800 MHz Clock Distribution IC, PLL Core, Dividers, Delay Adjust, Eight Outputs

Preliminary Technical Data

AD9510

FEATURES

- **Low phase noise phase-locked loop core**
  - **Reference input frequencies to 250 MHz**
  - **Programmable dual-modulus prescaler**
  - **Programmable charge pump (CP) current**
  - **Separate CP supply (VCP) extends tuning range**
- **Two 1.5 GHz, differential clock inputs**
- **8 programmable dividers, 1 to 32, all integers**
- **Phase select for output-to-output coarse delay adjust**
- **4 independent 800 MHz LVPECL outputs**
  - **Additive output jitter 225 fs rms**
- **4 independent 800 MHz/250 MHz LVDS/CMOS clock outputs**
  - **Additive output jitter 275 fs rms**
  - **Fine delay adjust on 2 outputs, 6-bit delay words**
- **4-wire or 3-wire serial control port**
- **Space-saving 64-lead LFCSP**

APPLICATIONS

- **Low jitter, low phase noise clock distribution**
- **Clocking high speed ADCs, DACs, DDS, DDC, DUC, MxFEs**
- **High performance wireless transceivers**
- **High performance instrumentation**
- **Broadband infrastructure**

FUNCTIONAL BLOCK DIAGRAM

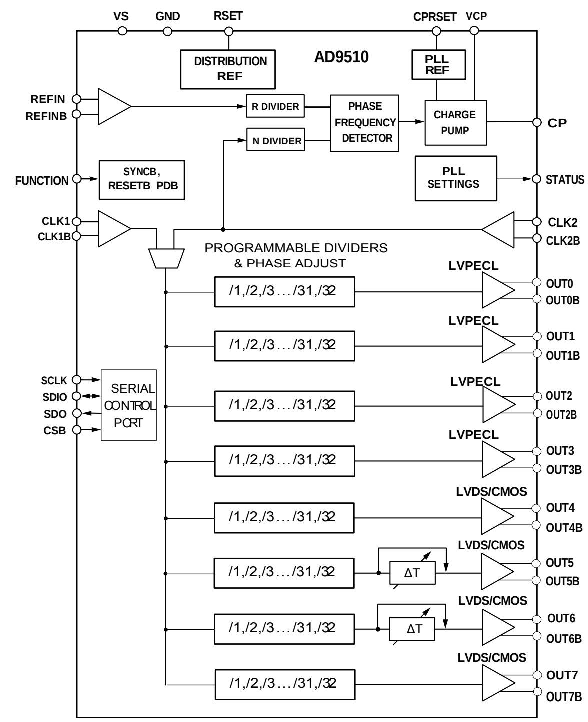

Figure 1.

GENERAL DESCRIPTION

The AD9510 provides a multi-output clock distribution function along with an on-chip PLL core. The design emphasizes low jitter and phase noise in order to maximize data converter performance. Other applications with demanding phase noise and jitter requirements also benefit from this part.

The PLL section consists of a programmable reference divider (R); a low noise phase frequency detector (PFD); a precision charge pump (CP); and a programmable feedback divider (N). By connecting an external VCXO or VCO to the CLK2/CLK2B pins, frequencies up to 1.5 GHz may be synchronized to the input reference.

There are eight independent clock outputs. Four outputs are LVPECL, and four are selectable as either LVDS or CMOS levels. The LVPECL and LVDS outputs operate to 800 MHz, and the CMOS outputs operate to 250 MHz.

Each output has a programmable divider that may be bypassed or set to divide by any integer up to 32. The phase of one clock output relative to another clock output may be varied by means of a divider phase select function that serves as a coarse timing adjustment. Two of the LVDS/CMOS outputs also feature programmable delay elements with a range of up to 10 ns of delay. This fine tuning delay block has 6-bit resolution, giving 64 possible delays from which to choose.

The AD9510 is ideally suited for data converter clocking applications where maximum converter performance is achieved by encode signals with subpicosecond jitter.

The AD9510 is available in a 64-lead LFCSP and may be operated from a single 3.3 V supply. An external VCO which requires an extended voltage range may be accommodated by connecting the charge pump supply (VCP) to 5.5 V. The temperature range is −40°C to +85°C.

Rev. PrA

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TABLE OF CONTENTS

REVISION HISTORY

11/04—Revision PrA: Preliminary Version

SPECIFICATIONS

V_S = 3.3 V ± 5%; $V_S \le V_{CP} \le$ 5.5 V, T_A = 25°C, R_{SET} = 4.12 kΩ, CPR_{SET} = 5.1 kΩ, unless otherwise noted.

PLL CHARACTERISTICS

Table 1.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
REFERENCE INPUTS (REFIN)					
Input Frequency	0		250	MHz	
Input Sensitivity, Differential		200		mV	
Input Voltage, Single-Ended	1.1		1.7	V	REFINB capacitively bypassed to RF ground
Input Common-Mode Voltage		1.6		V	Self-bias voltage of REFINB
Input Capacitance		2		pF	
Input Resistance		5		kΩ	
PHASE/FREQUENCY DETECTOR (PFD)					
Phase Frequency Detector Input Frequency			80	MHz	Antibacklash pulse width 0D <1:0> = 00
Phase Frequency Detector Input Frequency				MHz	Antibacklash pulse width 0D <1:0> = 01
Phase Frequency Detector Input Frequency				MHz	Antibacklash pulse width 0D <1:0> = 10
Antibacklash Pulse Width		1.3		ns	0D <1:0> = 00
Antibacklash Pulse Width		2.9		ns	0D <1:0> = 01
Antibacklash Pulse Width		6.0		ns	0D <1:0> = 10
CHARGE PUMP (CP)					
I_{CP} Sink/Source					Programmable
High Value		5		mA	
Low Value		625		µA	
Absolute Accuracy		2.5		%	$V_{CP} = V_S/2$
R_{SET} Range		2.7/10		kΩ	
I_{CP} Three-State Leakage		1		nA	
Sink and Source Current Matching		2		%	0.5 V < CP < V_{CP} – 0.5 V
I_{CP} vs. V_{CP}		1.5		%	0.5 V < CP < V_{CP} – 0.5 V
I_{CP} vs. Temperature		2		%	CP = $V_S/2$
RF CHARACTERISTICS (CLK2 – PLL FEEDBACK)					CLK2 is electrically identical to CLK1, the distribution only input (see Clock Inputs); can be used as differential or single-ended inputs
Input Frequency			1.5	GHz	Frequencies > 800 MHz require a minimum divide-by-2 see the Distribution section
Input Sensitivity, Differential		200		mV	
Input Common-Mode Voltage, V_{CM}		1.6		V	Self biased; enables ac coupling
Input Single-Ended Sensitivity		V_{CM} ± 100		mV	When dc-coupled, B input capacitively bypassed to RF ground
Input Resistance		5		kΩ	
Input Capacitance		2		pF	

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
NOISE CHARACTERISTICS					
In-band noise of the charge pump/ phase frequency detector (inband means within the LBW of the PLL)					The synthesizer phase noise floor is estimated by measuring the in-band phase noise at the output of the VCO and subtracting 20logN (where *N* is the N divider value).
@ 50 kHz PFD Frequency		−172		dBc/Hz	
@ 2 MHz PFD Frequency		−156		dBc/Hz	
@ 10 MHz PFD Frequency		−149		dBc/Hz	
@ 50 MHz PFD Frequency		−142		dBc/Hz	
PLL Figure of Merit		$-219 + 10 \times \log (f_{PFD})$		dBc/Hz	Approximation of the PFD/CP phase noise floor (in the flat region) inside the PLL loop bandwidth. When running closed loop this phase noise is gained up by 20 × log(N)[1]
PRESCALER					
Prescaler Input Frequency					
P = 2 DM (2/3)			500	MHz	
P = 4 DM (4/5)			750	MHz	
P = 8 DM (8/9)			1500	MHz	
P = 16 DM (16/17)			1500	MHz	
P = 32 DM (32/33)			1500	MHz	
Prescaler Output Frequency			300	MHz	
PLL DIGITAL LOCK DETECT WINDOW					Signal available at STATUS pin when selected by 08h <5:2>
Required to Lock (Coincidence of Edges)					Selected by register ODh
Low Range		3.5		ns	<5> = 1
High Range		9.5		ns	<5> = 0
To Unlock after Lock (Hysteresis)					Selected by register ODh
Low Range		7		ns	<5> = 1
High Range		15		ns	<5> = 0

[1] Example: $-219 + 10 \times \log (f_{PFD}) + 20 \times \log(N)$ should give the values for the in-band noise at the VCO output.

CLOCK INPUTS

Table 2.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
CLOCK INPUTS					CLK1 and CLK2 are electrically identical; can be used as differential or single-ended inputs
Input Frequency			1.5	GHz	Frequencies > 800 MHz require a minimum divide-by-2 see the Distribution section
Input Sensitivity, Differential		200		mV	
Input Common-Mode Voltage , V_{CM}		1.6		V	Self-biased; enables ac coupling
Input Single-Ended Sensitivity		$V_{CM} \pm 100$		mV	When dc-coupled, B input capacitively bypassed to RF ground
Input Resistance		5		kΩ	Self-biased
Input Capacitance		2		pF	
CLK1 to CLK2 Isolation				dB	

CLOCK OUTPUTS

Table 3.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
LVPECL CLOCK OUTPUTS					Termination = 50 Ω to V_S − 2 V; default
OUT0, OUT1 OUT2, OUT3; Differential					Output level setting 3C (3D) (3E) (3F) <3:2> = 10
Output Frequency			800	MHz	
Output High Voltage (V_{OH})	V_S − 1.2		V_S − 0.8	V	@ dc
Output Low Voltage (V_{OL})	V_S − 1.8		V_S − 1.6	V	@ dc
Output Differential Voltage (V_{OD})		800		mV	@ dc
Isolation LVPECL to LVPECL Output				dB	100 MHz output with 50 MHz aggressor
Isolation LVDS to LVPECL Output				dB	100 MHz output with 50 MHz aggressor
Isolation CMOS to LVPECL Output				dB	100 MHz output with 50 MHz aggressor
LVDS CLOCK OUTPUTS					Termination = 100 Ω differential; default
OUT4, OUT5, OUT6, OUT7; Differential					Output Level setting 40 (41) (42) (43) <2:1> = 01, 3.5 mA termination current
Output Frequency			800	MHz	
Differential Output Voltage (V_{OD})		350		mV	
Delta V_{OD}		5		mV	
Output Offset Voltage (V_{OS})		1.25		V	
Delta V_{OS}		5		mV	
Short-Circuit Current (I_{SA}, I_{SB})		13		mA	Output shorted to GND
Isolation LVDS to LVDS				dB	100 MHz output with 50 MHz aggressor
Isolation LVPECL to LVDS				dB	100 MHz output with 50 MHz aggressor
Isolation CMOS to LVDS				dB	100 MHz output with 50 MHz aggressor
CMOS CLOCK OUTPUTS					B outputs are inverted; termination = open
OUT4, OUT5, OUT6, OUT7; Single Ended					
Output Frequency			250	MHz	5 pF load
Output Voltage High (V_{OH})		2.7		V	
Output Voltage Low (V_{OL})		0.4		V	
Isolation CMOS to CMOS				dB	100 MHz output with 50 MHz aggressor
Isolation LVPECL to CMOS				dB	100 MHz output with 50 MHz aggressor
Isolation LVDS to CMOS				dB	100 MHz output with 50 MHz aggressor

TIMING CHARACTERISTICS

Table 4.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
LVPECL					Termination = 50 Ω to V_S − 2 V; default
					Output level setting 3C (3D) (3E) (3F) <3:2> = 10
Output Rise Time, t_{RP}		120		ps	20% to 80%
Output Fall Time, t_{FP}		120		ps	80% to 20%
CLK-TO-LVPECL OUT					CLK1 or CLK2
Propagation Delay, t_{PECL}					
Divide = Bypass		0.65		ns	
Divide = 2 – 32		0.65		ns	
Output Skew, t_{SKP}		25	50	ps	LVPECL to LVPECL on same part[1]
Output Skew, t_{SKP_AB}		150	300	ps	LVPECL to LVPECL on different parts[2]

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
LVDS					Termination = 100 Ω differential; default
					Output level setting 40 (41) (42) (43) <2:1> = 01, 3.5 mA termination current
Output Rise Time, t_{RL}		250		ps	20% to 80%
Output Fall Time, t_{FL}		250		ps	80% to 20%
CLK-TO-LVDS OUT					
Propagation Delay, t_{LVDS}					
Divide = Bypass		1.4		ns	
Divide = 2 – 32		1.4		ns	
Output Skew, t_{SKL}		50	100	ps	OUT4 to OUT7 on same part
Output Skew, t_{SKL_AB}		200	400	ps	LVDS on different parts
CLK-TO-LVDS OUT DELAY ADJUST CHANNEL					Delay off
Propagation Delay, t_{LVDSD}					OUT5 to OUT6 on same part
Divide = Bypass		1.45		ns	
Divide = 2 – 32		1.45		ns	
Output Skew, t_{SKLD}		50	100	ps	OUT5 to OUT6 on same part
CMOS					B outputs are inverted; termination = open
Output Rise Time, t_{RL}		300		ps	20% to 80%; C_{LOAD} = 3 pF
Output Fall Time, t_{FL}		300		ps	80% to 20%; C_{LOAD} = 3 pF
CLK-TO-CMOS OUT					
Propagation Delay, t_{CMOS}					C_{LOAD} = 3 pF
Divide = Bypass		1.4		ns	
Divide = 2 – 32		1.4		ns	
Output Skew, t_{SKC}		50	150	ps	CMOS to CMOS on same part
Output Skew, t_{SKC_AB}		200	400	ps	CMOS to CMOS on different parts
CLK-TO-CMOS OUT DELAY ADJUST CHANNEL					Delay off
Propagation Delay, t_{CMOSD}					C_{LOAD} = 3 pF
Divide = Bypass		1.45		ns	
Divide = 2 – 32		1.45		ns	
Output Skew, t_{SKCD}		50	150	ps	OUT5 to OUT6 on same part
LVPECL-TO-LVDS OUT					Everything the same; different logic
Output Skew, t_{SKP_L}		0.75		ns	LVPECL to LVDS on same part
LVPECL-TO-CMOS OUT					Everything the same; different logic
Output Skew, t_{SKP_C}		0.75		ns	LVPECL to CMOS on same part
LVDS-TO-CMOS OUT					Everything the same; different logic
Output Skew, t_{SKL_C}		100	150	ps	LVDS to CMOS on same part
DELAY ADJUST					OUT5 (OUT6); LVDS and CMOS
Shortest Delay Range					35h (39h) <5:0> 111111
Zero Scale		0.3		ns	36h (3Ah) <5:0> 000000
Full Scale		1.0		ns	36h (3Ah) <5:0> 111111
Linearity				%LSB	
Longest Delay Range					35h (39h) <5:0> 000000
Zero Scale		0.5		ns	36h (3Ah) <5:0> 000000
Full Scale		10		ns	36h (3Ah) <5:0> 111111
Linearity				%LSB	

[1] Defined as the worst-case difference between any two similar delay paths within a single device operating at the same voltage and temperature.
[2] Defined as the absolute worst-case difference between any two delay paths on any two devices operating at the same voltage and temperature. Part-to-part skew is the **total** skew difference; pin-to-pin skew + part-to-part skew.

