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 LVDS/CM OS outputs
- 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

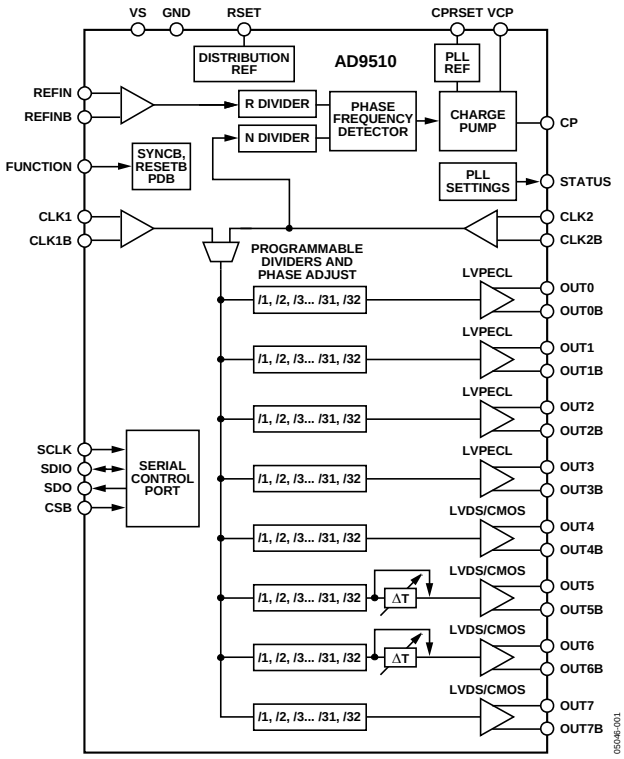

Figure 1.

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 full-scale ranges up to 10 ns of delay. This fine tuning delay block has 5-bit resolution, giving 32 possible delays from which to choose for each full-scale setting.

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 that 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. PrB

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REVISION HISTORY

02/05—Revision PrB: Preliminary Version

SPECIFICATIONS

PLL CHARACTERISTICS

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.

Table 1.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
REFERENCE INPUTS (REFIN)					
Input Frequency	0		250	MHz	
Input Sensitivity, Differential	---	200		mV	
Input Common-Mode Voltage, V_{CM}	---	1.6	---	V	Self-bias voltage of REFINB[1].
Input Single-Ended Sensitivity	---	V_{CM} ± 100		mV	When dc-coupled, REFINB capacitively bypassed to RF ground[1].
Input Capacitance		2		pF	
Input Resistance	---	5	---	kΩ	
PHASE/FREQUENCY DETECTOR (PFD)					
Phase Frequency Detector Input Frequency			80	MHz	Antibacklash pulse width 0Dh<1:0>= 00b.
Phase Frequency Detector Input Frequency			---	MHz	Antibacklash pulse width 0Dh<1:0>= 01b.
Phase Frequency Detector Input Frequency			---	MHz	Antibacklash pulse width 0Dh<1:0>= 10b.
Antibacklash Pulse Width		1.3		ns	0Dh<1:0>= 00b.
Antibacklash Pulse Width		2.9		ns	0Dh<1:0>= 01b.
Antibacklash Pulse Width		6.0		ns	0Dh<1:0>= 10b.
CHARGE PUMP (CP)					
I_{CP} Sink/Source					Programmable.
High Value		5		mA	
Low Value		625		µA	
Absolute Accuracy		2.5		%	$V_{CP} = V_S/2$.
CPR_{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, CLK2B capacitively bypassed to RF ground.
Input Capacitance		2		pF	
Input Resistance	---	5	---	kΩ	
NOISE CHARACTERISTICS					
In-Band Noise of the Charge Pump/ Phase Frequency Detector (In-Band 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	

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
PLL Figure of Merit		−219 + 10 × 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)[2].
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.
REFIN to CLK2 Delay		500		ps	

[1] REFIN and REFINB self-bias points are offset slightly to avoid chatter on an open input condition.
[2] Example: −219 + 10 × log(f_{PFD}) + 20 × 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, CLK2					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} ± 100		mV	When dc-coupled, B input capacitively bypassed to RF ground
Input Capacitance		2		pF	
Input Resistance	---	5	---	kΩ	Self-biased

CLOCK OUTPUTS

Table 3.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
LVPECL CLOCK OUTPUTS					Termination = 50 Ω to V_S − 2 V
OUT0, OUT1, OUT2, OUT3; Differential					Output level 3Ch (3Dh) (3Eh) (3Fh)<3:2>= 10b
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	Typical worst case, desired out to one other out[1]
Isolation LVDS-to-LVPECL Output		---		dB	Typical worst case, desired out to one other out[1]
Isolation CMOS-to-LVPECL Output		---		dB	Typical worst case, desired out to one other out[1]
LVDS CLOCK OUTPUTS					Termination = 100 Ω differential; default
OUT4, OUT5, OUT6, OUT7; Differential					Output Level 40h (41h) (42h) (43h)<2:1>= 01b 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	Typical worst case, desired out to one other out[1]
Isolation LVPECL to LVDS		---		dB	Typical worst case, desired out to one other out[1]
Isolation CMOS to LVDS		---		dB	Typical worst case, desired out to one other out[1]
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	Typical worst case, desired out to one other out[1]
Isolation LVPECL to CMOS		---		dB	Typical worst case, desired out to one other out[1]
Isolation LVDS to CMOS		---		dB	Typical worst case, desired out to one other out[1]

[1] Desired output is 100 MHz and 50 MHz on one other output; isolation is level of 50 MHz signal referred to the 100 MHz signal on the desired output. Results shown are typical worst case of isolation from a single output of indicated type.

TIMING CHARACTERISTICS

Table 4.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
LVPECL					Termination = 50 Ω to V_S − 2 V Output level 3Ch (3Dh) (3Eh) (3Fh)<3:2> = 10b
Output Rise Time, t_{RP}		125	---	ps	20% to 80%
Output Fall Time, t_{FP}		125	---	ps	80% to 20%
PROPAGATION DELAY, t_{PECL}, CLK1-to-LVPECL OUT					
Divide = Bypass	---	480	---	ps	
Divide = 2 – 32	---	535	---	ps	
PROPAGATION DELAY, t_{PECL}, CLK2-to-LVPECL OUT					
Divide = Bypass	---	---	---	ps	
Divide = 2 – 32	---	---	---	ps	
OUTPUT SKEW, LVPECL OUTPUTS					
OUT0 to OUT1 on Same Part, t_{SKP}	---	–35	---	ps	LVPECL to LVPECL on same part[1]
OUT0 to OUT1 Across Different Parts, t_{SKP_AB}		---		ps	LVPECL to LVPECL on different parts[2]

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
OUT2, OUT3 on Same Part, t_{SKP}	---	45	---	ps	LVPECL to LVPECL on same part[1]
OUT2, OUT3 Across Different Parts, t_{SKP_AB}		---		ps	LVPECL to LVPECL on different parts[2]
LVDS					Termination = 100 Ω differential Output level 40h (41h) (42h) (43h)<2:1> = 01b 3.5 mA termination current
Output Rise Time, t_{RL}		210	---	ps	20% to 80%
Output Fall Time, t_{FL}		215	---	ps	80% to 20%
PROPAGATION DELAY, t_{LVDS}, CLK-TO-LVDS OUT					Delay Off—OUT5, OUT6
OUT4, OUT5, OUT6, OUT7					
Divide = Bypass	---	1.30	---	ns	
Divide = 2 – 32	---	1.35	---	ns	
OUTPUT SKEW, LVDS Outputs					
OUT4 to OUT7 on Same Part, t_{SKV}	---	90	---	ps	LVDS to LVDS on same part[1]
OUT4 to OUT7 Across Different Parts, t_{SKV_AB}		---		ps	LVDS to LVDS on different parts[2]
OUT5 to OUT6 on Same Part, t_{SKVD}	---	−15	---	ps	LVDS to LVDS on same part[1] delay off
OUT5 to OUT6 Across Different Parts, t_{SKVD_AB}		---		ps	LVDS to LVDS on different parts[2] delay off
CMOS					B outputs are inverted; termination = open
Output Rise Time, t_{RC}		460	---	ps	20% to 80%; C_{LOAD} = 3 pF
Output Fall Time, t_{FC}		450	---	ps	80% to 20%; C_{LOAD} = 3 pF
PROPAGATION DELAY, t_{CMOS}, CLK-TO-CMOS OUT					Delay off on OUT5, OUT6
Divide = Bypass	---	1.20	---	ns	
Divide = 2 – 32	---	1.41	---	ns	
OUTPUT SKEW, CMOS OUTPUTS					
OUT4 to OUT7 on Same Part, t_{SKC}	---	---	---	ps	CMOS to CMOS on same part[1]
OUT4 to OUT7 Across Different Parts, t_{SKC_AB}		---		ps	CMOS to CMOS on different parts[2]
OUT5 to OUT6 on Same Part, t_{SKCD}	---	---	---	ps	CMOS to CMOS on same part[1] delay off
OUT5 to OUT6 Across Different Parts, t_{SKCD_AB}		---		ps	CMOS to CMOS on different parts[2] delay off
LVPECL-TO-LVDS OUT					Everything the same; different logic
Output Skew, t_{SKP_V}	---	0.90	---	ns	LVPECL to LVDS on same part
LVPECL-TO-CMOS OUT					Everything the same; different logic
Output Skew, t_{SKP_C}	---	0.95	---	ns	LVPECL to CMOS on same part
LVDS-TO-CMOS OUT					Everything the same; different logic
Output Skew, t_{SKV_C}	---	100	---	ps	LVDS to CMOS on same part
DELAY ADJUST					OUT5 (OUT6); LVDS and CMOS
Shortest Delay Range[3]					35h (39h) <5:1> 11111b
Zero Scale	---	0.3	---	ns	36h (3Ah) <5:1> 00000b
Full Scale		1.0		ns	36h (3Ah) <5:1> 11111b
Linearity		---		% LSB	
Longest Delay Range[3]					35h (39h) <5:1> 00000b
Zero Scale	---	0.5	---	ns	36h (3Ah) <5:1> 00000b
Full Scale		10		ns	36h (3Ah) <5:1> 11111b
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.
[3] Incremental delay. Does not include propagation delay.

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	
>1 MHz Offset		−165		dBc/Hz	

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
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.

