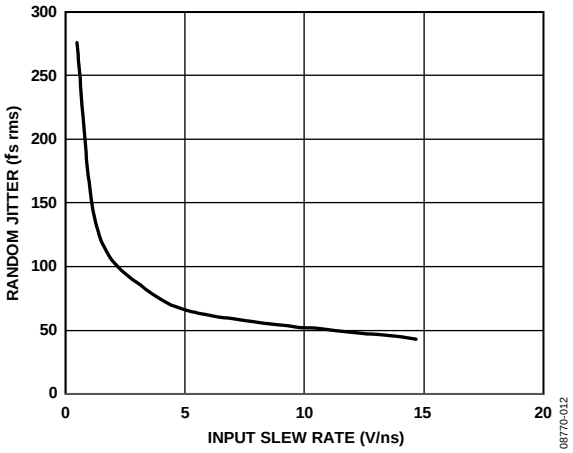

Figure 11. Random Jitter vs. Input Slew Rate, V_{ID} Method

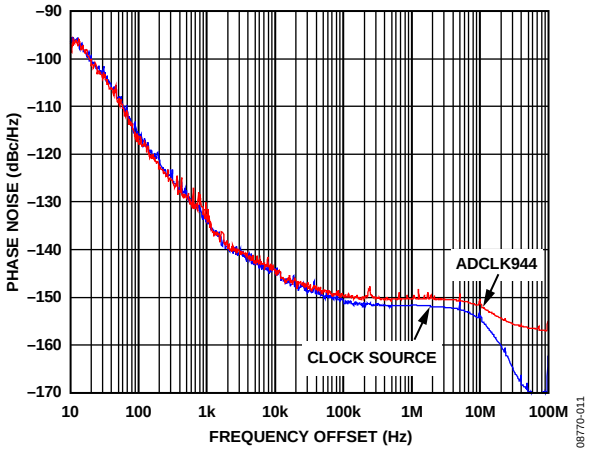

Figure 10. Absolute Phase Noise Measured at 1 GHz with Agilent E5052B

THEORY OF OPERATION

CLOCK INPUTS

The ADCLK944 accepts a differential clock input and distributes it to all four LVPECL outputs. The maximum specified frequency is the point at which the output voltage swing is 50% of the standard LVPECL swing (see Figure 4).

The device has a differential input equipped with center-tapped, differential, 100 Ω on-chip termination resistors. The input can accept dc-coupled LVPECL, CML, 3.3 V CMOS (single-ended, 3.3 V operation only), and ac-coupled 1.8 V CMOS, LVDS, and LVPECL inputs. A V_{REF} pin is available for biasing ac-coupled inputs (see Figure 20 and Figure 21).

Maintain the differential input voltage swing from approximately 400 mV p-p to no more than 3.4 V p-p. See Figure 18 through Figure 21 for various clock input termination schemes.

Output jitter performance is significantly degraded by an input slew rate below 1 V/ns, as shown in Figure 11. The ADCLK944 is specifically designed to minimize added random jitter over a wide input slew rate range. Whenever possible, clamp excessively large input signals with fast Schottky diodes because attenuators reduce the slew rate. Input signal runs of more than a few centimeters should be over low loss dielectrics or cables with good high frequency characteristics.

CLOCK OUTPUTS

The specified performance necessitates using proper transmission line terminations. The LVPECL outputs of the ADCLK944 are designed to directly drive 800 mV into a 50 Ω cable or into microstrip/stripline transmission lines terminated with 50 Ω referenced to V_{CC} − 2 V, as shown in Figure 13. The LVPECL output stage is shown in Figure 12. The outputs are designed for best transmission line matching. If high speed signals must be routed more than a centimeter, either the microstrip or the stripline technique is required to ensure proper transition times and to prevent excessive output ringing and pulse-width-dependent propagation delay dispersion.

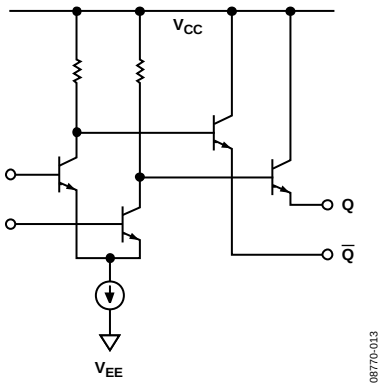

Figure 12. Simplified Schematic Diagram of the LVPECL Output Stage

Figure 13 through Figure 16 depict various LVPECL output termination schemes. When dc-coupled, V_{CC} of the receiving buffer should match VS_DRV.