CLOCK OUTPUT PHASE NOISE

Table 5.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
CLK1 TO LVPECL ADDITIVE PHASE NOISE					Distribution section only; does not include PLL or external VCO/VCXO
CLK1 = 622.08 MHz, OUTN = 622.08 MHz					Input slew rate > 1 V/ns
Divide Ratio = 1					
@ 10 Hz Offset		−125		dBc/Hz	
@ 100 Hz Offset		−132		dBc/Hz	
@ 1 kHz Offset		−140		dBc/Hz	
@ 10 kHz Offset		−148		dBc/Hz	
@ 100 kHz Offset		−153		dBc/Hz	
>1 MHz Offset		−154		dBc/Hz	
CLK1 = 622.08 MHz, OUTN = 155.52 MHz					
Divide Ratio = 4					
@ 10 Hz Offset		−130		dBc/Hz	
@ 100 Hz Offset		−140		dBc/Hz	
@ 1 kHz Offset		−148		dBc/Hz	
@ 10 kHz Offset		−155		dBc/Hz	
@ 100 kHz Offset		−161		dBc/Hz	
>1 MHz Offset		−161		dBc/Hz	
CLK1 = 622.08 MHz, OUTN = 38.88 MHz					
Divide Ratio = 16					
@ 10 Hz Offset		−145		dBc/Hz	
@ 100 Hz Offset		−152		dBc/Hz	
@ 1 kHz Offset		−161		dBc/Hz	
@ 10 kHz Offset		−165		dBc/Hz	
@ 100 kHz Offset		−165		dBc/Hz	
>1 MHz Offset		−166		dBc/Hz	
CLK1 = 491.52 MHz, OUTN = 61.44 MHz					
Divide Ratio = 8					
@ 10 Hz Offset		−131		dBc/Hz	
@ 100 Hz Offset		−142		dBc/Hz	
@ 1 kHz Offset		−153		dBc/Hz	
@ 10 kHz Offset		−160		dBc/Hz	
@ 100 kHz Offset		−165		dBc/Hz	
> 1 MHz Offset		−165		dBc/Hz	
CLK1 = 491.52 MHz, OUTN = 245.76 MHz					
Divide Ratio = 2					
@ 10 Hz Offset		−127		dBc/Hz	
@ 100 Hz Offset		−136		dBc/Hz	
@ 1 kHz Offset		−144		dBc/Hz	
@ 10 kHz Offset		−153		dBc/Hz	
@ 100 kHz Offset		−157		dBc/Hz	
>1 MHz Offset		−158		dBc/Hz	
CLK1 = 245.76 MHz, OUTN = 61.44 MHz					
Divide Ratio = 4					
@ 10 Hz Offset		−140		dBc/Hz	
@ 100 Hz Offset		−144		dBc/Hz	
@ 1 kHz Offset		−154		dBc/Hz	
@ 10 kHz Offset		−163		dBc/Hz	
@ 100 kHz Offset		−164		dBc/Hz	

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
>1 MHz Offset		−165		dBc/Hz	
CLK1-TO-LVDS ADDITIVE PHASE NOISE					Distribution section only; does not include PLL or external VCO/VCXO Characterization ongoing
CLK1 = 622.08 MHz, OUTN = 622.08 MHz					
Divide Ratio = 1					
@ 10 Hz Offset				dBc/Hz	
@ 100 Hz Offset				dBc/Hz	
@ 1 kHz Offset				dBc/Hz	
@ 10 kHz Offset				dBc/Hz	
@ 100 kHz Offset				dBc/Hz	
>1 MHz Offset				dBc/Hz	
CLK1 = 622.08 MHz, OUTN = 155.52 MHz					
Divide Ratio = 4					
@ 10 Hz Offset				dBc/Hz	
@ 100 Hz Offset				dBc/Hz	
@ 1 kHz Offset				dBc/Hz	
@ 10 kHz Offset				dBc/Hz	
@ 100 kHz Offset				dBc/Hz	
>1 MHz Offset				dBc/Hz	
CLK1 = 622.08 MHz, OUTN = 38.88 MHz					
Divide Ratio = 16					
@ 10 Hz Offset				dBc/Hz	
@ 100 Hz Offset				dBc/Hz	
@ 1 kHz Offset				dBc/Hz	
@ 10 kHz Offset				dBc/Hz	
@ 100 kHz Offset				dBc/Hz	
>1 MHz Offset				dBc/Hz	
CLK1 = 491.52 MHz, OUTN = 61.44 MHz					
Divide Ratio = 8					
@ 10 Hz Offset				dBc/Hz	
@ 100 Hz Offset				dBc/Hz	
@ 1 kHz Offset				dBc/Hz	
@ 10 kHz Offset				dBc/Hz	
@ 100 kHz Offset				dBc/Hz	
> 1 MHz Offset				dBc/Hz	
CLK1 = 491.52 MHz, OUTN = 245.76 MHz					
Divide Ratio = 2					
@ 10 Hz Offset				dBc/Hz	
@ 100 Hz Offset				dBc/Hz	
@ 1 kHz Offset				dBc/Hz	
@ 10 kHz Offset				dBc/Hz	
@ 100 kHz Offset				dBc/Hz	
>1 MHz Offset				dBc/Hz	
CLK1 = 245.76 MHz, OUTN = 61.44 MHz					
Divide Ratio = 4					
@ 10 Hz Offset				dBc/Hz	
@ 100 Hz Offset				dBc/Hz	
@ 1 kHz Offset				dBc/Hz	
@ 10 kHz Offset				dBc/Hz	
@ 100 kHz Offset				dBc/Hz	
>1 MHz Offset				dBc/Hz	

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
CLK1 to CMOS ADDITIVE PHASE NOISE					Distribution section only; does not include PLL or external VCO/VCXO
CLK1 = 245.76 MHz, OUTN = 245.76 MHz					
Divide Ratio = 1					
@ 10 Hz Offset		−117		dBc/Hz	
@ 100 Hz Offset		−124		dBc/Hz	
@ 1 kHz Offset		−131		dBc/Hz	
@ 10 kHz Offset		−141		dBc/Hz	
@ 100 kHz Offset		−146		dBc/Hz	
@ 1 MHz Offset		−150		dBc/Hz	
> 10 MHz Offset		−156		dBc/Hz	
CLK1 = 245.76 MHz, OUTN = 61.44 MHz					
Divide Ratio = 4					
@ 10 Hz Offset		−128		dBc/Hz	
@ 100 Hz Offset		−136		dBc/Hz	
@ 1 kHz Offset		−144		dBc/Hz	
@ 10 kHz Offset		−152		dBc/Hz	
@ 100 kHz Offset		−158		dBc/Hz	
@ 1 MHz Offset		−160		dBc/Hz	
>10 MHz Offset		−162		dBc/Hz	
CLK1 = 78.6432 MHz, OUTN = 78.6432 MHz					
Divide Ratio = 1					
@ 10 Hz Offset		−127		dBc/Hz	
@ 100 Hz Offset		−135		dBc/Hz	
@ 1 kHz Offset		−142		dBc/Hz	
@ 10 kHz Offset		−151		dBc/Hz	
@ 100 kHz Offset		−156		dBc/Hz	
@ 1 MHz Offset		−158		dBc/Hz	
>10 MHz Offset		−160		dBc/Hz	
CLK1 = 78.6432 MHz, OUTN = 39.3216 MHz					
Divide Ratio = 2					
@ 10 Hz Offset		−134		dBc/Hz	
@ 100 Hz Offset		−140		dBc/Hz	
@ 1 kHz Offset		−148		dBc/Hz	
@ 10 kHz Offset		−156		dBc/Hz	
@ 100 kHz Offset		−161		dBc/Hz	
> 1 MHz Offset		−162		dBc/Hz	

CLOCK OUTPUT ADDITIVE TIME JITTER[1]

Table 6.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
LVPECL OUTPUT ADDITIVE TIME JITTER					Distribution section only; does not include PLL or external VCO/VCXO
CLK1 = 622.08 MHz, OUT0:3 = 622.08 MHz		40		fs rms	BW = 12 kHz – 20 MHz
Divide Ratio = 1					(OC-12)
CLK1 = 622.08 MHz, OUT0:3 = 155.52 MHz		55		fs rms	BW = 12 kHz – 20 MHz
Divide Ratio = 4					(OC-3)
CLK1 = 200 MHz, OUT0:3 = 100 MHz		225		fs rms	Calculated from SNR of ADC method; F_C = 100 MHz with A_{IN} = 170 MHz
Divide Ratio = 2					
LVDS OUTPUT ADDITIVE TIME JITTER					Distribution section only; does not include PLL or external VCO/VCXO
CLK1 = 200 MHz, OUT4 = 100 MHz		275		fs rms	Calculated from SNR of ADC method; F_C = 100 MHz with A_{IN} = 170 MHz
CMOS OUTPUT ADDITIVE TIME JITTER					Distribution section only; does not include PLL or external VCO/VCXO
CLK1 = 200 MHz, OUT4 = 100 MHz		275		fs rms	Calculated from SNR of ADC method; F_C = 100 MHz with A_{IN} = 170 MHz

[1] Distribution section only; does not include PLL or external VCO/VCXO.

PLL AND DISTRIBUTION PHASE NOISE AND SPURIOUS

Table 7. PLL and Distribution

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
PHASE NOISE AND SPURIOUS					Depends on VCO/VCXO selection. Characterization ongoing.
Setup No.1					Measured at LVPECL clock outputs; ABP = 6 ns; I_{CP} = 5 mA; Ref = 30.72 MHz
245.76 MHz VCXO, F_{PFD} = 1.2288 MHz; R = 25, N = 200					
245.76 MHz Output					Divide by 1
Phase Noise @100 kHz Offset				dBc/Hz	
Spurious				dBc	First and second harmonics of F_{PFD}
61.44 MHz Output					Divide by 4
Phase Noise @100 kHz Offset				dBc/Hz	
Spurious				dBc	First and second harmonics of F_{PFD}
Setup No. 2					Measured at LVPECL clock outputs; ABP = 6 ns; I_{CP} = 5 mA; Ref = 30.72 MHz
245.76 MHz VCXO, F_{PFD} = 30.72 MHz; R = 1, N = 8					
245.76 MHz Output					Divide by 1
Phase Noise @100 kHz Offset				dBc/Hz	
Spurious				dBc	First and second harmonics of F_{PFD}
61.44 MHz Output					Divide by 4
Phase Noise @100 kHz Offset				dBc/Hz	
Spurious				dBc	First and second harmonics of F_{PFD}

SERIAL CONTROL PORT

Table 8.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
SDIO, CSB, SCLK		CMOS Levels			
Input Logic 1 Voltage				V	
Input Logic 0 Voltage				V	
Input Capacitance				pF	
SDIO, SDO		CMOS Levels			
Output Logic 1 Voltage				V	
Output Logic 0 Voltage				V	
CSB, SCLK		CMOS Levels			CSB and SCLK have 30 kΩ internal pull-down resistors
Input Logic 1 Current				µA	
Input Logic 0 Current				µA	
TIMING					
Clock Rate (SCLK, 1/t_{SCLK})			25	MHz	
Pulse-Width High, t_{PWH}	16		24	ns	
Pulse-Width Low, t_{PWL}	16		24	ns	
SDIO and CSB to SCLK Setup, t_{DS}				ns	
SCLK to SDIO Hold, t_{DH}				ns	
SCLK to Valid SDIO and SDO, t_{DV}				ns	

FUNCTION PIN

Table 9.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
INPUT CHARACTERISTICS		CMOS Levels			
Logic 1 Voltage				V	
Logic 0 Voltage				V	
Input Capacitance				pF	
Logic 1 Current				µA	
Logic 0 Current				µA	
RESET TIMING					
Pulse-Width Low				ns	
SYNC TIMING					
Pulse-Width Low	1.5			Clock cycles	Sync single chip; CLK1 or CL2, whichever is being used for distribution
Setup Time				ps	Sync multichip; Write CLK1 or CLK2, whichever is being used for distribution
Hold Time				ps	Sync multichip; Write CLK1 or CLK2, whichever is being used for distribution

STATUS PIN

Table 10.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
OUTPUT CHARACTERISTICS					
Output Voltage High (V_{OH})				mV	
Output Voltage Low (V_{OL})				mV	
MAXIMUM TOGGLE RATE			100	MHz	Applies when PLL mux is set to any divider or counter output, or PFD up/down pulse. Also applies in analog lock detect mode. Usually debug mode only. Beware that spurs may couple to output when this pin is toggling.
ANALOG LOCK DETECT					
Capacitance		3		pF	On-chip capacitance; used to calculate RC time constant for analog lock detect readback. Use pull-up resistor.

POWER

Table 11.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
POWER-UP DEFAULT MODE POWER DISSIPATION		650		mW	Power-up default state; does not include power dissipated in output load resistors.
MAXIMUM POWER DISSIPATION		1050		mW	All functions enabled, all outputs on and terminated, maximum clock rates, and frequencies. Does not include power dissipated in load resistors. (Pick these conditions.)
POWER DELTA					
CLK1, CLK2 Power-Down				mW	
Divider, DIV 2 – 32 to Bypass				mW	
LVPECL Output Power-Down					
Safe Power-Down (PD2)		56		mW	PD2 mode (safe) power-down is required when load resistors are connected. Delta does not include dissipation in load resistors.
Total Power-Down (PD3)		58		mW	PD3 mode; use only with no load resistors connected.
LVDS Output Power-Down		33	46	mW	
CMOS Output Power-Down		24	38	mW	
Delay Block Bypass				mW	
Delay Block Power-Down				mW	
PLL Section Power-Down		40		mW	

TIMING DIAGRAMS

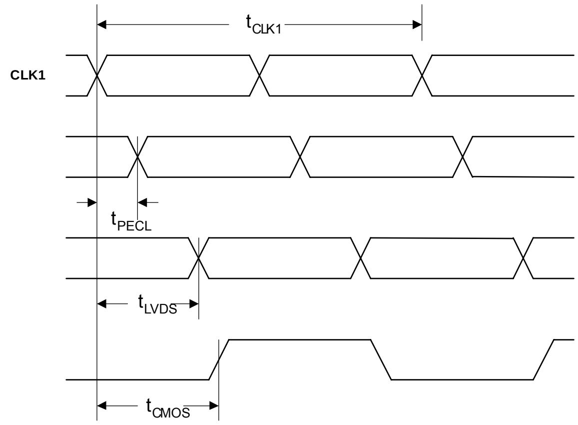

Figure 2. CLK1/CLK1B to Clock Output Timing, DIV = 1 Mode

ABSOLUTE MAXIMUM RATINGS

Table 12.