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
CSB, SCLK (INPUTS)					CSB and SCLK have 30 kΩ internal pull-down resistors
Input Logic 1 Voltage	---			V	
Input Logic 0 Voltage			---	V	
Input Logic 1 Current		---		µA	
Input Logic 0 Current		---		µA	
Input Capacitance		---		pF	
SDIO (WHEN INPUT)					
Input Logic 1 Voltage	---			V	
Input Logic 0 Voltage			---	V	
Input Logic 1 Current		---		µA	
Input Logic 0 Current		---		µA	
Input Capacitance		---		pF	
SDIO, SDO (OUTPUTS)					
Output Logic 1 Voltage	---			V	
Output Logic 0 Voltage			---	V	
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					
Logic 1 Voltage	---			V	
Logic 0 Voltage			---	V	
Logic 1 Current		---		µA	
Logic 0 Current		---		µA	
Capacitance		---		pF	
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.)
Full Sleep Power-Down		---	---		Maximum sleep is entered by setting 0Ah<1:0> = 01b and 58h<4>= 1b. This powers off the PLL BG and the distribution BG references. Does not include power dissipated in terminations.
Power-Down (PDB)		---	---		Set FUNCTION pin for PDB operation by setting 58h<6:5> = 11b. Pull PDB low. Does not include power dissipated in terminations.
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	Versus delay block operation at 10 ns fs with maximum delay; output clocking at 25 MHz.
Delay Block Power-Down		---	---	mW	Versus delay block bypass.
PLL Section Power-Down		40	---	mW	Versus PLL in loop with … (conditions)

TIMING DIAGRAMS

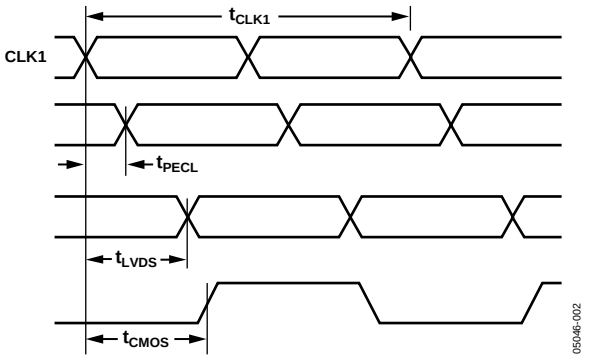

Figure 2. CLK1/CLK1B to Clock Output Timing, DIV = 1 Mode

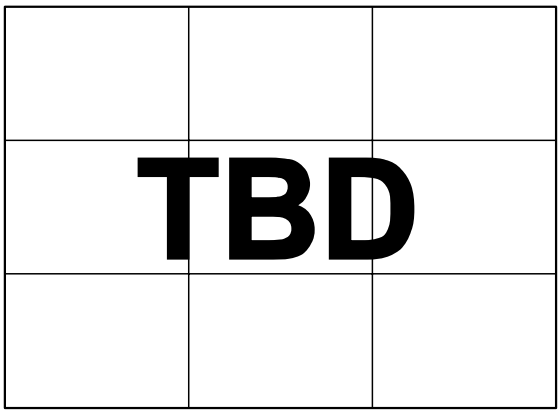

Figure 3. LVPECL Rise Time

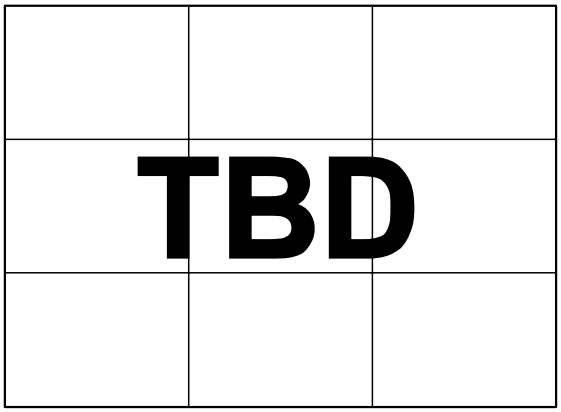

Figure 4. LVPECL Fall Time

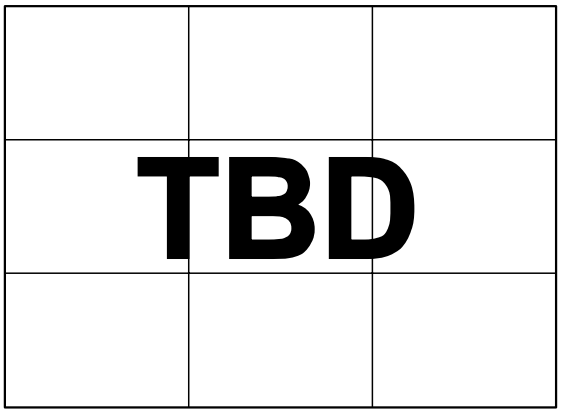

Figure 5. LVDS Timing

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

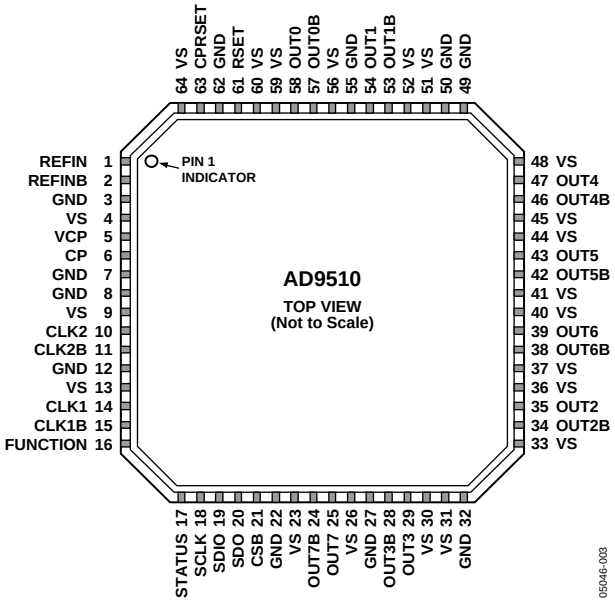

Figure 6. 64-Lead LFCSP Pin Configuration

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 = 4.12 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, 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 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

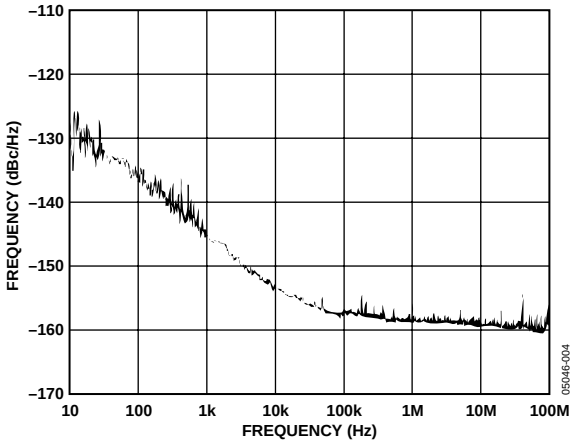

Figure 7. Phase Noise—LVPECL: 245.76 MHz

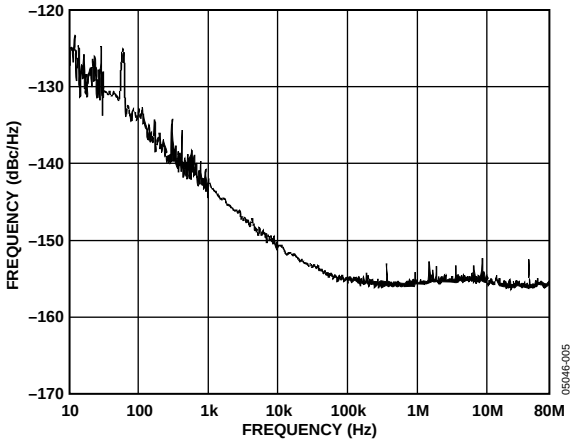

Figure 8. Phase Noise—LVPECL: 622MHz

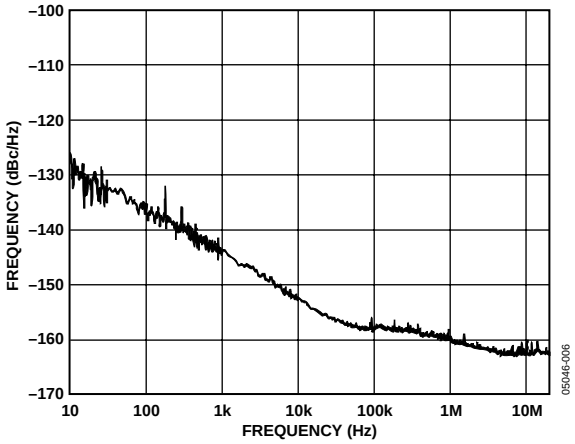

Figure 9. Phase Noise—CMOS: 61.44MHz

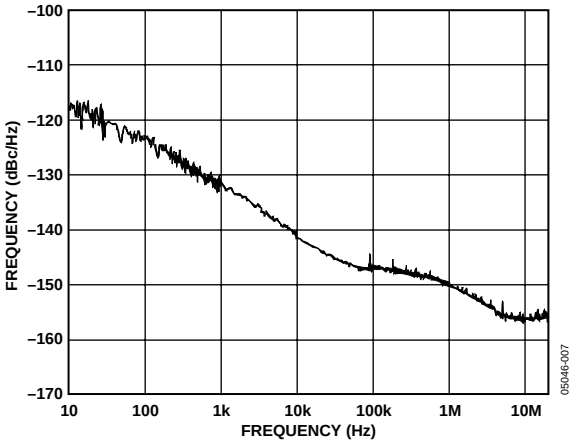

Figure 10. Phase Noise–CMOS: 245.76 MHz

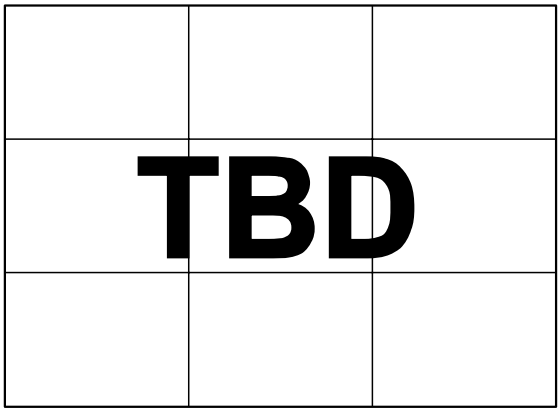

Figure 11.