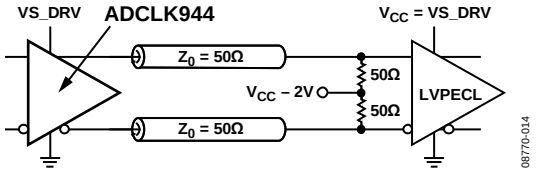

Figure 13. DC-Coupled, 3.3 V LVPECL

Thevenin-equivalent termination uses a resistor network to provide 50 Ω termination to a dc voltage that is below V_{OL} of the LVPECL driver. In this case, VS_DRV on the ADCLK944 should equal V_{CC} of the receiving buffer. Although the resistor combination shown in Figure 14 results in a dc bias point of VS_DRV − 2 V, the actual common-mode voltage is VS_DRV − 1.3 V because there is additional current flowing from the ADCLK944 LVPECL driver through the pull-down resistor.

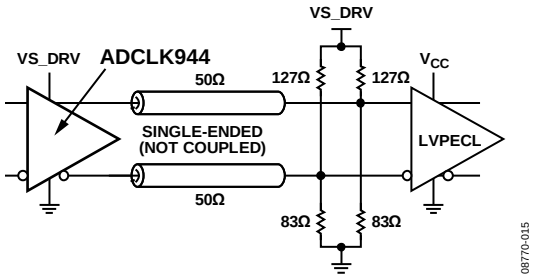

Figure 14. DC-Coupled, 3.3 V LVPECL Far-End Thevenin Termination

LVPECL Y-termination (see Figure 15) is an elegant termination scheme that uses the fewest components and offers both odd- and even-mode impedance matching. Even-mode impedance matching is an important consideration for closely coupled transmission lines at high frequencies. Its main drawback is that it offers limited flexibility for varying the drive strength of the emitter-follower LVPECL driver. This can be an important consideration when driving long trace lengths but is usually not an issue.

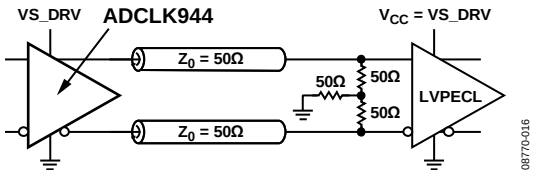

Figure 15. DC-Coupled, 3.3 V LVPECL Y-Termination

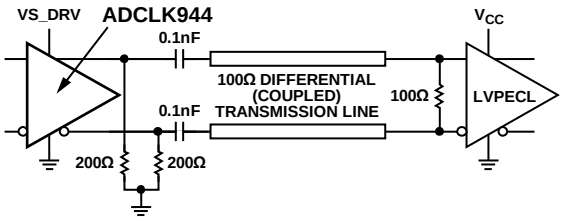

Figure 16. AC-Coupled LVPECL with Parallel Transmission Line

PCB LAYOUT CONSIDERATIONS

The ADCLK944 buffer is designed for very high speed applications. Consequently, high speed design techniques must be used to achieve the specified performance. It is critically important to use low impedance supply planes for both the negative supply (V_{EE}) and the positive supply (V_{CC}) planes as part of a multilayer board. Providing the lowest inductance return path for switching currents ensures the best possible performance in the target application.

The following references to the ground plane assume that the V_{EE} power plane is grounded for LVPECL operation. Note that, for ECL operation, the V_{CC} power plane becomes the ground plane.

It is also important to adequately bypass the input and output supplies. Place a 1 µF electrolytic bypass capacitor within several inches of each V_{CC} power supply pin to the ground plane. In addition, place multiple high quality 0.001 µF bypass capacitors as close as possible to each V_{CC} supply pin, and connect the capacitors to the ground plane with redundant vias. Select high frequency bypass capacitors for minimum inductance and ESR. To improve the effectiveness of the bypass at high frequencies, minimize parasitic layout inductance. Also, avoid discontinuities along input and output transmission lines; such discontinuities can affect jitter performance.

In a 50 Ω environment, input and output matching have a significant impact on performance. The buffer provides internal 50 Ω termination resistors for both the CLK and $\overline{\text{CLK}}$ inputs. Normally, the return side is connected to the reference pin that is provided. Bypass the termination potential using ceramic capacitors to prevent undesired aberrations on the input signal due to parasitic inductance in the termination return path. If the inputs are dc-coupled to a source, take care to ensure that the pins are within the rated input differential and common-mode voltage ranges.

If the return is floated, the device exhibits a 100 Ω cross-termination, but the source must then control the common-mode voltage and supply the input bias currents.

ESD/clamp diodes between the input pins prevent the application from developing excessive offsets to the input transistors. ESD diodes are not optimized for best ac performance. When a clamp is required, it is recommended that appropriate external diodes be used.

Exposed Metal Paddle

The exposed metal paddle on the ADCLK944 package is both an electrical connection and a thermal enhancement. For the device to function properly, the paddle must be properly attached to the V_{EE} pins.