Parameter or Pin	With Respect to	Min	Max	Unit
V_S	GND	−0.3	+3.6	V
V_{CP}	GND	−0.3	+6	V
V_{CP}	V_S	−0.3		V
REFIN, REFINB				V
RSET	GND			V
CPRSET	GND			V
CLK1. CLK1B, CLK2, CLK2B				V
CLK1	CLK1B			V
CLK2	CLK2B			V
SCLK, SDIO SDO, CSB	GND			V
Outputs 0, 1, 2, 3				V
Outputs 4, 5, 6, 7				V
FUNCTION				V
STATUS				V
Junction Temperature			150	°C
Storage Temperature		−65	+150	°C
Lead Temperature (10 sec)			300	°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 sections of this specification is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.

THERMAL CHARACTERISTICS[1]

Thermal Resistance

64-Lead LFCSP

θ_{JA} = 24°C/W

[1] Thermal impedance measurements were taken on a 4-layer board in still air, in accordance with EIA/JESD51-7.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

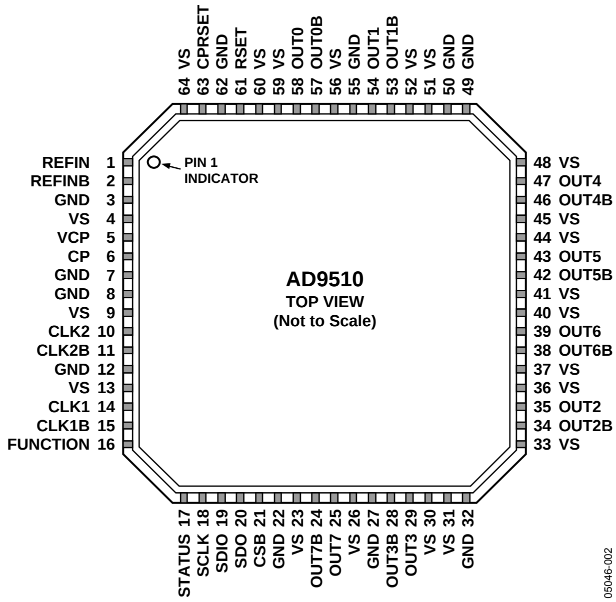

Figure 3. 64-Lead LFCSP Pin Configuration

Note that the exposed paddle on this package is an electrical connection as well as a thermal enhancement. For the device to function properly, the paddle must be attached to ground, GND.

Table 13. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	REFIN	PLL Reference Input.
2	REFINB	Complementary PLL Reference Input.
3, 7, 8, 12, 22, 27, 32, 49, 50, 55, 62	GND	Ground.
4, 9, 13, 23, 26, 30, 31, 33, 36, 37, 40, 41, 44, 45, 48, 51, 52, 56, 59, 60, 64	VS	Power Supply (3.3 V).
5	VCP	Charge Pump Power Supply. It should be greater than or equal to VS. VCP may be set as high as 5.5 V for VCOs requiring extended tuning range.
6	CP	Charge Pump Output.
10	CLK2	Clock Input Used to Connect External VCO/VCXO to Feedback Divider, N. CLK2 also drives the distribution section of the chip and may be used as a generic clock input when PLL is not used.
11	CLK2B	Complementary Clock Input Used in Conjunction with CLK2.
14	CLK1	Clock Input That Drives Distribution Section of the Chip.
15	CLK1B	Complementary Clock Input Used in Conjunction with CLK1.
16	FUNCTION	Multipurpose Input May Be Programmed as a Reset (RESETB), Sync (SYNCB), or Power-Down (PDB) Pin.
17	STATUS	Output Used to Monitor PLL Status and Sync Status.
18	SCLK	Serial Data Clock.
19	SDIO	Serial Data I/O.
20	SDO	Serial Data Output.
21	CSB	Serial Port Chip Select.
24	OUT7B	Complementary LVDS/Inverted CMOS Output.
25	OUT7	LVDS/CMOS Output.
28	OUT3B	Complementary LVPECL Output.
29	OUT3	LVPECL Output.
34	OUT2B	Complementary LVPECL Output.
35	OUT2	LVPECL Output.
38	OUT6B	Complementary LVDS/Inverted CMOS Output. OUT6 includes a delay block.
39	OUT6	LVDS/CMOS Output. OUT6 includes a delay block.
42	OUT5B	Complementary LVDS/Inverted CMOS Output. OUT5 includes a delay block.
43	OUT5	LVDS/CMOS Output. OUT5 includes a delay block.
46	OUT4B	Complementary LVDS/Inverted CMOS Output.
47	OUT4	LVDS/CMOS Output.
53	OUT1B	Complementary LVPECL Output.
54	OUT1	LVPECL Output.
57	OUT0B	Complementary LVPECL Output.
58	OUT0	LVPECL Output.
61	RSET	Current Set Resistor to Ground. Nominal value = 4.147 kΩ.
63	CPRSET	Charge Pump Current Set Resistor to Ground. Nominal value = 5.1 kΩ.

Note that the exposed paddle on this package is an electrical connection as well as a thermal enhancement. For the device to function properly, the paddle must be attached to ground, GND.

TERMINOLOGY

Phase Jitter and Phase Noise

An ideal sine wave can be thought of as having a continuous and even progression of phase with time from 0 to 360 degrees for each cycle. Actual signals, however, display a certain amount of variation from ideal phase progression over time. This phenomenon is called phase jitter. Although there are many causes that can contribute to phase jitter, one major component is due to random noise which is characterized statistically as being Gaussian (normal) in distribution.

This phase jitter leads to a spreading out of the energy of the sine wave in the frequency domain, producing a continuous power spectrum. This power spectrum is usually reported as a series of values whose units are dBc/Hz at a given offset in frequency from the sine wave (carrier). The value is a ratio (expressed in dB) of the power contained within a 1 Hz bandwidth with respect to the power at the carrier frequency. For each measurement the offset from the carrier frequency is also given.

It is also meaningful to integrate the total power contained within some interval of offset frequencies (for example, 10 kHz to 10 MHz). This is called the integrated phase noise over that frequency offset interval and can be readily related to the time jitter due to the phase noise within that offset frequency interval.

Phase noise has a detrimental effect on the performance of ADCs and DACs and RF mixers. It lowers the achievable dynamic range of the converters and mixers, although they are affected in somewhat different ways.

Time Jitter

Phase noise is a frequency domain phenomenon. In the time domain, the same effect is exhibited as time jitter. When observing a sine wave, the time of successive zero crossings is seen to vary. In the case of a square wave, the time jitter is seen as a displacement of the edges from their ideal (regular) times of occurrence. In both cases, the variations in timing from the ideal are the time jitter. Since these variations are random in nature, the time jitter is specified in units of seconds root mean square (rms) or 1 sigma of the Gaussian distribution.

Time jitter that occurs on a sampling clock for a DAC or an ADC decreases the SNR and dynamic range of the converter. A sampling clock with the lowest possible jitter provides the highest performance from a given converter.

Additive Phase Noise

It is the amount of phase noise that is attributable to the device or subsystem being measured. The phase noise of any external oscillators or clock sources has been subtracted. This makes it possible to predict the degree to which the device impacts the total system phase noise when used in conjunction with the various oscillators and clock sources, each of which contribute their own phase noise to the total. In many cases, the phase noise of one element dominates the system phase noise.

Additive Time Jitter

It is the amount of time jitter that is attributable just to the device or subsystem being measured. The time jitter of any external oscillators or clock sources has been subtracted. This makes it possible to predict the degree to which the device will impact the total system time jitter when used in conjunction with the various oscillators and clock sources, each of which contribute their own time jitter to the total. In many cases, the time jitter of the external oscillators and clock sources dominates the system time jitter.

TYPICAL PERFORMANCE CHARACTERISTICS

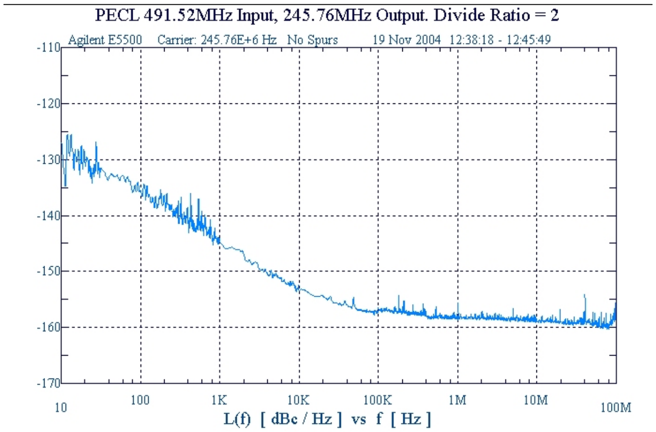

Figure 4. Phase Noise – LVPECL 245.76 MHz

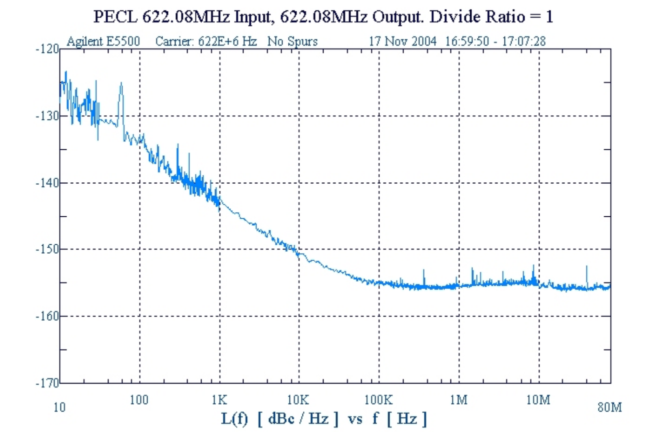

Figure 5. Phase Noise – LVPECL 622MHz

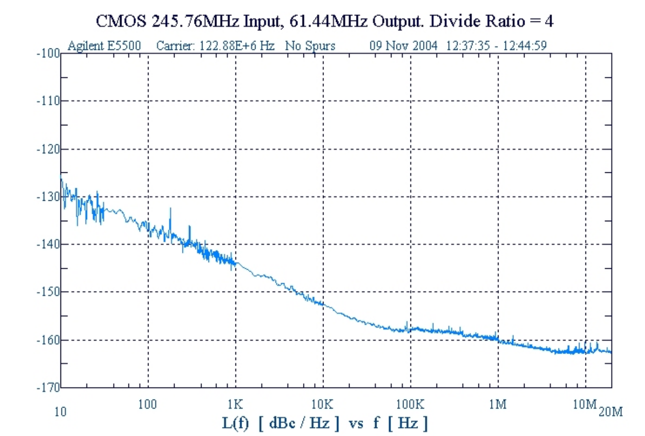

Figure 6. Phase Noise – CMOS 61.44MHz

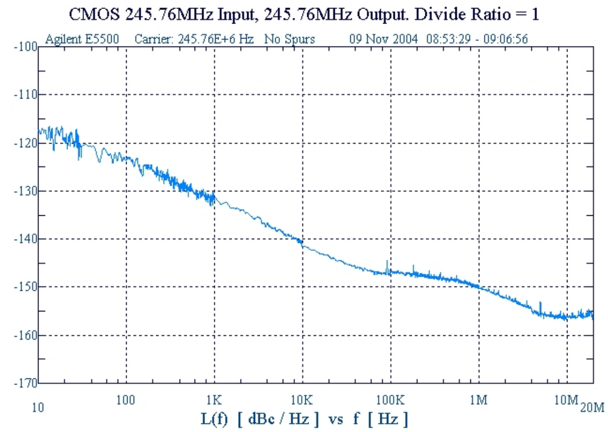

Figure 7. Phase Noise – CMOS 245.76 MHz

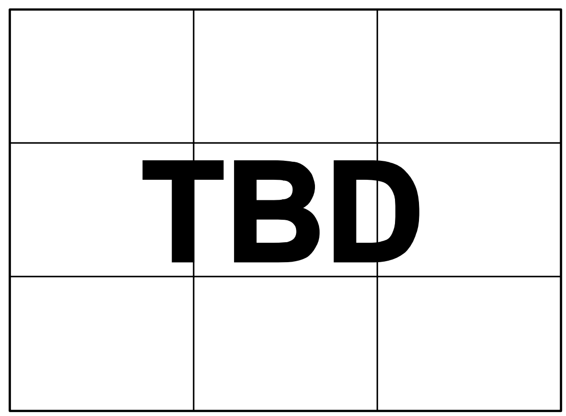

Figure 8.

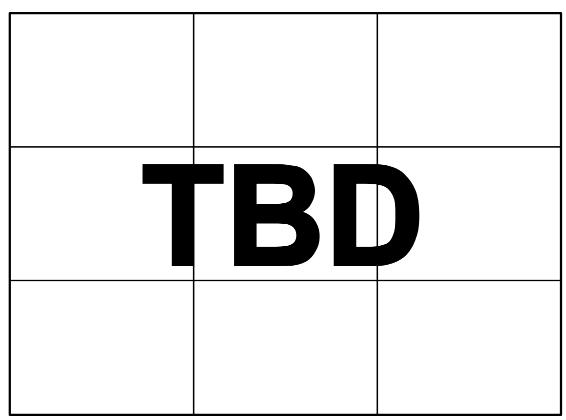

Figure 9.

TYPICAL MODES OF OPERATION

PLL with External VCXO/VCO Followed by Clock Distribution

This is the most common operational mode for the AD9510. An external oscillator (shown as VCO/VCXO) is phase locked to a reference input frequency applied to REFIN. The loop filter is usually a passive design. A VCO or a VCXO may be used. The CLK2 input is connected internally to the feedback divider, N. The CLK2 input provides the feedback path for the PLL. If the VCO/VCXO frequency exceeds maximum frequency of the output(s) being used, an appropriate divide ratio must be set in the corresponding divider(s) in the distribution section.