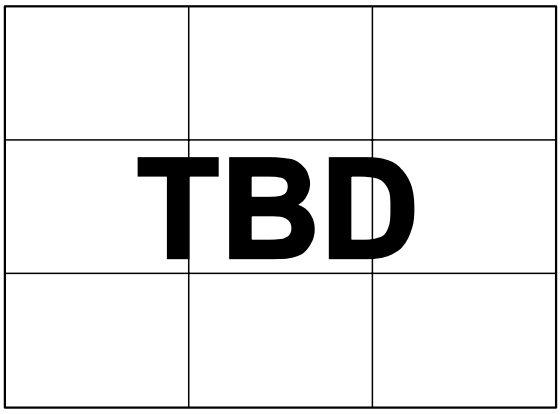

Figure 12.

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.

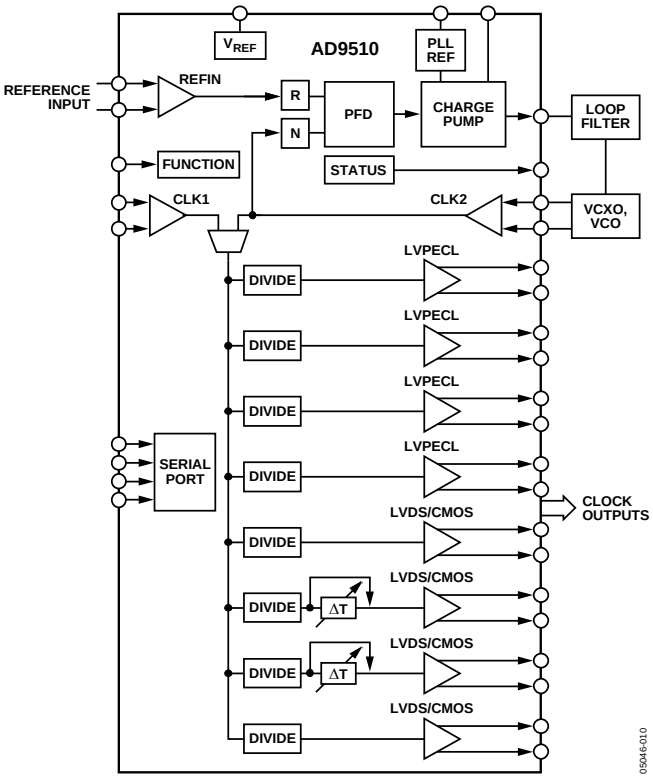

Figure 13. PLL and Clock Distribution Mode

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).

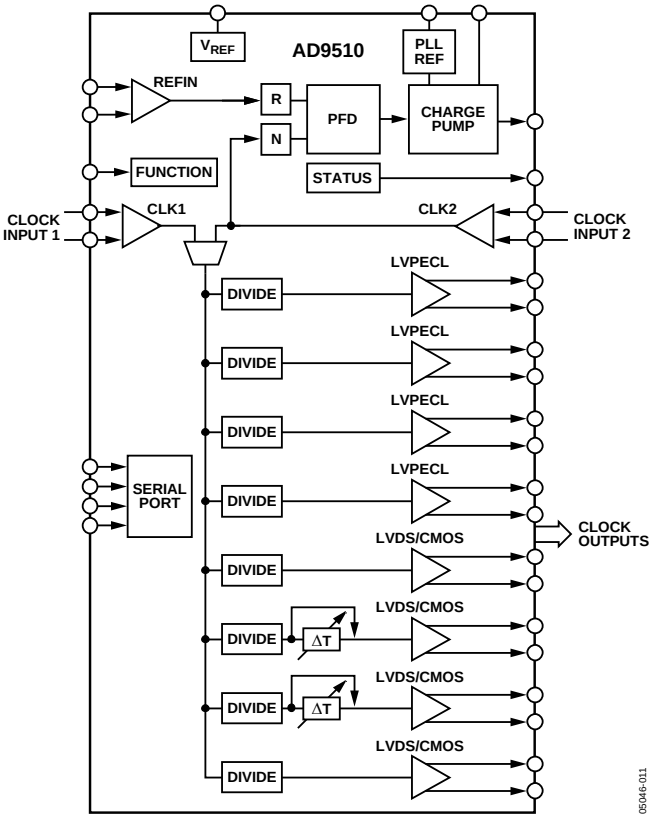

Figure 14. Clock Distribution Mode

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.

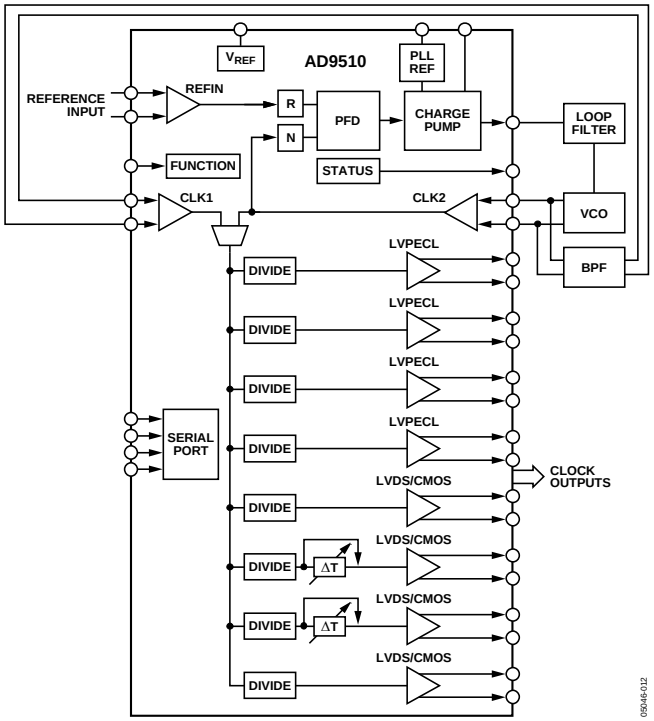

Figure 15. AD9510 with VCO and BPF Filter

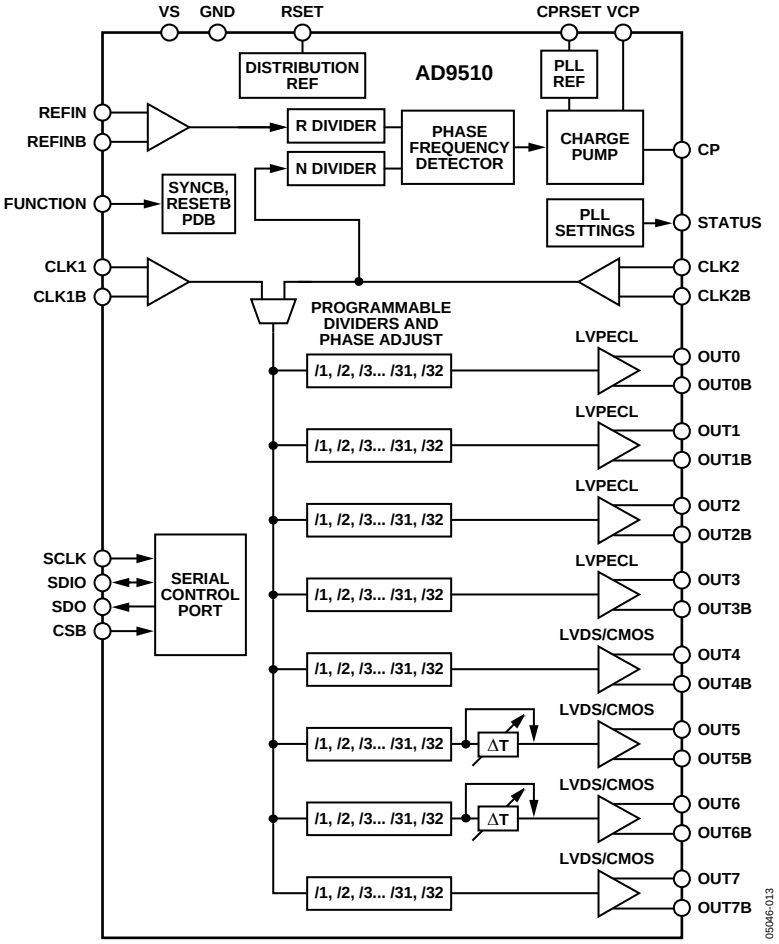

Figure 16. Functional Block Diagram

FUNCTIONAL DESCRIPTION

OVERALL

Figure 16 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 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 either LVDS or CMOS level outputs (OUT4, OUT5, OUT6, and OUT7). Two of these outputs (OUT5 and 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 SECTION

The AD9510 is partitioned into two sections: PLL and distribution. If desired, the PLL section can be used separately from the Distribution Section.

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 the ADF4106 does offering improved functionality at higher PFD rates. See Register Map Description section.

PLL REFERENCE INPUT—REFIN

The REFIN and REFINB pins can drive differentially or single-ended. These pins are internally self-biased; therefore, they should always be ac-coupled via capacitors. This also applies to the unused side when single-ended input is used. Figure 17 shows the equivalent circuit of REFIN.

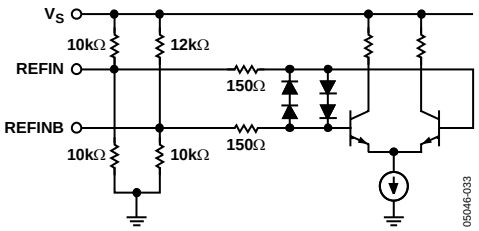

Figure 17. REFIN Equivalent Circuit

VCO/VCXO CLOCK INPUT—CLK2

The CLK2 differential input is 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 ac-coupled via capacitors.

Alternatively, CLK2 may be used as an input to the Distribution Section. This is accomplished by setting Register 45h<0> = 0. The default condition is for CLK1 to feed the Distribution Section.

See Figure 18 for the equivalent circuit of CLK1 and CLK2.

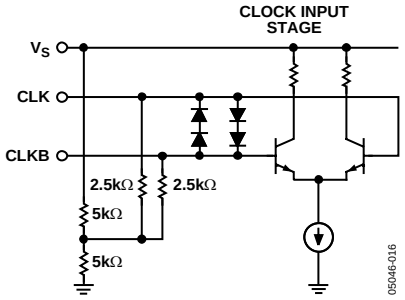

Figure 18 CLK1, CLK2 Equivalent Input Circuit

PLL REFERENCE DIVIDER—R

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 (OBh<5:0>, OCh<7:0>). 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. See Figure 17.