When properly mounted, the ADCLK944 also dissipates heat through its exposed paddle. The PCB acts as a heat sink for the ADCLK944. The PCB attachment must provide a good thermal path to a larger heat dissipation area. This requires a grid of vias from the top layer of the PCB down to the V_{EE} power plane (see Figure 17). The ADCLK944 evaluation board (ADCLK944/PCBZ) provides an example of how to attach the part to the PCB.

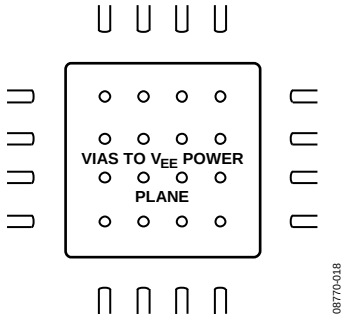

Figure 17. PCB Land for Attaching Exposed Paddle

INPUT TERMINATION OPTIONS

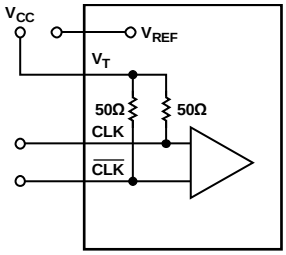

Figure 18. Interfacing to CML Inputs

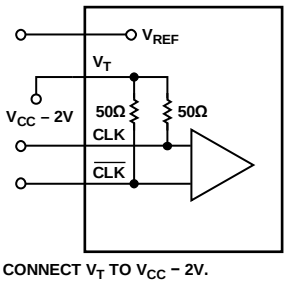

Figure 19. Interfacing to PECL Inputs

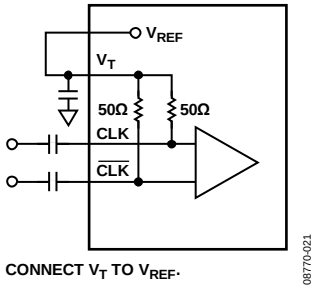

Figure 20. AC Coupling Differential Signal Inputs, Such as LVDS

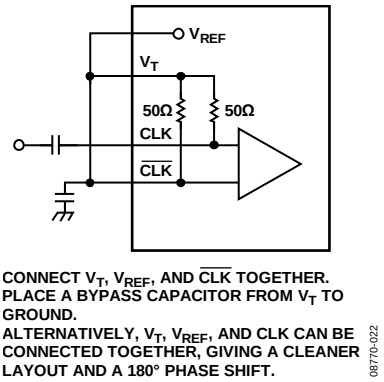

Figure 21. Interfacing to AC-Coupled, Single-Ended Inputs

OUTLINE DIMENSIONS

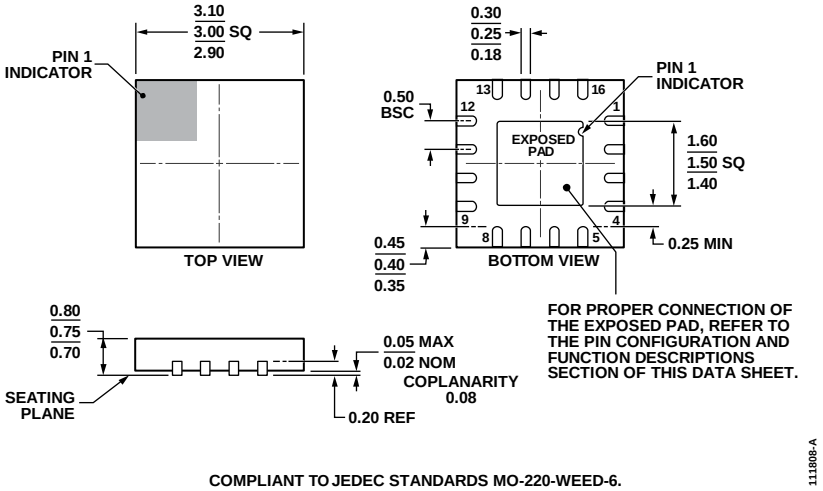

Figure 22. 16-Lead Lead Frame Chip Scale Package [LFCSP_WQ]
3 mm × 3 mm Body, Very Very Thin Quad
(CP-16-18)
Dimensions shown in millimeters

ORDERING GUIDE

Model[1]	Temperature Range	Package Description	Package Option	Branding Code
ADCLK944BCPZ-R2	−40°C to +85°C	16-Lead LFCSP_WQ	CP-16-18	Y2K
ADCLK944BCPZ-R7	−40°C to +85°C	16-Lead LFCSP_WQ	CP-16-18	Y2K
ADCLK944BCPZ-WP	−40°C to +85°C	16-Lead LFCSP_WQ	CP-16-18	Y2K
ADCLK944/PCBZ		Evaluation Board		

[1] Z = RoHS Compliant Part.