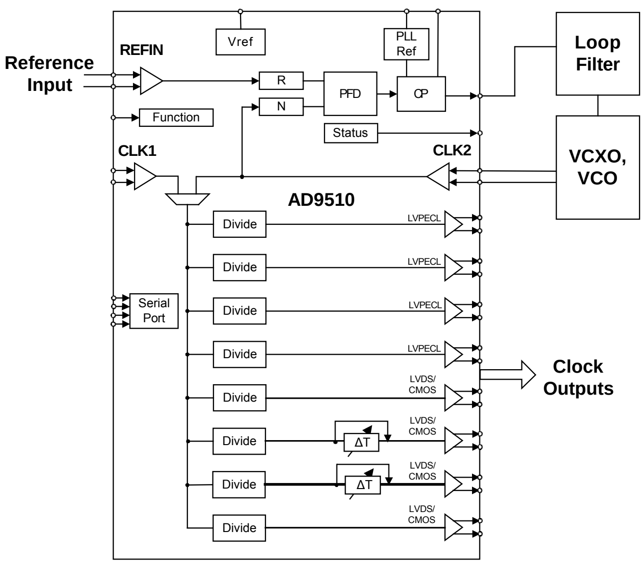

Figure 10. PLL and Clock Distribution Mode

Clock Distribution Only

In this mode, the PLL is not used. A customer can save power by initiating a PLL power-down and by powering down any unused clock channels.

In distribution mode, both CLK1 and CLK2 inputs are available for distribution to outputs via a low jitter multiplexer (MUX).

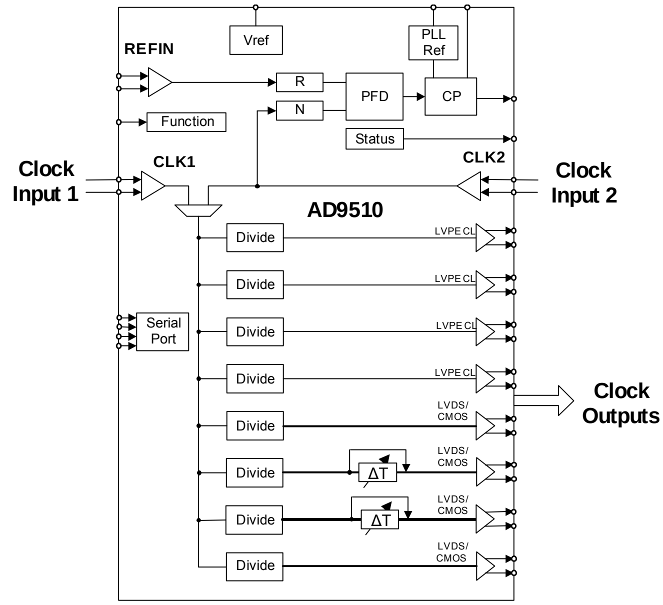

Figure 11. Clock Distribution Mode

PLL with External VCO and Band-Pass Filter Followed by Clock Distribution

An external band-pass filter may be used to possibly improve the phase noise and spurious characteristics of the PLL output. This option is most appropriate when the desire is to optimize cost by choosing a less expensive VCO combined with a moderately priced filter. Note that the BPF is shown outside of the VCO to N divider path, with the BP filter outputs routed to CLK1.

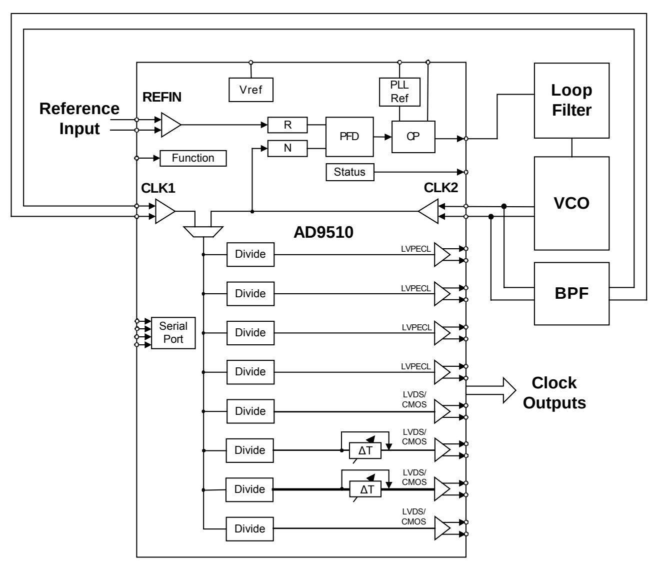

Figure 12. AD9510 with VCO and BPF Filter

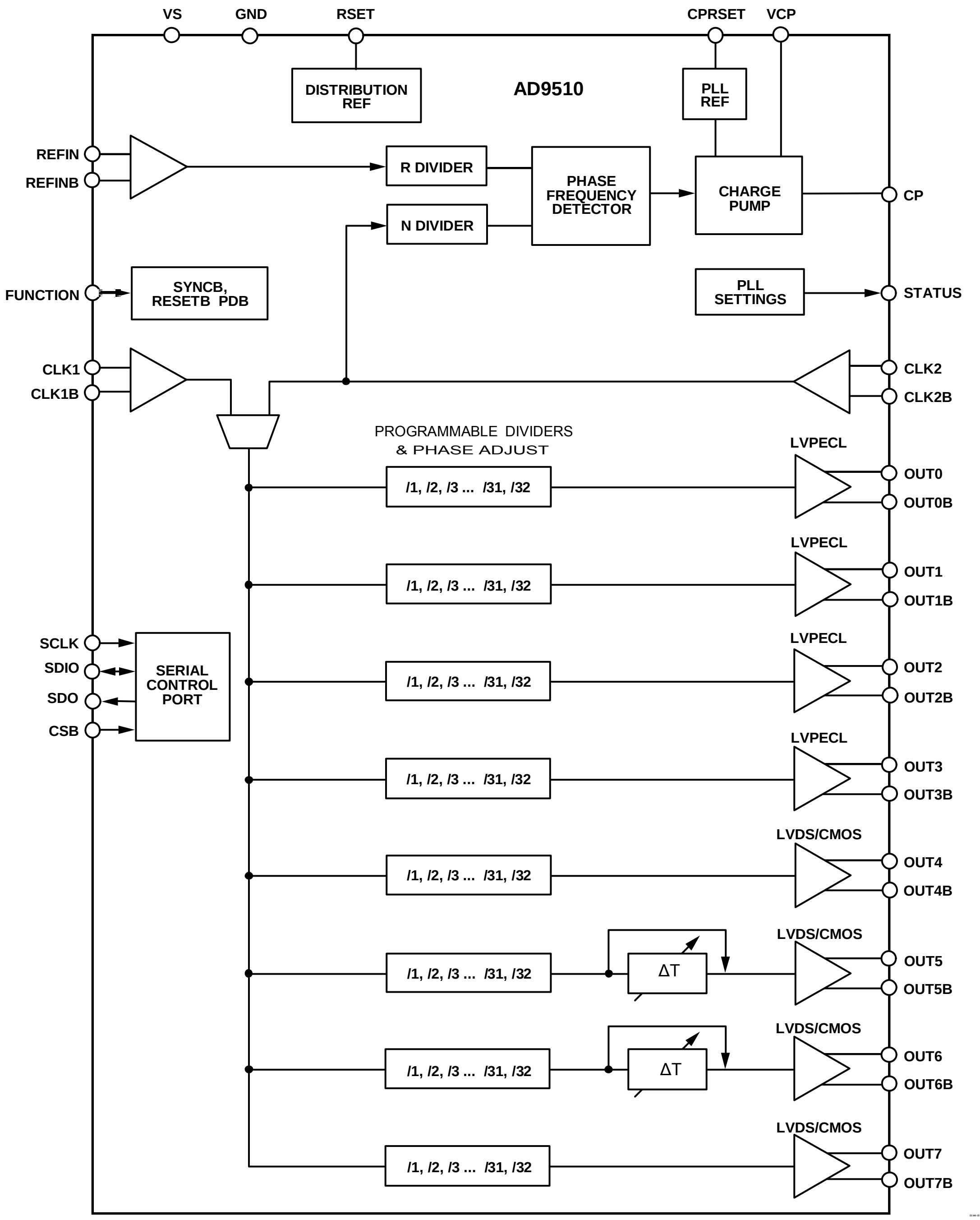

Figure 13. Functional Block Diagram

FUNCTION DESCRIPTION

OVERALL

Figure 13 shows a block diagram of the AD9510. The chip combines a programmable PLL core with a configurable clock distribution system. A complete PLL requires the addition of a suitable external VCO (or VCXO) and loop filter. This PLL can be used to lock to a reference input signal and produce an output that is related to the input frequency by the ratio defined by the programmable R and N dividers. The PLL offers some jitter clean up of the external reference signal, depending on the loop bandwidth and the phase noise performance of the VCO (VCXO).

The output from the VCO (VCXO) can be applied to the clock distribution section of the chip, where it can be divided by any integer value from 1 to 32. The duty cycle and relative phase of the outputs can be selected. There are four LVPECL outputs, (OUT0, OUT1, OUT2, and OUT3) and four outputs that can be selected as either LVDS or CMOS level outputs (OUT4, OUT5, OUT6, and OUT7). Two of these outputs (OUT5, OUT6) can also make use of a variable delay block.

Alternatively, the clock distribution section can be driven directly by an external clock signal, and the PLL can be powered off. Whenever the clock distribution section is used alone, there is no clock clean-up. The jitter of the input clock signal is passed along directly to the distribution section and may dominate at the clock outputs.

PLL OPERATION

The AD9510 has a complete PLL core on-chip, requiring only an external loop filter and VCO/VCXO. This PLL is based on the ADF4106, a PLL noted for its superb low phase noise performance. The operation of the AD9510 PLL is nearly identical to that of the ADF4106, offering an advantage to those with experience with the ADF series of PLLs. Differences include the addition of differential inputs at REFIN and CLK2, a different control register architecture, and the prescaler has been changed to allow N as low as 1. The AD9510 PLL also implements the digital lock detect feature somewhat differently than does the ADF4106 offering improved functionality at higher PFD rates. Refer to Register Map Description for details.

The PLL section can be used entirely separately from the distribution system, if so desired.

PLL REFERENCE INPUT

The REFIN and REFINB pins can be driven differentially or single-ended. These pins are internally self-biased, so they should always be capacitively coupled. This also applies to the unused side when single-ended input is used.

PLL REFERENCE DIVIDER

The REFIN/REFINB inputs are routed to reference divider, R, which is a 14-bit counter. R may be programmed to any value from 0 to 16383 via its control register. The output of the R divider goes to one of the phase/frequency detector inputs. The maximum allowable frequency into the phase/frequency detector (PFD) must not be exceeded. This means that the REFIN frequency divided by R must be less than the maximum allowable PFD frequency.

VCO/VCXO CLOCK INPUT

The CLK2 differential input may be used as a second distribution input, or it may be used to connect an external VCO or VCXO to the PLL . Only the CLK2 input port has a connection to the PLL N divider. This input can receive up to 1.5 GHz. These inputs are internally self-biased and must be capacitively coupled.

CLK1 is electrically identical, but normally feeds the distribution section instead. See Figure 16 for the equivalent circuit of CLK1/CLK2.

VCO/VCXO FEEDBACK DIVIDER

The N divider is a combination of a prescaler and two counters, A and B. Although the AD9510's PLL is similar to the ADF4106, the AD9510 has a redesigned prescaler that allows for lower values of N. The prescaler has both a dual modulus (DM) mode and a fixed divide (FD) mode. The AD9510 prescaler modes are shown in Table 14.

Table 14. PLL Prescaler Modes

Mode (FD = Fixed Divide; DM = Dual Modulus)	Divide By
FD	1
FD	2
P = 2 DM	P/P + 1 = 2/3
P = 4 DM	P/P + 1 = 4/5
P = 8 DM	P/P + 1 = 8/9
P = 16 DM	P/P + 1 = 16/17
P = 32 DM	P/P + 1 = 32/33
FD	3

When using the prescaler in a FD mode, the A counter is not used, and the B counter may need to be bypassed. The DM prescaler modes set some upper limits on the frequency, which can be applied to CLK2 . These are shown in Table 15.

Table 15. Frequency Limits per Prescaler Mode

Mode (DM = Dual Modulus)	CLK2
P = 2 DM (2/3)	< 500 MHz
P = 4 DM (4/5)	< 750 MHz
P = 8 DM (8/9)	< 1.5 GHz
P = 16 DM	< 1.5 GHz
P = 32 DM	< 1.5 GHz

A AND B COUNTERS

The AD9510 B Counter has a bypass mode (B = 1) that is not available on the ADF4106. The B counter bypass mode is only valid when using the prescaler in a FD mode. The B counter is bypassed by writing 1 to the B counter bypass bit in the register map. Note that the A counter is not used when prescaler is in FD mode.

Note also that the A/B Counters have their own reset bit that is primarily intended for test. A and B counters can also be reset using the shared R, A, and B counters reset bit.

SETTING VALUES FOR P, A, B, AND R

When operating the AD9510 in a dual-modulus mode, the input reference frequency, F_{REF}, is related to the VCO output frequency, F_{VCO}.

$$F_{VCO} = (F_{REF}/R) \times (PB + A) = F_{REF} \times N/R$$

When operating the prescaler in a fixed divide mode the A counter is not used and the equation simplifies to

$$F_{VCO} = (F_{REF}/R) \times (PB) = F_{REF} \times N/R$$

By using combinations of dual modulus and fixed divide modes, the AD9510 can achieve values of N all the way down to N = 1. Table 16 shows how a 10 MHz reference input may be locked to any integer multiple of N. Note that the same value of N may be derived in different ways, as illustrated by the case of N = 12.