VCO/VCXO FEEDBACK DIVIDER—N (P, A, B)

The N divider is a combination of a prescaler, P, (3 bits) and two counters, A (6 bits) and B (13 bits). 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) 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)	Value in 0Ah<4:2>	Divide By
FD	000	1
FD	001	2
P = 2 DM	010	P/P + 1 = 2/3
P = 4 DM	011	P/P + 1 = 4/5
P = 8 DM	100	P/P + 1 = 8/9
P = 16 DM	101	P/P + 1 = 16/17
P = 32 DM	110	P/P + 1 = 32/33
FD	111	3

When using the prescaler in 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, see Table 15.

Table 15. Frequency Limits of Each 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 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 the prescaler is in FD mode.

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

DETERMINING 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 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 19 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 0Dh <1:0> control the width of the pulse.

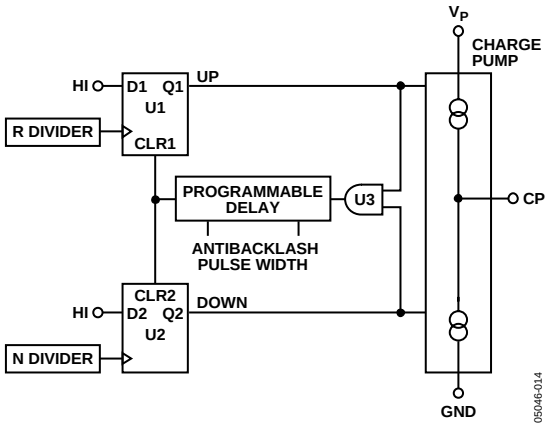

Figure 19. PFD Simplified Schematic and Timing (In Lock)

ANTIBACKLASH PULSE

The PLL features a programmable antibacklash pulse width that is set by the value in Register 0Dh<1:0>. The default antibacklash pulse width is 1.3 ns. The antibacklash pulse eliminates the dead zone around the phase-locked condition and thereby reduces the potential for certain spurs that could be impressed on the VCO signal.

STATUS PIN

The output multiplexer on the AD9510 allows access to various signals and internal points on the chip at the STATUS pin. Figure 20 shows a block diagram of the STATUS pin section. The function of the STATUS pin is controlled by Register 08h<5:2>.

PLL Digital Lock Detect

The STATUS pin can display two types of PLL lock detect: digital (DLD) and analog (ALD). Whenever digital lock detect is desired, the STATUS pin provides a CMOS level signal, which can be active high or active low.

The digital lock detect has one of two time windows, as selected by Register 0Dh<5>. The default (ODh<5> = 0) requires the signal edges on the inputs to the PFD to be coincident within 9.5 ns in order to set the DLD true, which then must separate by at least 15 ns in order to give DLD = false.

The other setting (ODh<5> = 1) makes these coincidence times 3.5 ns for DLD = true and 7 ns for DLD = false.

The DLD may be disabled by writing to Register 0Dh<6> = 1.

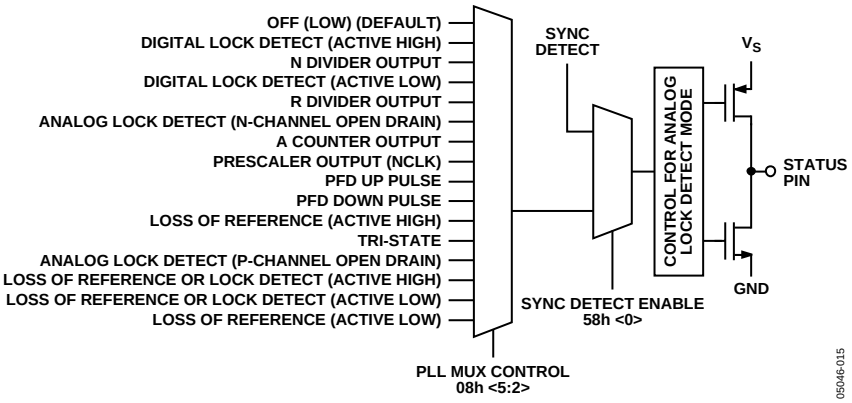

Figure 20. STATUS Pin Circuit CLK1 Clock Input

PLL Analog Lock Detect

An analog lock detect (ALD) signal may be selected. When ALD is selected, the signal at the STATUS pin is either an open-drain, p-channel (08h<5:2> = 1100) or an open-drain, n-channel (08h<5:2> = 0101).

The analog lock detect signal is true (relative to the selected mode) with brief false pulses. These false pulses get shorter as the inputs to the PFD are nearer to coincidence and longer as they are further from coincidence.

In order to extract a usable analog lock detect signal, an external RC network is required in order to provide an analog filter with the appropriate RC constant to allow for the discrimination of a lock condition by an external voltage comparator. A 1 kΩ resistor in parallel with a small capacitance usually fulfills this requirement. However, some experimentation may be required to get the desired operation.

The analog lock detect function may introduce some spurious energy into the clock outputs. It is prudent to limit the use of the ALD when the best possible jitter/phase noise performance is required on the clock outputs.

LOSS OF REFERENCE

The AD9510 PLL can warn of a loss-of-reference signal at REFIN. The loss-of-reference monitor internally sets a flag called LREF. Externally, this signal can be observed in several ways on the STATUS pin, depending on the PLL MUX control settings in Register 08h<5:2>. The LREF alone can be observed as an active high signal by setting 08h<5:2> = <1010> or as an active low signal by setting 08h<5:2> = <1111>.

The loss-of-reference circuit is clocked by the signal from the VCO, which means that there must be a VCO signal present in order to detect a loss of reference.

The digital lock detect (DLD) block of the AD9510 requires a PLL reference signal to be present in order for the digital lock detect output to be valid. It is possible to have a digital lock detect indication (DLD = true) that remains true even after a loss-of-the reference signal. For this reason, the digital lock detect signal alone cannot be relied upon if the reference has been lost. There is a way to combine the DLD and the LREF into a single signal at the STATUS pin. Set 08h<5:2> = <1101> to get a signal that is the logical OR of the DLD and the LREF active high. If an active low version of this signal is desired, set 08h<5:2> = <1110>.

The reference monitor is enabled only after the DLD signal has been high for the number of PFD cycles set by the value in 07h<6:5>. This delay is measured in PFD cycles. The delay ranges from 3 PFD cycles (default) to 24 PFD cycles. When the reference goes away, LREF goes true and the charge pump goes into tri-state.

User intervention is required to take the part out of this state. First, 07h<2> = 0 must be written in order to disable the loss-of-reference circuit, taking the charge pump out of tri-state and causing LREF to go false. A second write of 07h<2> = 1 is required to re-enable the loss-of-reference circuit.

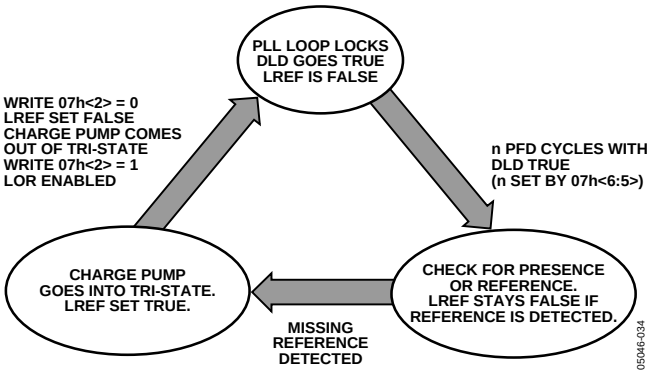

Figure 21. Loss of Reference Sequence of Events

FUNCTION PIN

The FUNCTION pin (16) has three functions that are selected by the value in Register 58h<6:5>. There is an internal 30 kΩ pull-down resistor on this pin.

RESETB: 58h<6:5> = 00b (Default)

In its default mode, the FUNCTION pin acts as RESETB, which generates an asynchronous reset or hard reset when pulled low. The resulting reset writes the default values into the serial control port buffer registers as well as loading them into the chip control registers. The AD9510 immediately resumes operation according to the default values. When the pin is taken high again, an asynchronous sync is issued (see the SYNCB: 58h<6:5> = 01b section).

SYNCB: 58h<6:5> = 01b

The FUNCTION pin may be used to cause a synchronization or alignment of phase among the various clock outputs. The synchronization applies only to clock outputs that:

- are not powered down
- the divider is not masked (no sync = 0)
- are not bypassed (bypass = 0)

SYNCB is level and rising edge sensitive. When SYNCB is low, the set of affected outputs are held in a predetermined state, defined by each divider's start high bit. On a rising edge, the dividers begin after a predefined number of fast clock cycles (fast clock is the selected clock input, CLK1 or CLK2) as determined by the values in the divider's phase offset bits.

The SYNCB application of the FUNCTION pin is always active, regardless of whether the pin is also assigned to perform reset or power-down. When the SYNCB function is selected, the FUNCTION pin does not act as either RESETB or PDB.

PDB: 58h<6:5> = 11b

The FUNCTION pin may also be programmed to work as an asynchronous full chip power-down, PDB. In PDB mode, the FUNCTION pin is active low. The chip remains in a power-down state until PDB is returned to logic high. The chip returns to the settings programmed prior to the power-down.

See the Chip Power-Down or Sleep Mode—PDB section for more details on what occurs during a PDB initiated power-down.

DISTRIBUTION SECTION

As previously mentioned, the AD9510 is partitioned into two operational sections: PLL and distribution. The PLL Section was discussed previously. If desired, the distribution section can be used separately from the PLL section.

CLK1 CLOCK INPUT

Either CLK1 or CLK2 may be selected as the input to the distribution section. The CLK1 input can only be connected to drive the distribution section. CLK1 is selected as the source for the distribution section by setting Register 45h<0> = 1. This is the power-up default state. CLK1 works for inputs up to 1500 MHz.

See Figure 18 for the CLK1 and CLK2 equivalent input circuit. The CLK1 input is fully differential and self-biased. The signal should be ac-coupled using capacitors. If a single-ended input must be used, this can be accommodated by ac coupling to one side of the differential input only. The other side of the input should be bypassed to a quiet ac ground by a capacitor.

If only the distribution section of the AD9510 is used, the unselected clock input should be powered down in order to eliminate any possibility of unwanted crosstalk between the selected clock input and the unselected clock input.