Table 16. P, A, B, R – Smallest Values for N

F_{REF}	R	P	A	B	N	F_{VCO}	Mode	Notes
10	1	1	X	1	1	10	FD	P = 1, B = 1 (Bypassed)
10	1	2	X	1	2	20	FD	P = 2, B = 1 (Bypassed)
10	1	1	X	3	3	30	FD	P = 1, B = 3
10	1	1	X	4	4	40	FD	P = 1, B = 4
10	1	1	X	5	5	50	FD	P = 1, B = 5
10	1	2	X	3	6	60	FD	P = 2, B = 3
10	1	2	0	3	6	60	DM	P/P + 1 = 2/3, A = 0, B = 3
10	1	2	1	3	7	70	DM	P/P + 1 = 2/3, A = 1, B = 3
10	1	2	2	3	8	80	DM	P/P + 1 = 2/3, A = 2, B = 3
10	1	2	1	4	9	90	DM	P/P + 1 = 2/3, A = 1, B = 4
10	1	2	X	5	10	100	FD	P = 2, B = 5
10	1	2	0	5	10	100	DM	P/P + 1 = 2/3, A = 0, B = 5
10	1	2	1	5	11	110	DM	P/P + 1 = 2/3, A = 1, B = 5
10	1	2	X	6	12	120	FD	P = 2, B = 6
10	1	2	0	6	12	120	DM	P/P + 1 = 2/3, A = 0, B = 6
10	1	4	0	3	12	120	DM	P/P + 1 = 4/5, A = 0, B = 3
10	1	4	1	3	13	130	DM	P/P + 1 = 4/5, A = 1, B = 3

PHASE FREQUENCY DETECTOR (PFD) AND CHARGE PUMP

The PFD takes inputs from the R counter and N counter (N = BP + A) and produces an output proportional to the phase and frequency difference between them. Figure 14 is a simplified schematic. The PFD includes a programmable delay element that controls the width of the antibacklash pulse. This pulse ensures that there is no dead zone in the PFD transfer function and minimizes phase noise and reference spurs. Two bits in Register 0D <1:0> control the width of the pulse.

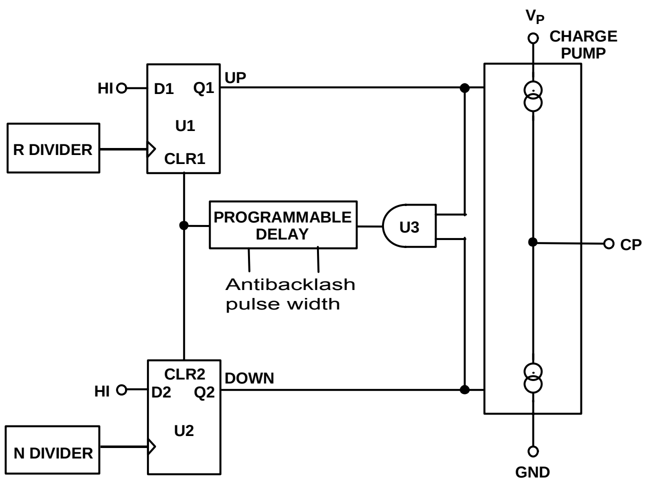

Figure 14. PFD Simplified Schematic and Timing (In Lock)

STATUS PIN

The output multiplexer on the AD9510 allows access to various internal points on the chip. The state of the STATUS pin is controlled by Register 08 <5:2>. Figure 15 shows the STATUS pin section in block diagram form.

Lock Detect

The STATUS pin can be programmed for two types of lock detect: digital and analog.

See Table 20 OD <5> for the description of this function.

The N-channel, open-drain, analog lock detect should be operated with an external pull-up resistor of 30 kΩ nominal. When lock is detected, the output is high with narrow, low going pulses.

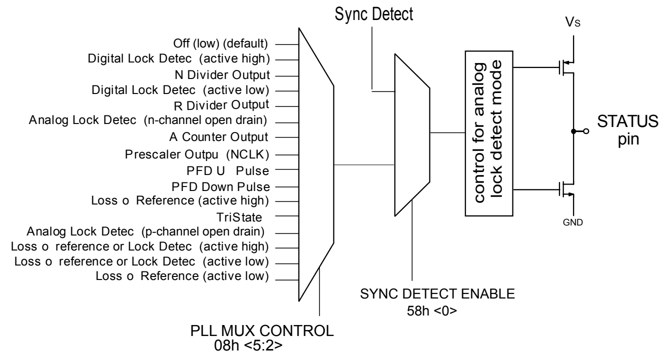

Figure 15. STATUS Pin Circuit

CLK1 CLOCK INPUT

CLK1 is the distribution only clock input. This clock input is selected by default on power-up. It is usable for inputs up to 1500 MHz.

CLK2 is electrically identical but feeds the PLL N divider as well as being selectable as the input for the distribution section through the clock select MUX.

If the distribution section is being used only, it is recommended that the unselected clock input be powered down in order to eliminate any possibility of unwanted crosstalk between the selected clock input and the unselected clock input.

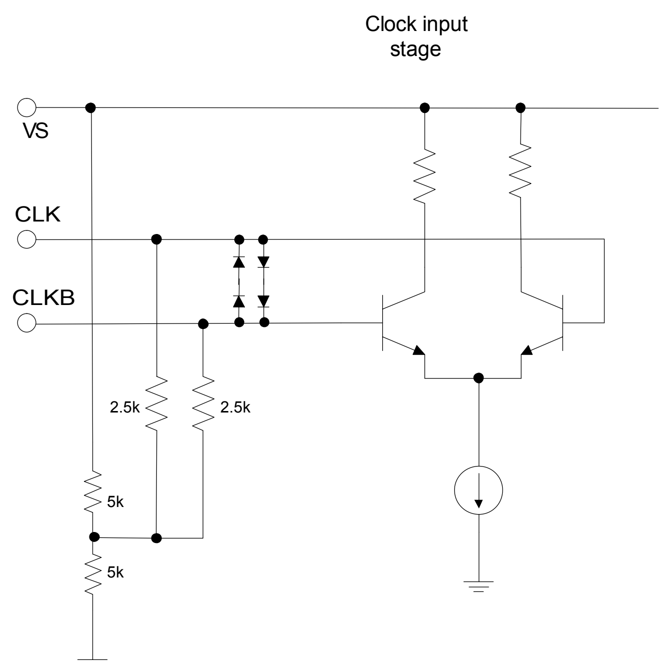

Figure 16. CLK1, CLK2 Equivalent Input Circuit

SERIAL CONTROL PORT

The AD9510 serial control port is a flexible, synchronous, serial communications port that allows an easy interface with many industry-standard microcontrollers and microprocessors. The AD9510 serial control port is compatible with most synchronous transfer formats, including both the Motorola SPI® and Intel® SSR protocols. The serial control port allows read/write access to all registers that configure the AD9510. Single or multiple byte transfers are supported, as well as MSB first or LSB first transfer formats. The AD9510 serial control port can be configured for single pin I/O (SDIO only) or two unidirectional pins for in/out (SDIO/SDO).

SERIAL CONTROL PORT PIN DESCRIPTIONS

SCLK (serial clock) is the serial shift clock. This pin is an input. SCLK is used to synchronize serial control port reads and writes. Write data bits are registered on the rising edge of this clock, and read data bits are registered on the falling edge. This pin is internally pulled down by a 30 kΩ resistor to ground.

SDIO (serial data input/output) is a dual-purpose pin and acts as either an input only in 4-wire mode or as an input/output in 3-wire mode. The AD9510 defaults to 3-wire mode (single pin I/O—SDIO only). Four-wire mode (two unidirectional pins for I/O – SDIO/SDO) may be enabled by setting 1 into the SDO enable register at Address 00h, Bit <7>.

SDO (serial data out) is used in the 4-wire mode only as a separate output pin for readback data. The AD9510 defaults to 3-wire mode. Four-wire mode may be enabled by setting 1 into the SDO enable register at Address 00h, Bit <7>.

CSB (chip select bar) is an active low control that gates the read and write cycles. When CSB is high, SDO and SDIO are in a high impedance state. This pin is internally pulled down by a 30 kΩ resistor to ground.

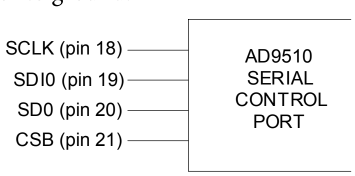

Figure 17. Serial Control Port

GENERAL OPERATION OF SERIAL CONTROL PORT

There are three phases to a communication cycle with the AD9510. Phase 1 is the instruction cycle, which is the writing of a 16-bit instruction word into the AD9510, coincident with the first 16 SCLK rising edges. The instruction word provides the AD9510 serial control port with information regarding the data transfer cycle (Phase 2) of the communication cycle. The Phase 1 instruction word defines whether the upcoming data transfer is read or write, the number of bytes in the data transfer, and the starting register address for the first byte of the data transfer.

Write

If the instruction word (Phase 1) is for a write operation (I15 = 0), then Phase 2 is the transfer of data into the serial control port buffer of the AD9510. The length of the transfer (1, 2, 3, or 4 data bytes) is indicated by 2 bits (W1:W0) in the instruction byte. Multibyte data transfer is the preferred method. Single byte data transfers are useful to reduce CPU overhead when only one byte of data needs to be loaded. CSB can be raised after each sequence of 8 bits (except the last byte) to stall the bus. The serial transfer resumes when CSB is lowered. Stalling on nonbyte boundaries resets the serial control port.

Since data is written into a serial control port buffer area, not directly into the AD9510's actual control registers, a Phase 3 operation is needed in order to transfer the serial control port buffer contents to the actual control registers of the AD9510, thereby causing them to take effect. Phase 3 consists of writing a high bit (one) to Address 5Ah, Bit <0>. This update bit is self-clearing (it is not required to write a 0 to it in order to clear it). Since any number of bytes of data may be changed before issuing an update, the update simultaneously enables all register changes since any previous update.

Read

If the instruction word (Phase 1) is for a read operation (I15 = 1), the next N × 8 SCLK cycles clock out the data from the address specified in the instruction word, where N is 1 to 4 as determined by W1:W0. The readback data is valid on the falling edge of SCLK.

The default mode of the AD9510 serial control port is 3-wire mode; therefore, the requested data normally appears on the SDIO pin. It is possible to set the AD9510 to 4-wire mode by setting 1 into the SDO enable register at Address 00h, Bit <7>. In 4-wire mode, the readback data appears on the SDO pin.

A readback request reads the data that is in the serial control port buffer area not the active data in the AD9510's actual control registers.

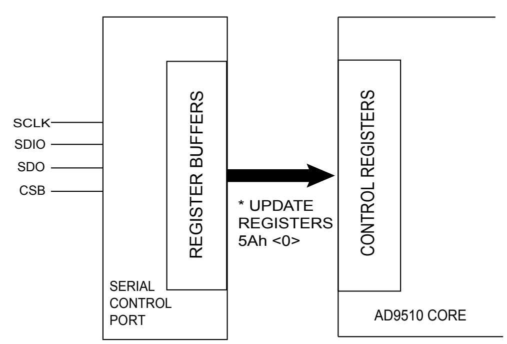

Figure 18. Relationship between Serial Control Port Register Buffers and Control Registers of the AD9510

The AD9510 uses Addresses 00h to 5Ah. Although the AD9510 serial control port allows for both 8-bit and 16-bit instructions, the 8-bit instruction mode provides access only to five address bits (A4 to A0), which restricts its use to the address space 00h to 01F. The AD9510 defaults to 16-bit instruction mode on power-up. The 8-bit instruction mode (although defined for this serial control port) is not useful for the AD9510; therefore, it is not discussed in this data sheet.

THE INSTRUCTION WORD (16 BITS)

The MSB of the instruction word is $R/\overline{W}$, which indicates whether the instruction will be a read or a write. The next two bits, W1:W0, indicate the length of the transfer in bytes. The final 13 bits are the address (A12:A0) at which to begin the read or write operation. For a write, the instruction word is followed by the number of bytes of data indicated by Bits W1:W0, which is interpreted according to Table 17.

Table 17. Byte Transfer Count

W1	W0	Bytes to Transfer
0	0	1
0	1	2
1	0	3
1	1	4

A12:A0: These 13 bits select the address within the register map which is written to or read from during the data transfer portion of the communications cycle. For multibyte transfers, this address is the starting byte address. In MSB first mode, subsequent bytes increment the address.

MSB/LSB FIRST TRANSFERS

The AD9510 instruction word and byte data may be MSB first or LSB first. The default for the AD9510 is MSB first. The LSB first mode may be set by writing 1 to Address 00h, Bit <6>. This takes effect immediately (since it only affects the operation of the serial control port) and does not require that an update be executed. Immediately after the LSB first bit is set, all serial control port operations are changed to LSB first order.

When MSB first mode is active, the instruction and data bytes must be written from MSB to LSB. Multibyte data transfers in MSB first format start with an instruction byte that includes the register address of the most significant data byte. Subsequent data bytes must follow in order from high address to low address. In MSB first mode, the serial control port internal byte address generator decrements for each data byte of the multibyte transfer cycle.

When LSB_First = 1 (LSB first), the instruction and data bytes must be written from LSB to MSB. Multibyte data transfers in LSB first format start with an instruction byte that includes the register address of the least significant data byte followed by multiple data bytes. The serial control port internal byte address generator increments for each byte of the multibyte transfer cycle.

The AD9510 serial control port data address decrements from the data address written toward 0x00 for multibyte I/O operations if the MSB first mode is active. The serial control port address increments from the data address written toward 0x1F for multibyte I/O operations if the LSB first mode is active.

Table 18. Serial Control Port, 16-Bit Instruction Word, MSB First

MSB **LSB**

I15	I14	I13	I12	I11	I10	I9	I8	I7	I6	I5	I4	I3	I2	I1	I0
$R/\overline{W}$	W1	W0	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0

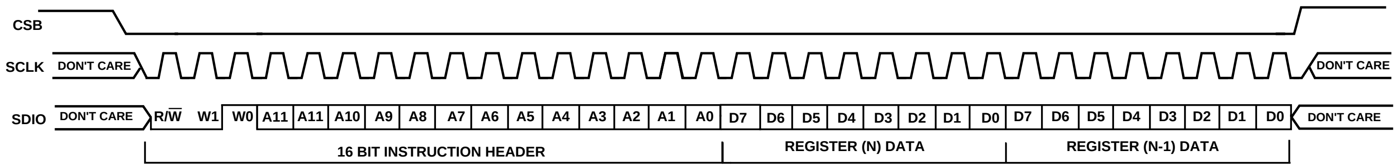

Figure 19. Serial Control Port Write—MSB First, 16-Bit Instruction, 2 Bytes Data

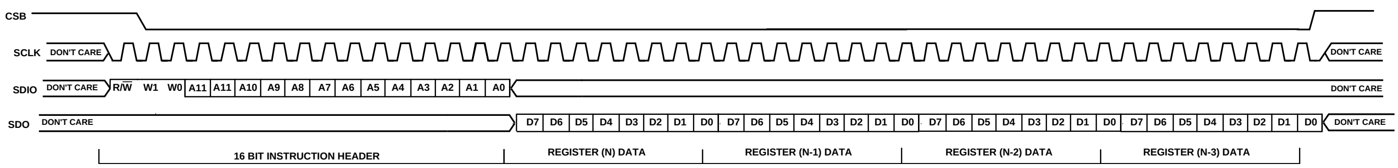

Figure 20. Serial Control Port Read—MSB First, 16-Bit Instruction, 4 Bytes Data

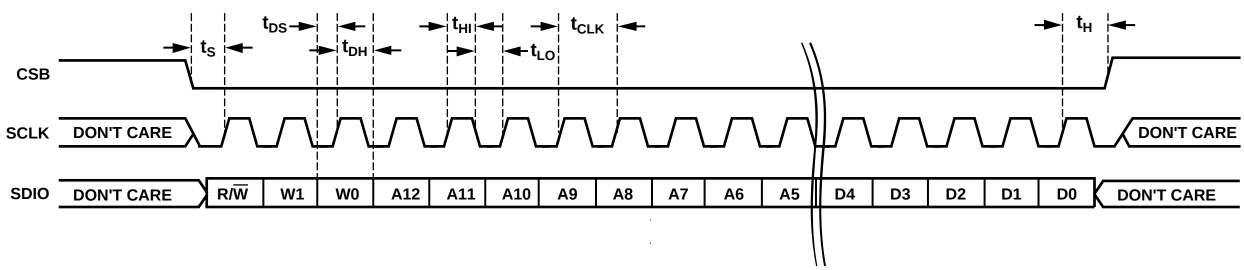

Figure 21. Serial Control Port Write–MSB First, 16-Bit Instruction, Timing Measurements

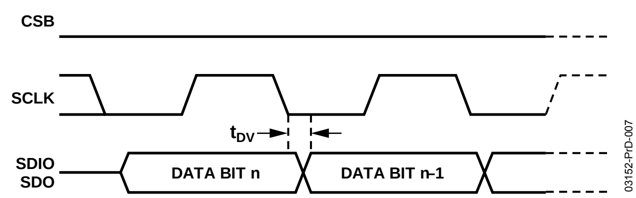

Figure 22. Timing Diagram for Serial Control Port Register Read

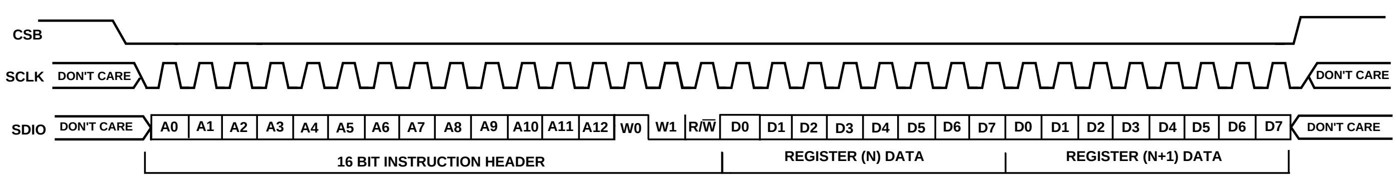

Figure 23. Serial Control Port Write—LSB First, 16-Bit Instruction, 2 Bytes Data

REGISTER MAP AND DESCRIPTION

SUMMARY TABLE

Table 19. AD9510 Register Map

Addr (Hex)	Parameter Name	Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)	Def. Value (Hex)	Notes
00	Serial Control Port Configuration	SDO Active	LSB First	Soft Reset	Long_Ins	Long_Ins	Soft Reset	LSB First	SDO Active	10	<7:4> Mirror <3:0>
01		Blank									
02		Reserved									
03		Blank									
	PLL										PLL Starts in Power-Down
04	A Counter	Blank		6-Bit A Counter <5:0>						00	N Divider (A)
05	B Counter	Blank			13-Bit B Counter Bits (MSB) 12:8 <4:0>					00	N Divider (B)
06	B Counter	13-Bit B Counter Bits 7:0 (LSB) <7:0>								00	N Divider (B)
07	PLL 1	Reserved	LOR lock_del <6:5>		LOR Mode <4:3>		LOR Enable	Test	Test	00	
08	PLL 2	Reserved	PFD Polarity	PLL Mux Select <5:2>				CP Mode <1:0>		00	
09	PLL 3	Reserved	CP Current <6:4>			Reserved	Reset R Counter	Reset N Counter	Reset All Counters	00	
0A	PLL 4	Reserved	B Bypass	Reserved	Prescaler P <4:2>			Power-Down <1:0>		01	N Divider (P)
0B	R Divider	Blank		14-Bit R Divider Bits (MSB) 13:8 <5:0>						00	R Divider
0C	R Divider	14-Bit R Divider Bits (MSB) 13:8 <5:0>								00	R Divider
0D	PLL 5	Reserved	Digital Lock Det. Enable	Digital Lock Det. Window	Reserved			Antibacklash Pulse-Width <1:0>		00	
OE-33		Blank									
	FINE DELAY ADJUST										Fine Delays Bypassed
34	Delay Bypass 5	Blank							Bypass	01	Bypass Delay
35	Delay Full-Scale 5	Blank		Ramp Capacitor <5:3>			Ramp Current <2:0>			00	Max. Delay Full-Scale
36	Delay Word 5	Blank		6-Bit Delay Word <5:0>						00	Min. Delay Value
37	Delay FS Adjust 5	Blank					I Adjust for Process <2:0>			04	Midpoint
38	Delay Bypass 6	Blank							Bypass	01	Bypass Delay
39	Delay Full-Scale 6	Blank		Ramp Capacitor <5:3>			Ramp Current <2:0>			00	Max. Delay Full-Scale
3A	Delay Word 6	Blank		6-Bit Delay Word <5:0>						00	Min. Delay Value

Addr (Hex)	Parameter Name	Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)	Def. Value (Hex)	Notes
3B	Delay FS Adjust 6	Blank					I Adjust for Process <2:0>			04	Midpoint
	OUTPUTS										
3C	LVPECL OUT0	Blank				Output Level <3:2>		Power-Down <1:0>		0A	OFF
3D	LVPECL OUT1	Blank				Output Level <3:2>		Power-Down <1:0>		08	ON
3E	LVPECL OUT2	Blank				Output Level <3:2>		Power-Down <1:0>		08	ON
3F	LVPECL OUT3	Blank				Output Level <3:2>		Power-Down <1:0>		08	ON
40	LVDS_CMOS OUT 4	Blank			CMOS Inverted Driver On	Logic Select	Output Level <2:1>		Output Power	02	LVDS, ON
41	LVDS_CMOS OUT 5	Blank			CMOS Inverted Driver On	Logic Select	Output Level <2:1>		Output Power	02	LVDS, ON
42	LVDS_CMOS OUT 6	Blank			CMOS Inverted Driver On	Logic Select	Output Level <2:1>		Output Power	03	LVDS, OFF
43	LVDS_CMOS OUT 7	Blank			CMOS Inverted Driver On	Logic Select	Output Level <2:1>		Output Power	03	LVDS, OFF
44		Blank		Test			Test				
	CLK1 AND CLK2										Input Receivers
45	Clocks select, Power-Down (PD) Options	Test		CLKs in PD	REFIN PD	CLK to PLL PD	CLK2 PD	CLK1 PD	Select CLK IN	01	All Clocks ON, Select CLK1
46,47		Blank									
	DIVIDERS										
48	Divider 0	Low Cycles <7:4>				High Cycles <3:0>				00	Divide by 2
49	Divider 0	Bypass	No Sync	Force	Start H/L	Phase Offset <3:0>				00	Phase = 0
4A	Divider 1	Low Cycles <7:4>				High Cycles <3:0>				00	Divide by 2
4B	Divider 1	Bypass	No Sync	Force	Start H/L	Phase Offset <3:0>				00	Phase = 0
4C	Divider 2	Low Cycles <7:4>				High Cycles <3:0>				11	Divide by 4
4D	Divider 2	Bypass	No Sync	Force	Start H/L	Phase Offset <3:0>				00	Phase = 0
4E	Divider 3	Low Cycles <7:4>				High Cycles <3:0>				33	Divide by 8
4F	Divider 3	Bypass	No Sync	Force	Start H/L	Phase Offset <3:0>				00	Phase = 0
50	Divider 4	Low Cycles <7:4>				High Cycles <3:0>				00	Divide by 2
51	Divider 4	Bypass	No Sync	Force	Start H/L	Phase Offset <3:0>				00	Phase = 0
52	Divider 5	Low Cycles <7:4>				High Cycles <3:0>				11	Divide by 4
53	Divider 5	Bypass	No Sync	Force	Start H/L	Phase Offset <3:0>				00	Phase = 0
54	Divider 6	Low Cycles <7:4>				High Cycles <3:0>				00	Divide by 2
55	Divider 6	Bypass	No Sync	Force	Start H/L	Phase Offset <3:0>				00	Phase = 0
56	Divider 7	Low Cycles <7:4>				High Cycles <3:0>				00	Divide by 2

Addr (Hex)	Parameter Name	Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)	Def. Value (Hex)	Notes
57	Divider 7	Bypass	No Sync	Force	Start H/L	Phase Offset <3:0>				00	Phase = 0
	FUNCTION										
58	FUNCTION Pin and Sync	Reserved	Set FUNCTION Pin		PD Sync	PD All Ref.	Sync Reg.	Sync Select	Sync Enable	00	FUNCTION Pin = RESETB
59		Reserved									
5A	Update Registers	Blank							Update Registers	00	Self-Clearing Bit
	END										

REGISTER MAP DESCRIPTION

The is a detailed description of each of the control register functions. The registers are listed by hexadecimal address. Reference to a specific bit or range of bits within a register is accomplished by the use of angle brackets. For example, <3> refers to Bit 3, while <5:2> refers to the range of bits from Bit 5 through Bit 2. Table 20 describes the functionality of the control registers on a bit-by-bit basis. For a more concise (but less descriptive) table see Table 19.

Table 20. AD9510 Register Descriptions

Reg. Addr. (Hex)	Bit(s)	Name	Description
		Serial Control Port Configuration	Note: <7:4> mirror <3:0> to ensure that this register can be accessed regardless of the state of <1> or <6> (the bit that sets LSB first).
00	<0>	SDO Active	When set causes SDO to become active. When clear, the SDO pin remains in tri-state and all read data is routed to the SDIO pin. (Default = 0.)
00	<1>	LSB First	When set causes input and output data to be oriented as LSB first. Additionally, addressing increments. If this bit is clear, data is oriented as MSB first and addressing decrements. (Default = 0, MSB first.)
00	<2>	Soft Reset	When a 1 is written to this bit, the chip executes a soft reset, restoring default values to all of the internal registers. This bit is self-clearing. A 0 does not have to be written to clear it.
00	<3>	Long Instruction	When set, the instruction phase is 16 bits. When clear, the instruction phase is 8 bits. The default, and only, mode for this part is long instruction. (Default = 1.)
00	<4>	Long Instruction	Same as <3>.
00	<5>	Soft Reset	Same as <2>.
00	<6>	LSB First	Same as <1>.
00	<7>	SDO Active	Same as <0>.
		Unused	
01	<7:0>		Reserved or not used.
02	<7:0>		Reserved or not used.
03	<7:0>		Reserved or not used.
		PLL Settings	
04	<5:0>	A Counter	6-bit A counter <5:0>.
04	<7:6>		Reserved or not used.
05	<4:0>	B Counter MSBs	13-bit B counter (MSB) <12:8>.
05	<7:5>		Reserved or not used.
06	<7:0>	B Counter LSBs	13-bit B counter (LSB) <7:0>.
07	<1:0>		Reserved or not used.
07	<2>	LOR Enable	1 = enables the loss of reference (LOR) function; (Default = 0).
07	<4:3>		Reserved or not used (default = 00).
07	<6:5>	LOR Initial Lock Detect Delay	LOR initial lock detect delay. Once a lock detect is indicated, this is the number of phase frequency detector (PFD) cycles that occur prior to turning on the LOR monitor. **<6> / <5> / LOR Initial Lock Deteck Delay** 0 / 0 / 3 PFD Cycles (Default) 0 / 1 / 6 PFD Cycles 1 / 0 / 12 PFD Cycles 1 / 1 / 24 PFD Cycles
07	<7>		Reserved or not used