DIVIDERS

Each of the eight clock outputs of the AD9510 has its own divider. The divider may be bypassed in order to get an output at the same frequency as the input (1×). When a divider is bypassed, it is also powered down to save power.

All integer divide ratios from 2 to 32 may be selected.

Each divider may be configured for divide ratio, phase, and duty cycle. The phase and duty cycle values that can be selected depend on the divide ratio that is chosen.

Setting the Divide Ratio

The divide ratio is determined by the values written via the SCP to the registers that control each individual output, OUT0 to OUT7. These are the even numbered registers beginning at 48h and going through 56h. Each of these registers are divided into bits that control the number of clock cycles that the divider output stays high (high_cycles <3:0>) and the number of clock cycles that the divider output stays low (low_cycles <7:4>). Each value is 4 bits and has the range of 0 to 15.

The divide ratio is set by

$$Divide\ Ratio = (high\_cycles + 1) + (low\_cycles + 1)$$

Example 1:

Set the Divide Ratio = 2

high_cycles = 0

low_cycles = 0

Divide Ratio = (0 + 1) + (0 + 1) = 2

Example 2:

Set Divide Ratio = 8

high_cycles = 3

low_cycles = 3

Divide Ratio = (3 + 1) + (3 + 1) = 8

Note that a Divide Ratio of 8 may also be obtained by setting:

high_cycles = 2

low_cycles = 4

Divide Ratio = (2 + 1) + (4 + 1) = 8

Although the second set of settings produce the same divide ratio, the resulting duty cycle is not the same. See the Setting the Duty Cycle section for an explanation of how the duty cycle and divide ratio are related.

Setting the Duty Cycle

Different divide ratios have different duty cycle options. For example, if Divide Ratio = 2, the only duty cycle possible is 50%. If the Divide Ratio = 4, the duty cycle may be 25%, 50%, or 75%.

The duty cycle is set by

Duty Cycle = (*high_cycles* + 1)/((*high_cycles* + 1) + (*low_cycles* + 1))

See Table 17 for the values for the available duty cycles for each divide ratio.

Table 17. Duty Cycle and Divide Ratio

		48h to 56h	
Divide Ratio	**Duty Cycle (%)**	**LO <7:4>**	**HI<3:0>**
2	50	0	0
3	67	0	1
3	33	1	0
4	50	1	1
4	75	0	2
4	25	2	0
5	60	1	2
5	40	2	1
5	80	0	3
5	20	3	0
6	50	2	2
6	67	1	3
6	33	3	1
6	83	0	4
6	17	4	0
7	57	2	3
7	43	3	2
7	71	1	4
7	29	4	1
7	86	0	5
7	14	5	0
8	50	3	3
8	63	2	4
8	38	4	2
8	75	1	5
8	25	5	1
8	88	0	6
8	13	6	0
9	56	3	4
9	44	4	3
9	67	2	5
9	33	5	2
9	78	1	6
9	22	6	1
9	89	0	7
9	11	7	0
10	50	4	4
10	60	3	5
10	40	5	3
10	70	2	6
10	30	6	2
10	80	1	7
10	20	7	1
10	90	0	8
10	10	8	0
11	55	4	5
11	45	5	4
11	64	3	6
11	36	6	3
11	73	2	7
11	27	7	2
11	82	1	8
11	18	8	1
11	91	0	9
11	9	9	0
12	50	5	5
12	58	4	6
12	42	6	4
12	67	3	7
12	33	7	3
12	75	2	8
12	25	8	2
12	83	1	9
12	17	9	1
12	92	0	A
12	8	A	0
13	54	5	6
13	46	6	5
13	62	4	7
13	38	7	4

Divide Ratio	Duty Cycle (%)	48h to 56h	
		LO <7:4>	HI<3:0>
13	69	3	8
13	31	8	3
13	77	2	9
13	23	9	2
13	85	1	A
13	15	A	1
13	92	0	B
13	8	B	0
14	50	6	6
14	57	5	7
14	43	7	5
14	64	4	8
14	36	8	4
14	71	3	9
14	29	9	3
14	79	2	A
14	21	A	2
14	86	1	B
14	14	B	1
14	93	0	C
14	7	C	0
15	53	6	7
15	47	7	6
15	60	5	8
15	40	8	5
15	67	4	9
15	33	9	4
15	73	3	A
15	27	A	3
15	80	2	B
15	20	B	2
15	87	1	C
15	13	C	1
15	93	0	D
15	7	D	0
16	50	7	7
16	56	6	8
16	44	8	6
16	63	5	9
16	38	9	5
16	69	4	A
16	31	A	4
16	75	3	B
16	25	B	3
16	81	2	C
16	19	C	2
16	88	1	D
16	13	D	1
16	94	0	E
16	6	E	0
17	53	7	8

Divide Ratio	Duty Cycle (%)	48h to 56h	
		LO <7:4>	HI<3:0>
17	47	8	7
17	59	6	9
17	41	9	6
17	65	5	A
17	35	A	5
17	71	4	B
17	29	B	4
17	76	3	C
17	24	C	3
17	82	2	D
17	18	D	2
17	88	1	E
17	12	E	1
17	94	0	F
17	6	F	0
18	50	8	8
18	56	7	9
18	44	9	7
18	61	6	A
18	39	A	6
18	67	5	B
18	33	B	5
18	72	4	C
18	28	C	4
18	78	3	D
18	22	D	3
18	83	2	E
18	17	E	2
18	89	1	F
18	11	F	1
19	53	8	9
19	47	9	8
19	58	7	A
19	42	A	7
19	63	6	B
19	37	B	6
19	68	5	C
19	32	C	5
19	74	4	D
19	26	D	4
19	79	3	E
19	21	E	3
19	84	2	F
19	16	F	2
20	50	9	9
20	55	8	A
20	45	A	8
20	60	7	B
20	40	B	7
20	65	6	C
20	35	C	6

Divide Ratio	Duty Cycle (%)	48h to 56h	
		LO <7:4>	HI<3:0>
20	70	5	D
20	30	D	5
20	75	4	E
20	25	E	4
20	80	3	F
20	20	F	3
21	52	9	A
21	48	A	9
21	57	8	B
21	43	B	8
21	62	7	C
21	38	C	7
21	67	6	D
21	33	D	6
21	71	5	E
21	29	E	5
21	76	4	F
21	24	F	4
22	50	A	A
22	55	9	B
22	45	B	9
22	59	8	C
22	41	C	8
22	64	7	D
22	36	D	7
22	68	6	E
22	32	E	6
22	73	5	F
22	27	F	5
23	52	A	B
23	48	B	A
23	57	9	C
23	43	C	9
23	61	8	D
23	39	D	8
23	65	7	E
23	35	E	7
23	70	6	F
23	30	F	6
24	50	B	B
24	54	A	C
24	46	C	A
24	58	9	D
24	42	D	9
24	63	8	E
24	38	E	8
24	67	7	F
24	33	F	7
25	52	B	C
25	48	C	B
25	56	A	D
25	44	D	A
25	60	9	E
25	40	E	9
25	64	8	F
25	36	F	8
26	50	C	C
26	54	B	D
26	46	D	B
26	58	A	E
26	42	E	A
26	62	9	F
26	38	F	9
27	52	C	D
27	48	D	C
27	56	B	E
27	44	E	B
27	59	A	F
27	41	F	A
28	50	D	D
28	54	C	E
28	46	E	C
28	57	B	F
28	43	F	B
29	52	D	E
29	48	E	D
29	55	C	F
29	45	F	C
30	50	E	E
30	53	D	F
30	47	F	D
31	52	E	F
31	48	F	E
32	50	F	F

Divider Phase Offset

The phase of each output may also be selected, depending on the divide ratio chosen. This is selected by writing the appropriate values to the registers which set the phase and start high/low bit for each output. These are the odd numbered registers from 49h to 57h. Each divider has a 4-bit phase offset <3:0> and a start high or low bit <4>.

Following a sync pulse, the phase offset word determines how many fast clock (CLK1 or CLK2) cycles to wait before initiating a clock output edge. The Start H/L bit determines if the divider output starts low or high. By giving each divider a different phase offset, output-to-output delays can be set in increments of the fast clock period, t_{CLK}.

Figure 22 shows four dividers, each set for DIV = 4, 50% duty cycle. By incrementing the phase offset from 0 to 3, each output is offset from the initial edge by a multiple of t_{CLK}.

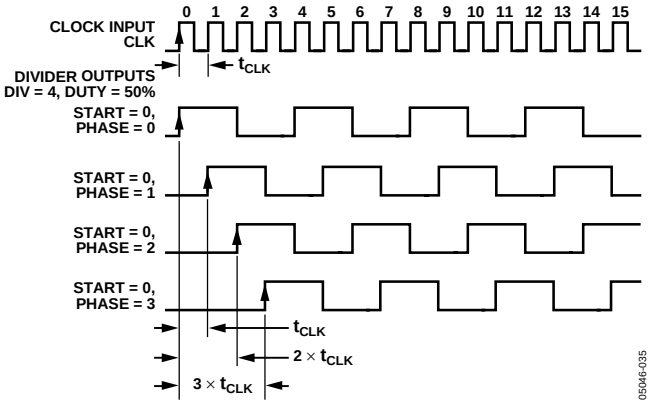

Figure 22. Phase Offset—All Dividers Set for DIV = 4, Phase Set from 0 to 3

For example:

CLK1 = 491.52 MHz,

t_{CLK1} = 1/491.52 = 2.0345 ns

For DIV = 4

Phase Offset 0 = 0 ns

Phase Offset 1 = 2.0345 ns

Phase Offset 2 = 4.069 ns

Phase Offset 3 = 6.104 ns

The four outputs may also be described as:

OUT1 = 0°

OUT2 = 90°

OUT3 = 180°

OUT4 = 270°

Setting the phase offset to Phase = 4 results in the same relative phase as the first channel, Phase = 0° or 360°.

In general, by combining the 4-bit phase offset and the Start H/L bit, there are 32 possible phase offset states (see Table 18).