<table>
<tr><th>Reg. Addr. (Hex)</th><th>Bit(s)</th><th>Name</th><th>Description</th></tr>
<tr><td>08</td><td><1:0></td><td>Charge Pump Mode</td><td>
<table>
<tr><th><1></th><th><0></th><th>Charge Pump Mode</th></tr>
<tr><td>0</td><td>0</td><td>Tri-Stated (Default)</td></tr>
<tr><td>0</td><td>1</td><td>Pump Up</td></tr>
<tr><td>1</td><td>0</td><td>Pump Down</td></tr>
<tr><td>1</td><td>1</td><td>Normal Operation</td></tr>
</table>
</td></tr>
<tr><td>08</td><td><5:2></td><td>PLL Mux Control</td><td>
<table>
<tr><th><5></th><th><4></th><th><3></th><th><2></th><th>MUXOUT</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>Off (Signal Goes Low) (Default)</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>Digital Lock Detect (Active High)</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>N Divider Output</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>Digital Lock Detect (Active High)</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>R Divider Output</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1</td><td>Analog Lock Detect (N Channel Open-Drain)</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>A Counter Output</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>1</td><td>Prescaler Output (NCLK)</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>PFD Up Pulse</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>PFD Down Pulse</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td><td>Loss of Reference (Active High)</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td><td>Tri-State</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>Analog Lock Detect (P Channel Open-Drain)</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td><td>Loss of Reference or Lock Detect (Active High)</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>Loss of Reference or Lock Detect (Active Low)</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>Loss of Reference (Active High)</td></tr>
<tr><td colspan="5">MUXOUT is the PLL portion of the STATUS Output MUX.</td></tr>
</table>
</td></tr>
<tr><td>08</td><td><6></td><td>Phase-Frequency Detector (PFD) Polarity</td><td>0 = negative (default), 1 = positive.</td></tr>
<tr><td>08</td><td><7></td><td></td><td>Reserved or not used.</td></tr>
<tr><td>09</td><td><0></td><td>Reset All Counters</td><td>0 = normal (default), 1 = reset R, A, and B counters.</td></tr>
<tr><td>09</td><td><1></td><td>N-Counter Reset</td><td>0 = normal (default), 1 = reset A and B counters.</td></tr>
<tr><td>09</td><td><2></td><td>R-Counter Reset</td><td>0 = normal (default), 1 = reset R counter.</td></tr>
<tr><td>09</td><td><3></td><td></td><td>Reserved or not used.</td></tr>
<tr><td>09</td><td><6:4></td><td>Charge Pump (CP) Current Setting</td><td>
<table>
<tr><th><6></th><th><5></th><th><4></th><th>I_{CP} (mA)</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0.62</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1.25</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1.87</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>2.50</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>3.12</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>3.75</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>4.37</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>5.00</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Reg. Addr. (Hex)</th><th>Bit(s)</th><th>Name</th><th>Description</th></tr>
<tr><td></td><td></td><td></td><td>Default = 000.
These currents assume: CP_RSET = 5.1 kΩ.
Actual current can be calculated by: CP_lsb = 3.1875/CP_RSET.</td></tr>
<tr><td>09</td><td><7></td><td></td><td>Reserved or not used.</td></tr>
<tr><td>0A</td><td><1:0></td><td>PLL Power-Down</td><td>01 = asynchronous power-down (default).
<table>
<tr><th><1></th><th><0></th><th>Mode</th></tr>
<tr><td>0</td><td>0</td><td>Normal Operation</td></tr>
<tr><td>0</td><td>1</td><td>Asynchronous Power-Down</td></tr>
<tr><td>1</td><td>0</td><td>Normal Operation</td></tr>
<tr><td>1</td><td>1</td><td>Synchronous Power-Down</td></tr>
</table></td></tr>
<tr><td>0A</td><td><4:2></td><td>Prescaler Value
P/P+1</td><td>
<table>
<tr><th><4></th><th><3></th><th><2></th><th>Mode</th><th>Prescaler Mode</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>FD</td><td>Divide-by-1</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>FD</td><td>Divide-by-2</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>DM</td><td>2/3</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>DM</td><td>4/5</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>DM</td><td>8/9</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>DM</td><td>16/17</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>DM</td><td>32/33</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>FD</td><td>Divide-by-3</td></tr>
</table>
DM = Dual Modulus, FD = Fixed Divide.</td></tr>
<tr><td>0A</td><td><5></td><td></td><td>Reserved or not used.</td></tr>
<tr><td>0A</td><td><6></td><td>B Counter Bypass</td><td>Only valid when operating the prescaler in fixed divide (FD) mode. When this bit is set, the B counter is divide-by-1. This allows the prescaler setting to determine the divide for the N divider.</td></tr>
<tr><td>0A</td><td><7></td><td></td><td>Reserved or not used.</td></tr>
<tr><td>0B</td><td><5:0></td><td>14-Bit Reference Counter, MSBs</td><td>R divider (MSB) <13:8>.</td></tr>
<tr><td>0C</td><td><7:0></td><td>14-Bit Reference Counter, R LSBs</td><td>R divider (MSB) <7:0>.</td></tr>
<tr><td>0D</td><td><1:0></td><td>Antibacklash Pulse-Width</td><td>
<table>
<tr><th><1></th><th><0></th><th>Antibacklash Pulse-Width (ns)</th></tr>
<tr><td>0</td><td>0</td><td>1.3 (Default)</td></tr>
<tr><td>0</td><td>1</td><td>2.9</td></tr>
<tr><td>1</td><td>0</td><td>6.0</td></tr>
<tr><td>1</td><td>1</td><td>1.3</td></tr>
</table></td></tr>
<tr><td>0D</td><td><4:2></td><td></td><td>Reserved or not used.</td></tr>
<tr><td>0D</td><td><5></td><td>Digital Lock Detect Window</td><td>
<table>
<tr><th><5></th><th>Digital Lock Detect Window (ns)</th><th>Digital Lock Detect Loss of Lock Threshold (ns)</th></tr>
<tr><td>0 (Default)</td><td>9.5</td><td>15</td></tr>
<tr><td>1</td><td>3.5</td><td>7</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Reg. Addr. (Hex)</th><th>Bit(s)</th><th>Name</th><th>Description</th></tr>
<tr><td></td><td></td><td></td><td>If the time difference of the rising edges at the inputs to the PFD are less than the lock detect window time, the digital lock detect flag is set. The flag remains set until the time difference is greater than loss-of-lock threshold.</td></tr>
<tr><td>0D</td><td><6></td><td>Lock Detect Disable</td><td>0 = normal lock detect operation (default).
1 = disable lock detect.</td></tr>
<tr><td>0D</td><td><7></td><td></td><td>Reserved or not used.</td></tr>
<tr><td></td><td></td><td>Unused</td><td></td></tr>
<tr><td>0E-33</td><td></td><td></td><td>Reserved or not used.</td></tr>
<tr><td></td><td></td><td>Fine Delay Adjust</td><td></td></tr>
<tr><td>34
(38)</td><td><0></td><td>Delay Control
OUT5
(OUT6)</td><td>Delay block control bit.
Bypasses delay block and powers it down (default = 1).</td></tr>
<tr><td>34
(38)</td><td><7:1></td><td></td><td>Reserved or not used.</td></tr>
<tr><td>35
(39)</td><td><2:0></td><td>Ramp Control
OUT5
(OUT6)</td><td>The slowest ramp (200 μs) sets the longest full scale of approximately 10 ns.
<table>
<tr><th><2></th><th><1></th><th><0></th><th>Ramp Current (μs)</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>200</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>400</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>600</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>800</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1000</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1200</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1400</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1600</td></tr>
</table></td></tr>
<tr><td>35
(39)</td><td><5:3></td><td>Ramp Control
OUT5
(OUT6)</td><td>Selects the number of capacitors in ramp generation circuit.
More capacitors => slower ramp.
<table>
<tr><th><5></th><th><4></th><th><3></th><th>Number of Capacitors</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>4 (Default)</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>3</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>3</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>2</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table></td></tr>
<tr><td>36
(3A)</td><td><5:0></td><td>Reference Value
OUT5
(OUT6)</td><td>Sets delay within full scale of the ramp. There are 64 steps to control the reference value for the comparator.
000000 => zero delay (default).
111111 => maximum delay.</td></tr>
<tr><td>37
(3B)</td><td><2:0></td><td>Delay Fine Tune
OUT5
(OUT6)</td><td>The delay fine tune slightly increases or decreases the ramp current (–8% to +13%) to negate the process variation of the caps. Defaults to 100, which is the midpoint.</td></tr>
</table>

<table>
<tr><th>Reg. Addr. (Hex)</th><th>Bit(s)</th><th>Name</th><th>Description</th></tr>
<tr><td>3C
(3D)
(3E)
(3F)</td><td><1:0></td><td>Power Down
LVPECL
OUT0
(OUT1)
(OUT2)
(OUT3)</td><td>
<table>
<tr><th>Mode</th><th><1></th><th><0></th><th>Description</th><th>Output</th></tr>
<tr><td>ON</td><td>0</td><td>0</td><td>Normal operation</td><td>ON</td></tr>
<tr><td>PD1</td><td>0</td><td>1</td><td>Test only—do not use</td><td>OFF</td></tr>
<tr><td>PD2</td><td>1</td><td>0</td><td>Safe power-down
Partial power-down; use if output has load resistors</td><td>OFF</td></tr>
<tr><td>PD3</td><td>1</td><td>1</td><td>Total power-down
Use only if output has no load resistors</td><td>OFF</td></tr>
</table>
</td></tr>
<tr><td>3C
(3D)
(3E)
(3F)</td><td><3:2></td><td>Output Level
LVPECL
OUT0
(OUT1)
(OUT2)
(OUT3)</td><td>This sets output single-ended voltage levels for LVPECL outputs
<table>
<tr><th><3></th><th><2></th><th>Output Voltage (mV)</th></tr>
<tr><td>0</td><td>0</td><td>490</td></tr>
<tr><td>0</td><td>1</td><td>330</td></tr>
<tr><td>1</td><td>0</td><td>805 (Default)</td></tr>
<tr><td>1</td><td>1</td><td>650</td></tr>
</table>
</td></tr>
<tr><td>3C
(3D)
(3E)
(3F)</td><td><7:4></td><td></td><td>Reserved or not used.</td></tr>
<tr><td>40
(41)
(42)
(43)</td><td><0></td><td>Power-Down
LVDS/CMOS
OUT4
(OUT5)
(OUT6)
(OUT7)</td><td>Power-down bit for both output and LVDS driver.
0 = LVDS/CMOS on (default).
1 = LVDS/CMOS power-down.</td></tr>
<tr><td>40
(41)
(42)
(43)</td><td><2:1></td><td>Output Current Level
LVDS
OUT4
(OUT5)
(OUT6)
(OUT7)</td><td></td></tr>
</table>

Reg. Addr. (Hex)	Bit(s)	Name	Description			
			<2>	**<1>**	**Current (mA)**	**Termination (Ω)**
			0	0	1.75	100
			0	1	3.5 (Default)	100
			1	0	5.25	50
			1	1	7	50
40 (41) (42) (43)	<3>	LVDS/CMOS Select OUT4 (OUT5) (OUT6) (OUT7)	0 = LVDS (default). 1 = CMOS.			
40 (41) (42) (43)	<4>	Inverted CMOS Driver OUT4 (OUT5) (OUT6) (OUT7)	Affects output only when in CMOS mode. 0 = disable inverted CMOS driver (default). 1 = enable inverted CMOS driver.			
40 (41) (42) (43)	<7:5>		Reserved or not used.			
44	<7:0>		Reserved or not used.			
45	<0>	Clock Select	0: CLK2 drives distribution section. 1: CLK1 drives distribution section (default).			
45	<1>	CLK1 Power-Down	1 = CLK1 input is powered down (default = 0).			
45	<2>	CLK2 Power-Down	1 = CLK2 input is powered down (default = 0).			
45	<3>	Prescaler Clock Power-Down	1 = shut down clock signal to PLL prescaler (default = 0).			
45	<4>	REFIN Power-Down	1 = power-down REFIN (default = 0).			
45	<5>	All Clock Inputs Power-Down	1 = power-down CLK1 and CLK2 inputs and associated bias and internal clock tree; (default = 0).			
45	<7:6>		Reserved or not used.			
46	<7:0>		Reserved or not used.			
47	<7:0>		Reserved or not used.			
48 (4A) (4C) (4E) (50) (52) (54) (56)	<3:0>	Divider High OUT0 (OUT1) (OUT2) (OUT3) (OUT4) (OUT5) (OUT6) (OUT7)	Number of clock cycles divider output stays high.			

Reg. Addr. (Hex)	Bit(s)	Name	Description
 48 (4A) (4C) (4E) (50) (52) (54) (56)	<7:4>	Divider Low OUT0 (OUT1) (OUT2) (OUT3) (OUT4) (OUT5) (OUT6) (OUT7)	Number of clock cycles divider output stays low.
 49 (4B) (4D) (4F) (51) (53) (55) (57)	<3:0>	Phase Offset OUT0 (OUT1) (OUT2) (OUT3) (OUT4) (OUT5) (OUT6) (OUT7)	Phase offset (default = 0000).
 49 (4B) (4D) (4F) (51) (53) (55) (57)	<4>	Start OUT0 (OUT1) (OUT2) (OUT3) (OUT4) (OUT5) (OUT6) (OUT7)	Selects start high or start low. (Default = 0).
 49 (4B) (4D) (4F) (51) (53) (55) (57)	<5>	Force OUT0 (OUT1) (OUT2) (OUT3) (OUT4) (OUT5) (OUT6) (OUT7)	Forces individual outputs to the state specified in start (above). This function requires that Nosync (below) also be set. (Default = 0).
 49 (4B) (4D) (4F) (51) (53) (55) (57)	<6>	Nosync OUT0 (OUT1) (OUT2) (OUT3) (OUT4) (OUT5) (OUT6) (OUT7)	Ignore chip-level sync signal (default = 0).

Reg. Addr. (Hex)	Bit(s)	Name	Description
49 (4B) (4D) (4F) (51) (53) (55) (57)	<7>	Bypass Divider OUT0 (OUT1) (OUT2) (OUT3) (OUT4) (OUT5) (OUT6) (OUT7)	Bypass and power-down divider logic; route clock directly to output (default = 0).
		Other	
58	<0>	SYNC Detect Enable	1 = enable SYNC detect (default = 0).
58	<1>	SYNC Select	1 = raise flag if slow clocks are out-of-sync by 0.5 to 1 high speed clock cycles. 0 (default) = raise flag if slow clocks are out-of-sync by 1 to 1.5 high speed clock cycles.
58	<2>	Soft SYNC	Soft SYNC bit works the same as the FUNCTION pin when in SYNCB mode, except that this bit's polarity is reversed. That is a High level forces selected outputs into a known state, and a High > Low transition triggers a sync (default = 0).
58	<3>	Dist Ref Power Down	1 = power-down the references for the distribution section (default = 0).
58	<4>	SYNC Power Down	1 = power-down the SYNC (default = 0).
58	<6:5>	FUNCTION Pin Select	**<6> | <5> | Function** 0 | 0 | RESETB (Default) 0 | 1 | SYNCB 1 | 0 | Test Only; Do Not Use 1 | 1 | PDB
58	<7>		Reserved or not used.
59	<7:0>		Reserved or not used.
5A	<0>	Update Registers	A 1 written to this bit updates all registers and transfers all serial control port register buffer contents to the control registers on next rising SCLK edge. This is a self-clearing bit. A 0 does not have to be written in order to clear it.
5A	<7:1>		Reserved or not used.
		END	

APPLICATIONS

USING THE AD9510 OUTPUTS FOR ADC CLOCK APPLICATIONS

Any high speed analog-to-digital converter (ADC) is extremely sensitive to the quality of the sampling clock provided by the user. An ADC can be thought of as a sampling mixer; and any noise, distortion, or timing jitter on the clock is combined with the desired signal at the A/D output. Clock integrity requirements scale with the analog input frequency and resolution, with higher analog input frequency applications at >= 14-bit resolution being the most stringent. The theoretical SNR of an ADC is limited by the ADC resolution and the jitter on the sampling clock. Considering an ideal ADC of infinite resolution where the step size and quantization error can be ignored, the available SNR is can be expressed approximately by

$$SNR = 20 \times \log\left[\frac{1}{2\pi f t_J}\right]$$

where *f* is the highest analog frequency being digitized, and t_j is the rms jitter on the sampling clock. The figure below shows required sampling clock jitter as function of analog frequency and effective number of bits (ENOB)

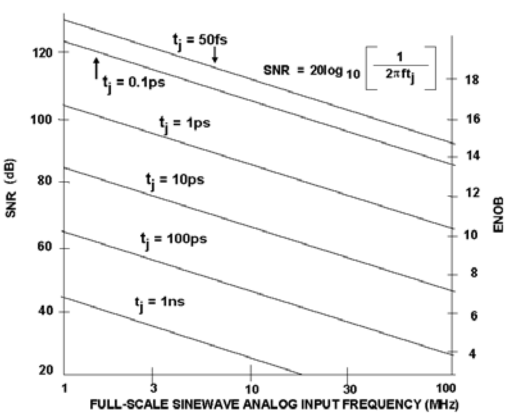

Figure 24. ENOB and SNR vs. Analog Input Frequency

(See Application Note AN-501 at www.analog.com for more information).

Many high performance ADC's feature differential clock inputs to simplify the task of providing the required low jitter clock on a noisy PCB. *(Distributing a single-ended clock on a noisy PCB can result in coupled noise on the sample clock. Differential distribution has inherent common-mode rejection that can provide superior clock performance in a noisy environment.)* The AD9510 features both LVPECL and LVDS outputs that provide differential clock outputs, which enable clock solutions that maximize converter SNR performance. The input requirements of the ADC (differential or single-ended, logic level, termination) should be considered when selecting the best clocking/converter solution.

CMOS CLOCK DISTRIBUTION

The AD9510 provides four clock outputs (OUT4 to OUT7) which are selectable as either CMOS or LVDS levels. When selected as CMOS, these outputs provide a way to drive devices requiring CMOS level logic at their clock inputs. Due to factors inherent to CMOS logic, the jitter performance of these outputs cannot equal that of the LVPECL and LVDS outputs. However, for many clocking needs within a system, CMOS clock levels are appropriate.

Whenever single-ended CMOS clocking is used, some of the following general guidelines should be followed.

Point-to-point nets should be designed such that a driver only has one receiver on the net, if possible. This allows for simple termination schemes and minimize ringing due to possible mismatched impedances on the net. Series termination at the source is generally required to provide transmission line matching and/or to reduce current transients at the driver. The value of the resistor is dependent on board design and timing requirements (typically 10 Ω to 100 Ω is used). CMOS outputs are also limited in terms of the capacitive load or trace length that they can drive, typically trace lengths less than 3 inches are recommended to preserve signal rise/fall times and preserve signal integrity. Simulation results for the AD9510 CMOS outputs with a 1-inch and 3-inch trace load are shown in Figure 26. In this example, the series resistor is 10 Ω and the trace impedance is 60 Ω. Signal integrity, in this example, has started to degrade already at a 3-inch trace length.

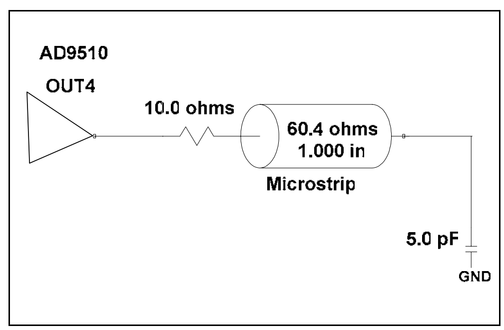

Figure 25. Series Termination of CMOS Output

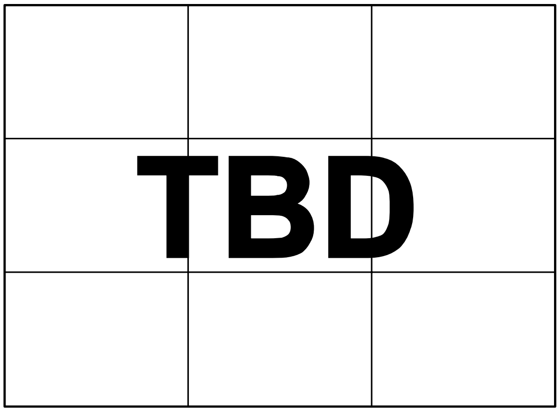

Figure 26. CMOS Output Waveforms

Termination at the far end of the PCB trace is a second option. The CMOS outputs of the AD9510 do not supply enough current to provide a full voltage swing with a low impedance resistive, far-end termination, as shown in Figure 28. The far end termination network should match the PCB trace impedance and provide the desired switching point. The reduced signal swing may still meet receiver input requirements in some applications. This can be useful when driving long trace lengths on less critical nets.

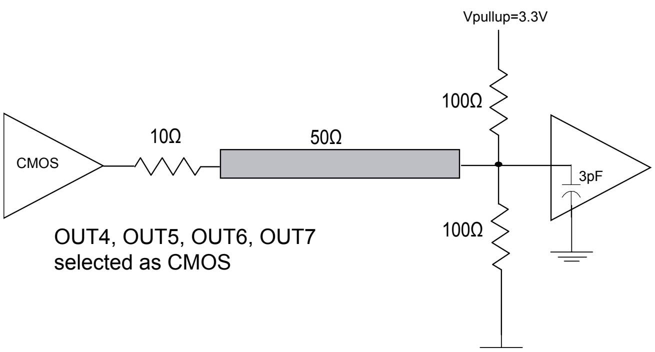

Figure 27. CMOS Output with Far-End Termination

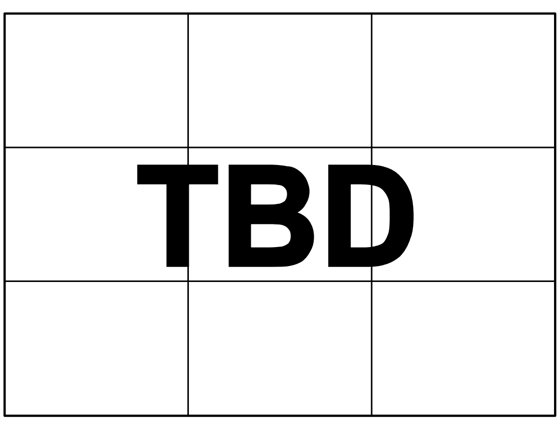

Figure 28. Far-End Termination of CMOS Output Waveform

Because of the limitations of single-ended CMOS clocking, consider using differential outputs when driving high speed signals over long traces. The AD9510 offers both LVPECL and LVDS outputs that are better suited for driving long traces where the inherent noise immunity of differential signaling provides superior performance for clocking converters.

LVPECL CLOCK DISTRIBUTION

The low voltage positive emitter coupled logic (LVPECL) outputs of the AD9510 provide the lowest jitter clock signals available from the AD9510. The LVPECL outputs (because they are open emitter) require a dc termination to bias the output transistors. A simplified equivalent circuit in Figure 29 shows the LVPECL output stage.

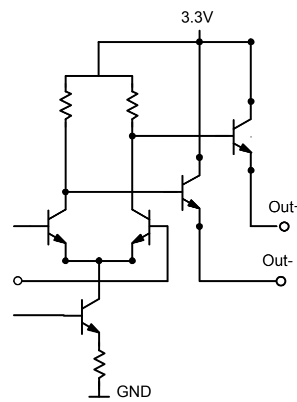

Figure 29. Simplified LVPECL Output Stage

In most applications, a standard LVPECL far-end termination is recommended, as shown in Figure 30. The resistor network is designed to match the transmission line impedance (50 Ω) and the desired switching threshold (1.3 V). Figure 32 shows a typical LVPECL clock waveform.

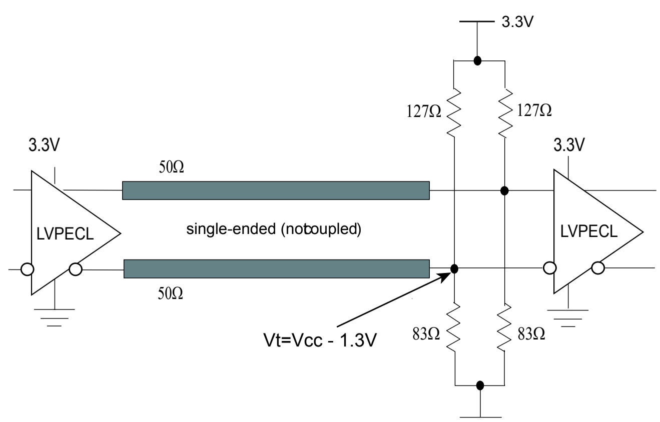

Figure 30. LVPECL Far-End Termination

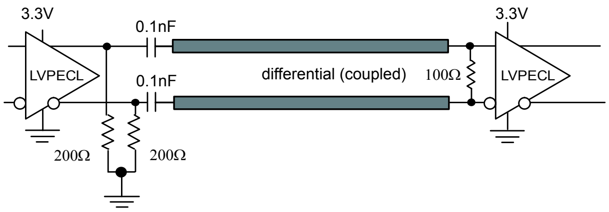

Figure 31 LVPECL with Parallel Transmission Line

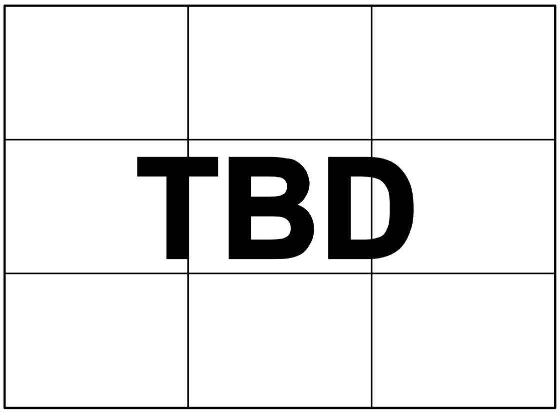

Figure 32. Typical LVPECL Outputs

LVDS CLOCK DISTRIBUTION

Low voltage differential signaling (LVDS) is a second differential output option for the AD9510. LVDS provides clock signals with jitter performance nearly as good as that obtainable from LVPECL, and better than CMOS. LVDS uses a current-mode output stage with several user-selectable current levels. A 3.5 mA output current yields 350 mV output swing across a standard LVDS output termination of 100 Ω, meeting ANSI 644 requirements.

A recommended termination circuit is shown for the LVDS outputs in Figure 33.

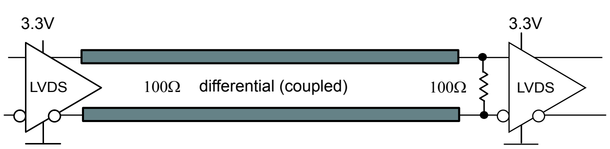

Figure 33. LVDS Output Termination

A typical LVDS output waveform is shown in Figure 34.

(See Application Note AN-586 at www.analog.com for more information on LVDS).

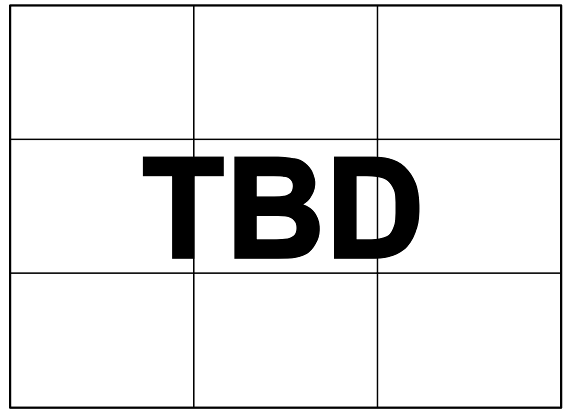

Figure 34. Typical LVDS Output Waveforms

POWER AND GROUNDING CONSIDERATIONS, AND POWER SUPPLY REJECTION

Many applications seek high speed and performance under less than ideal operating conditions. In these application circuits, the implementation and construction of the PCB is as important as the circuit design. Proper RF techniques must be used for device selection, placement, and routing, as well as power supply bypassing and grounding to ensure optimum performance.

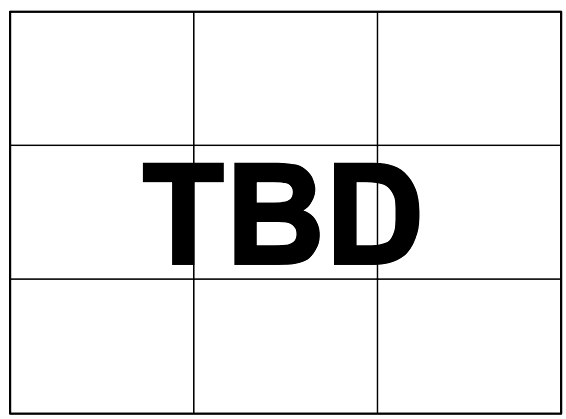

Figure 35. Differential LC Filter for Single 3.3 V Applications

OUTLINE DIMENSIONS

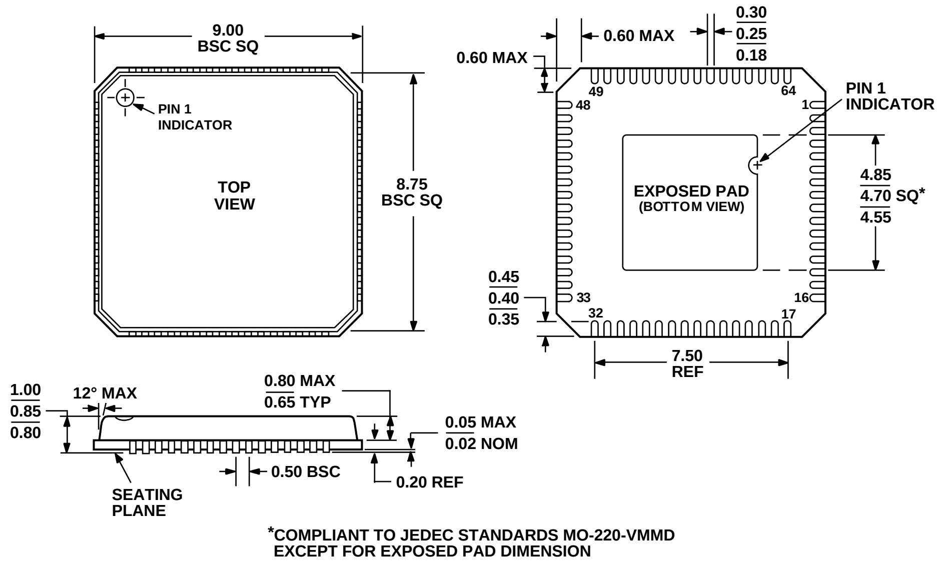

Figure 36. 64-Lead Frame Chip Scale Package [LFCSP]
9 mm × 9 mm Body (CP-64-1)
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Options
AD9510	–40°C to +85°C	64-Lead Chip Scale Package (LFCSP)	CP-64-1
AD9510PCB		Evaluation Board	