Table 18. Phase Offset—Start H/L Bit

Phase Offset (Fast Clock Rising Edges)	49h to 57h	
	Phase Offset <3:0>	Start H/L <4>
0	0	0
1	1	0
2	2	0
3	3	0
4	4	0
5	5	0
6	6	0
7	7	0
8	8	0
9	9	0
10	10	0
11	11	0
12	12	0
13	13	0
14	14	0
15	15	0
16	0	1
17	1	1
18	2	1
19	3	1
20	4	1
21	5	1
22	6	1
23	7	1
24	8	1
25	9	1
26	10	1
27	11	1
28	12	1
29	13	1
30	14	1
31	15	1

The resolution of the phase offset is set by the fast clock period (t_{CLK}) at CLK1 or CLK2. As a result, every divide ratio does not have 32 unique phase offsets available. Typically, the number of unique phase offsets is equal to the divide ratio integer (see Table 18):

DIV = 4

Unique Phase Offsets Are Phase = 0, 1, 2, 3

DIV= 7

Unique Phase Offsets Are Phase = 0, 1, 2, 3, 4, 5, 6

DIV = 18

Unique Phase Offsets Are Phase = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17

Phase offsets may be related to degrees by calculating the phase step for a particular divide ratio:

Phase Step = 360°/(*Divide Ratio*) = 360°/*DIV*

Using some of the same examples:

DIV = 4

Phase Step = 360°/4 = 90°

Unique Phase Offsets in Degrees Are Phase = 0°, 90°, 180°, 270°

DIV = 7

Phase Step = 360°/7 = 51.43°

Unique Phase Offsets in Degrees Are Phase = 0°, 51.43°, 102.86°, 154.29°, 205.71°, 257.15°, 308.57°

DELAY BLOCK

OUT5 and OUT6 (LVDS/CMOS) include an analog delay element that can be programmed (Register 34h to Register 3Ah) to give variable time delays (Δt) in the clock signal passing through that output, with respect to the other outputs that are not delayed.

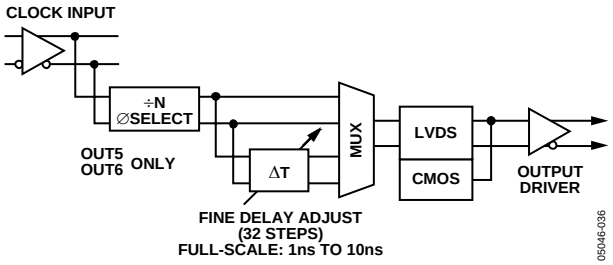

Figure 23. Analog Delay (OUT5 andOUT6)

The amount of delay that can be used is determined by the frequency of the clock being delayed. The amount of delay can approach one-half cycle of the clock period. For example, for a 10 MHz clock, the delay can extend to the full 10 ns maximum of which the delay element is capable. However, for a 100 MHz clock, the maximum delay is less than 5 ns (or half of the period).

OUT5 and OUT6 allow for a full-scale delay in the range 1 ns to 10 ns. The full-scale delay is selected by choosing a combination of ramp current and the number of capacitors by writing the appropriate values into Register 35h and Register 39h. There are 32 fine delay settings for each full scale, set by Register 36h and Register 3Ah.

This path adds some jitter greater than that specified for the nondelay outputs. This means that the delay function should be used primarily for clocking digital chips, such as FPGA, ASIC, DUC, and DDC, rather than data converters. The jitter is higher for long full scales (~10 ns). This is because the delay block uses a ramp and trip points to create the variable delay. A longer ramp means more noise has a chance of being introduced.

Calculating the Delay

The following values and equations are used to calculate the delay of the delay block.

Value of Ramp Current Control Bits (*Register 35h or Register 39h* <2:0>) = *Iramp_bits*

I_{RAMP} = 200 μA × (*Iramp_bits* + 1)

No. of Caps = No. of 0s + 1 *in Ramp Control Capacitor* (*Register 35h or Register 39h* <5:3>) that is, 101 = 1 + 1 = 2; 110 = 2; 100 = 2 + 1 = 3; 001 = 2 + 1 = 3; 111 = 0 + 1 = 1)

Delay_Range = 200 μA × ((*No. of Caps* + 3)/(I_{RAMP})) × 1.776 ns

Offset = $0.0014x^5 - 0.0279x^4 + 0.2132x^3 - 0.7408x^2 + 1.1774x - 0.0655$, where x = No. of Caps × 200 μA/I_{RAMP}

Delay_Full_Scale = Delay Range + Offset

Fine_Adj = Value of Delay Fine Adjust (*Register 36h or Register 3Ah* <5:1>), that is, 11111 = 31

Delay (Estimated) = *Delay_Full_Scale* × *Fine_adj* × (1/31)

OUTPUTS

The AD9510 offers three different output level choices: LVPECL, LVDS, and CMOS. OUT0 to OUT3 are LVPECL only. OUT4 to OUT7 may be selected as either LVDS or CMOS. Each output may be enabled or turned off as needed, to save power.

The simplified equivalent circuit of the LVPECL outputs is shown in Figure 24.

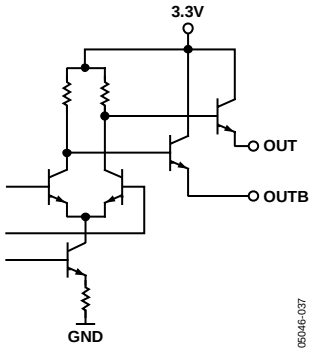

Figure 24. LVPECL Output Simplified Equivalent Circuit

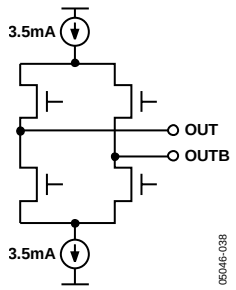

Figure 25. LVDS Output Simplified Equivalent Circuit

POWER-DOWN MODES

Chip Power-Down or Sleep Mode—PDB

The PDB chip power-down turns off most of the functions and currents in the AD9510. When the PDB mode is enabled, a chip power-down is activated by taking the FUNCTION pin to a logic low level. The chip remains in this power-down state until PDB is brought back to logic high. When woken up, the AD9510 returns to the settings programmed into its registers prior to the power-down.

The PDB power-down mode shuts down the currents on the chip, except the bias current necessary to maintain the LVPECL outputs in a safe shutdown mode. This is needed to protect the LVPECL output circuitry from damage that could be caused by certain termination and load configurations. Because this is not a complete power-down, it can be called sleep mode.

When the AD9510 is in a PDB power-down or sleep mode, the chip is in the following state:

- The PLL is off (asynchronous power-down).
- All clocks and sync circuits are off.
- All dividers are off.
- All LVDS/CMOS outputs are off.
- All LVPECL outputs are in safe off mode.
- The serial control port is active, and the chip responds to commands.

PLL Power-Down

The PLL section of the AD9510 may be selectively powered down. There are three PLL power-down modes, set by the values in Register 0Ah<1:0>, as shown in Table 19.

Table 19. Register 0Ah: PLL Power-Down

<1>	<0>	Mode
0	0	Normal Operation
0	1	Asynchronous Power-Down
1	0	Normal Operation
1	1	Synchronous Power-Down

In asynchronous power-down mode, the device powers down as soon as the registers are updated.

In synchronous power-down mode, the PLL power-down is gated by the charge pump to prevent unwanted frequency jumps. The device goes into power-down on the occurrence of the next charge pump event after the registers are updated.

Distribution Power-Down

The distribution section can be powered down by writing to Register 58h<3> = 1. This turns off the bias to the distribution section. The power-down mode also shuts off the protection circuitry that keeps the LVPECL outputs in safe mode. This mode should be avoided if any of the LVPECL outputs are terminated in ways that could cause reverse biasing of the output transistors, resulting in damage to these devices.

When combined with the PLL power-down (above), this mode results in the lowest possible power-down current for the AD9510.

Individual Clock Output Power-Down

Any of the eight clock distribution outputs may be powered down individually by writing to the appropriate registers via the SCP. The register map details the individual power-down settings for each output. The LVDS/CMOS outputs may be powered down regardless of their output load configuration. However, the LVPECL outputs have multiple power-down modes, which gives the user flexibility in dealing with either loaded/terminated or unloaded/unterminated outputs.

Individual Circuit Block Power Downs

Many of the AD9510 circuit blocks (CLK1, CLK2, REFIN, and so on) may be powered down individually. This gives flexibility in configuring the part for power savings when all chip functionality is not needed.

RESET MODES

The AD9510 has several ways to force the chip into a reset condition.

Power-On Reset—Start-Up Conditions when VS Is Applied

A power-on reset (POR) is issued when the VS power supply is turned on. This initializes the chip to the power-on conditions that are determined by the default register settings. These are indicated in the default value column of Table 23).

Asynchronous Reset via the FUNCTION Pin

As mentioned in the Function Pin section, a hard reset, RESETB: 58h<6:5> = 00b (Default), restores the chip to the default settings.

Soft Reset via the Serial Port

The serial control port allows for a soft reset by writing to Register 00h<5> = 1. When <5> is set to 1, the chip executes a soft reset. This restores the default values to the internal registers. Once this is completed, <5> is cleared automatically.

SINGLE-CHIP SYNCHRONIZATION

The AD9510 clocks can be synchronized to each other at any time. The outputs of the clocks are forced into a known state with respect to each other and then allowed to continue clocking from that state in synchronicity. Before a synchronization is done, the Function Pin should be set as the SYNCB: 58h<6:5> = 01b input. Synchronization is done by forcing the FUNCTION pin low, creating a SYNCB signal and then releasing it.

See the SYNCB: 58h<6:5> = 01b section for a more detailed description of what happens when the SYNCB: 58h<6:5> = 01b signal is issued.

MULTICHIP SYNCHRONIZATION

The AD9510 provides a means of synchronizing two or more AD9510s. This is not an active synchronization; it requires user monitoring and action. The arrangement of two AD9510s to be synchronized is shown in Figure 26.

Synchronization of two or more AD9510s requires a fast clock and a slow clock. The fast clock can be up to 1 GHz and may be the clock driving the master AD9510 CLK1 input or one of the outputs of the master. The fast clock acts as the input to the distribution section of the slave AD9510 and is connected to its CLK1 input. The PLL may be used on the master, but the slave PLL is not used.

The slow clock is the clock that is synchronized across the two chips. This clock must be no faster than one-fourth of the fast clock, and no greater than 250 MHz. The slow clock is taken from one of the outputs of the master AD9510 and acts as the REFIN (or CLK2) input to the slave AD9510. One of the outputs of the slave must provide this same frequency back to the CLK2 (or REFIN) input of the slave.

Multichip synchronization is enabled by writing Register 58h<0> = 1 on the slave AD9510. When this bit is set, the STATUS pin becomes the output for the SYNC signal. A low signal indicates an in-sync condition, and a high indicates an out-of-sync condition.

Register 58h<1> selects the number of fast clock cycles that are the maximum separation of the slow clock edges that are considered synchronized. When 58h<1> = 0 (default), the slow clock edges must be coincident within 1 to 1.5 high speed clock cycles. If the coincidence of the slow clock edges is closer than this amount, the SYNC flag stays low. If the coincidence of the slow clock edges is greater than this amount, the SYNC flag is set high. When Register 58h<1> = 1, the amount of coincidence required is 0.5 fast clock cycles to 1 fast clock cycles.

Whenever the SYNC flag is set (high), indicating an out-of-sync condition, a SYNCB signal applied simultaneously at the FUNCTION pins of both AD9510s brings the slow clocks into synchronization.

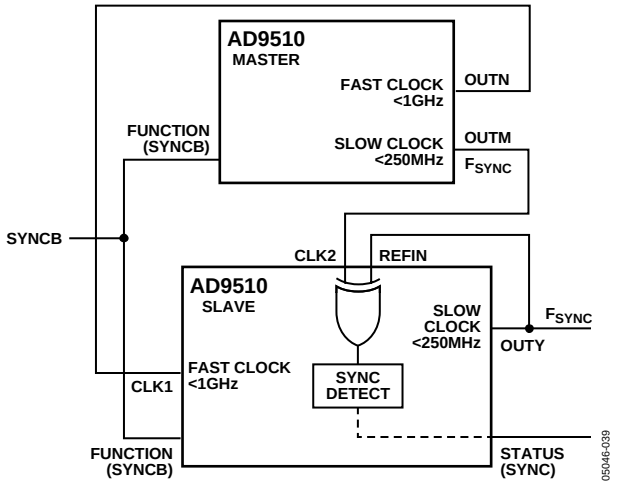

Figure 26. Multichip Synchronization

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 00h<7>.

SDO (serial data out) is used only in the 4-wire mode 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 00h<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.

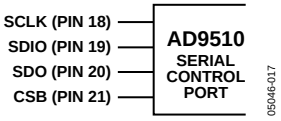

Figure 27. Serial Control Port

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 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 00h<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.

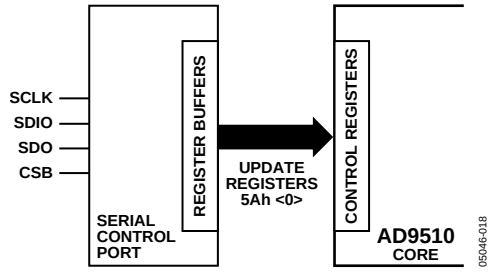

Figure 28. Relationship Between Serial Control Port Register Buffers and Control Registers of the AD9510

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 to five address bits (A4 to A0) only, 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 20.

Table 20. 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 that 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 21. 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

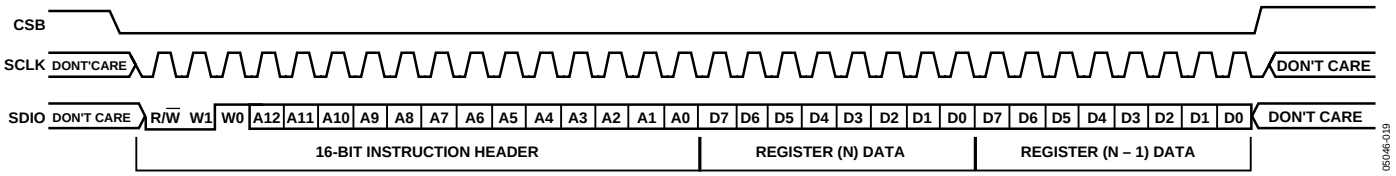

Figure 29. Serial Control Port Write—MSB First, 16-Bit Instruction, 2 Bytes Data

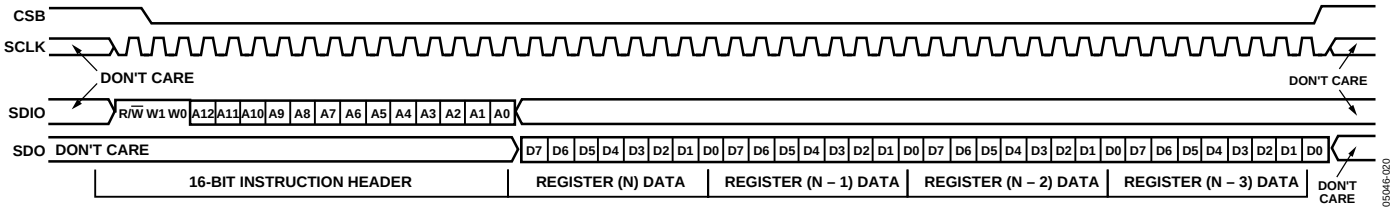

Figure 30. Serial Control Port Read—MSB First, 16-Bit Instruction, 4 Bytes Data

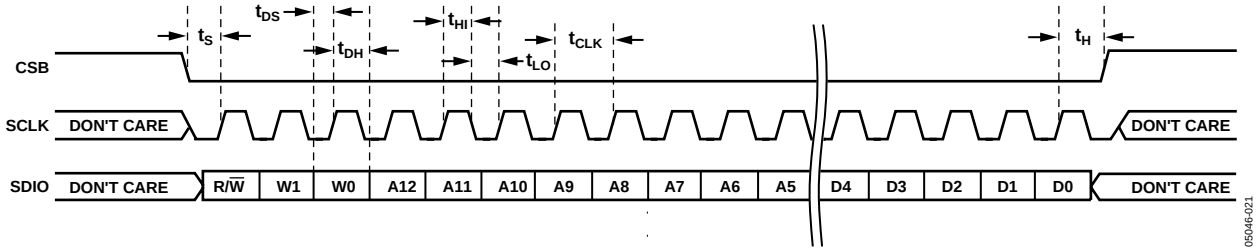

Figure 31. Serial Control Port Write–MSB First, 16-Bit Instruction, Timing Measurements

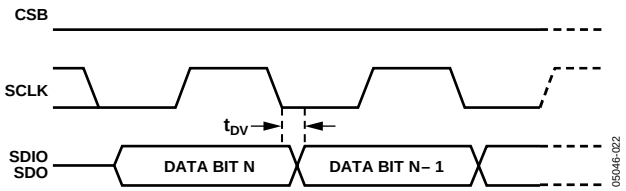

Figure 32. Timing Diagram for Serial Control Port Register Read

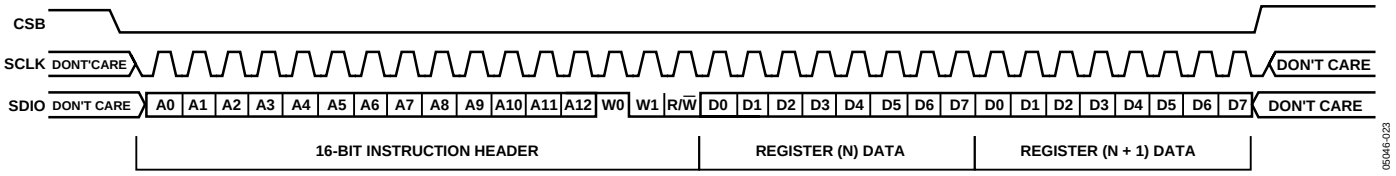

Figure 33. Serial Control Port Write—LSB First, 16-Bit Instruction, 2 Bytes Data

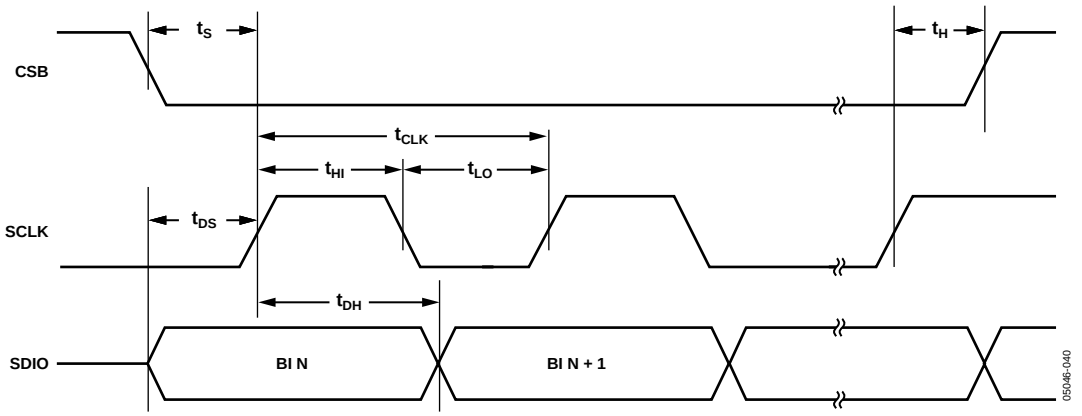

Figure 34 Serial Control Port Timing—Write

Table 22. Serial Control Port Timing

Parameter	Meaning
t_{DS}	Setup time between data and rising edge of SCLK
t_{DH}	Hold time between data and rising edge of SCLK
t_{CLK}	Period of the clock
t_S	Setup time between CSB and SCLK
t_H	Hold time between CSB and SCLK
t_{HI}	Minimum period that SCLK should be in a logic high state
t_{LO}	Minimum period that SCLK should be in a logic low state

REGISTER MAP AND DESCRIPTION

SUMMARY TABLE

Table 23. 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		Not Used									
02		Not Used									
03		Not Used									
	PLL										PLL Starts in Power-Down
04	A Counter	Not Used		6-Bit A Counter <5:0>						00	N Divider (A)
05	B Counter	Not Used			13-Bit B Counter Bits 12:8 (MSB) <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	Not Used	LOR Lock_Del <6:5>		Not Used		LOR Enable	Not Used		00	
08	PLL 2	Not Used	PFD Polarity	PLL Mux Select <5:2>				CP Mode <1:0>		00	
09	PLL 3	Not Used	CP Current <6:4>			Not Used	Reset R Counter	Reset N Counter	Reset All Counters	00	
0A	PLL 4	Not Used	B Bypass	Not Used	Prescaler P <4:2>			Power-Down <1:0>		01	N Divider (P)
0B	R Divider	Not Used		14-Bit R Divider Bits 13:8 (MSB) <5:0>						00	R Divider
0C	R Divider	14-Bit R Divider Bits 13:8 (MSB) <7:0>								00	R Divider
0D	PLL 5	Not Used	Digital Lock Det. Enable	Digital Lock Det. Window	Not Used			Antibacklash Pulse-Width <1:0>		00	
OE-33		Not Used									
	FINE DELAY ADJUST										Fine Delays Bypassed
34	Delay Bypass 5	Not Used							Bypass	01	Bypass Delay
35	Delay Full-Scale 5	Not Used		Ramp Capacitor <5:3>			Ramp Current <2:0>			00	Max. Delay Full-Scale
36	Delay Fine Adjust 5	Not Used		5-Bit Fine Delay <5:1>					Not Used	00	Min. Delay Value
37		Not Used								04	
38	Delay Bypass 6	Not Used							Bypass	01	Bypass Delay
39	Delay Full-Scale 6	Not Used		Ramp Capacitor <5:3>			Ramp Current <2:0>			00	Max. Delay Full-Scale
3A	Delay Fine Adjust 6	Not Used		5-Bit Fine Delay <5:1>					Not Used	00	Min. Delay Value
3B		Not Used								04	

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
	OUTPUTS										
3C	LVPECL OUT0	Not Used				Output Level <3:2>		Power-Down <1:0>		0A	OFF
3D	LVPECL OUT1	Not Used				Output Level <3:2>		Power-Down <1:0>		08	ON
3E	LVPECL OUT2	Not Used				Output Level <3:2>		Power-Down <1:0>		08	ON
3F	LVPECL OUT3	Not Used				Output Level <3:2>		Power-Down <1:0>		08	ON
40	LVDS_CMOS OUT 4	Not Used			CMOS Inverted Driver On	Logic Select	Output Level <2:1>		Output Power	02	LVDS, ON
41	LVDS_CMOS OUT 5	Not Used			CMOS Inverted Driver On	Logic Select	Output Level <2:1>		Output Power	02	LVDS, ON
42	LVDS_CMOS OUT 6	Not Used			CMOS Inverted Driver On	Logic Select	Output Level <2:1>		Output Power	03	LVDS, OFF
43	LVDS_CMOS OUT 7	Not Used			CMOS Inverted Driver On	Logic Select	Output Level <2:1>		Output Power	03	LVDS, OFF
44		Not Used									
	CLK1 AND CLK2										Input Receivers
45	Clocks Select, Power-Down (PD) Options	Not Used		CLKs in PD	REFIN PD	CLK to PLL PD	CLK2 PD	CLK1 PD	Select CLK IN	01	All Clocks ON, Select CLK1
46, 47		Not Used									
	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
57	Divider 7	Bypass	No Sync	Force	Start H/L	Phase Offset <3:0>				00	Phase = 0
	FUNCTION										
58	FUNCTION Pin and Sync	Not Used	Set FUNCTION Pin		PD Sync	PD All Ref.	Sync Reg.	Sync Select	Sync Enable	00	FUNCTION Pin = RESETB
59		Not Used									
5A	Update Registers	Not Used							Update Registers	00	Self-Clearing Bit
	END										

REGISTER MAP DESCRIPTION

Table 24 lists the AD9510 control registers by hexadecimal address. A specific bit or range of bits within a register is indicated by 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 24 describes the functionality of the control registers on a bit-by-bit basis. For a more concise (but less descriptive) table, see Table 23.

Table 24. 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 1 is written to this bit, the chip executes a soft reset, restoring default values to 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>
		Not Used	
01	<7:0>		Not Used
02	<7:0>		Not Used
03	<7:0>		Not Used
		PLL Settings	
04	<5:0>	A Counter	6-Bit A Counter <5:0>
04	<7:6>		Not Used
05	<4:0>	B Counter MSBs	13-Bit B Counter (MSB) <12:8>
05	<7:5>		Not Used
06	<7:0>	B Counter LSBs	13-Bit B Counter (LSB) <7:0>
07	<1:0>		Not Used
07	<2>	LOR Enable	1 = Enables the Loss-of-Reference (LOR) Function; (Default = 0)
07	<4:3>		Not Used
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 Detect Delay** 0 / 0 / 3 PFD Cycles (Default) 0 / 1 / 6 PFD Cycles 1 / 0 / 12 PFD Cycles 1 / 1 / 24 PFD Cycles
07	<7>		Not Used
08	<1:0>	Charge Pump Mode	
			<1> / **<0>** / **Charge Pump Mode** 0 / 0 / Tri-Stated (Default) 0 / 1 / Pump-Up 1 / 0 / Pump-Down 1 / 1 / Normal Operation

Reg. Addr. (Hex)	Bit(s)	Name	Description
08	<5:2>	PLL Mux Control	

<5>	<4>	<3>	<2>	MUXOUT
0	0	0	0	Off (Signal Goes Low) (Default)
0	0	0	1	Digital Lock Detect (Active High)
0	0	1	0	N Divider Output
0	0	1	1	Digital Lock Detect (Active Low)
0	1	0	0	R Divider Output
0	1	0	1	Analog Lock Detect (N Channel, Open-Drain)
0	1	1	0	A Counter Output
0	1	1	1	Prescaler Output (NCLK)
1	0	0	0	PFD Up Pulse
1	0	0	1	PFD Down Pulse
1	0	1	0	Loss-of-Reference (Active High)
1	0	1	1	Tri-State
1	1	0	0	Analog Lock Detect (P Channel, Open-Drain)
1	1	0	1	Loss-of-Reference or Lock Detect (Active High)
1	1	1	0	Loss-of-Reference or Lock Detect (Active Low)
1	1	1	1	Loss-of-Reference (Active Low)

MUXOUT is the PLL portion of the STATUS output MUX

08	<6>	Phase-Frequency Detector (PFD) Polarity	0 = Negative (Default), 1 = Positive
08	<7>		Not Used
09	<0>	Reset All Counters	0 = Normal (Default), 1 = Reset R, A, and B Counters
09	<1>	N-Counter Reset	0 = Normal (Default), 1 = Reset A and B Counters
09	<2>	R-Counter Reset	0 = Normal (Default), 1 = Reset R Counter
09	<3>		Not Used
09	<6:4>	Charge Pump (CP) Current Setting	

<6>	<5>	<4>	I_{CP} (mA)
0	0	0	0.62
0	0	1	1.25
0	1	0	1.87
0	1	1	2.50
1	0	0	3.12
1	0	1	3.75
1	1	0	4.37
1	1	1	5.00

Default = 000
These currents assume: CPR_{SET} = 5.1 kΩ
Actual current can be calculated by: CP_lsb = 3.1875/CPR_{SET}

09	<7>		Not Used
0A	<1:0>	PLL Power-Down	01 = Asynchronous Power-Down (Default)

<1>	<0>	Mode
0	0	Normal Operation
0	1	Asynchronous Power-Down
1	0	Normal Operation
1	1	Synchronous Power-Down

Reg. Addr. (Hex)	Bit(s)	Name	Description
0A	<4:2>	Prescaler Value (P/P+1)	

<4>	<3>	<2>	Mode	Prescaler Mode
0	0	0	FD	Divide by 1
0	0	1	FD	Divide by 2
0	1	0	DM	2/3
0	1	1	DM	4/5
1	0	0	DM	8/9
1	0	1	DM	16/17
1	1	0	DM	32/33
1	1	1	FD	Divide by 3

DM = Dual Modulus, FD = Fixed Divide.

Reg. Addr. (Hex)	Bit(s)	Name	Description
0A	<5>		Not Used
0A	<6>	B Counter Bypass	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.
0A	<7>		Not Used
0B	<5:0>	14-Bit Reference Counter, MSBs	R Divider (MSB) <13:8>
0C	<7:0>	14-Bit Reference Counter, R LSBs	R Divider (MSB) <7:0>
0D	<1:0>	Antibacklash Pulse-Width	

<1>	<0>	Antibacklash Pulse Width (ns)
0	0	1.3 (Default)
0	1	2.9
1	0	6.0
1	1	1.3

Reg. Addr. (Hex)	Bit(s)	Name	Description
0D	<4:2>		Not Used
0D	<5>	Digital Lock Detect Window	

<5>	Digital Lock Detect Window (ns)	Digital Lock Detect Loss-of-Lock Threshold (ns)
0 (Default)	9.5	15
1	3.5	7

Reg. Addr. (Hex)	Bit(s)	Name	Description
		Digital Lock Detect Window	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 the loss-of-lock threshold.
0D	<6>	Lock Detect Disable	0 = Normal Lock Detect Operation (Default) 1 = Disable Lock Detect
0D	<7>		Not Used
		Unused	
0E-33			Not Used
		Fine Delay Adjust	
	<0>	Delay Control	Delay Block Control Bit
34 (38)		OUT5 (OUT6)	Bypasses Delay Block and Powers It Down (Default = 1)
34 (38)	<7:1>		Not Used
	<2:0>	Ramp Current	
35 (39)		OUT5 (OUT6)	The slowest ramp (200 µs) sets the longest full scale of approximately 10 ns.

Reg. Addr. (Hex)	Bit(s)	Name	Description			
			<2>	**<1>**	**<0>**	**Ramp Current (µs)**
			0	0	0	200
			0	0	1	400
			0	1	0	600
			0	1	1	800
			1	0	0	1000
			1	0	1	1200
			1	1	0	1400
			1	1	1	1600
35 (39)	<5:3>	Ramp Capacitor OUT5 (OUT6)	Selects the Number of Capacitors in Ramp Generation Circuit More Capacitors => Slower Ramp			
			<5>	**<4>**	**<3>**	**Number of Capacitors**
			0	0	0	4 (Default)
			0	0	1	3
			0	1	0	3
			0	1	1	2
			1	0	0	3
			1	0	1	2
			1	1	0	2
			1	1	1	1
36 (3A)	<5:1>	Delay Fine Adjust OUT5 (OUT6)	Sets Delay Within Full Scale of the Ramp; There Are 32 Steps 00000 => Zero Delay (Default) 11111 => Maximum Delay			
3C (3D) (3E) (3F)	<1:0>	Power-Down LVPECL OUT0 (OUT1) (OUT2) (OUT3)	**Mode**	**<1>**	**<0>**	**Description** / **Output**
			ON	0	0	Normal Operation / ON
			PD1	0	1	Test Only—Do Not Use / OFF
			PD2	1	0	Safe Power-Down Partial Power-Down; Use If Output Has Load Resistors / OFF
			PD3	1	1	Total Power-Down Use Only If Output Has No Load Resistors / OFF
3C (3D) (3E)	<3:2>	Output Level LVPECL OUT0 (OUT1)	Output Single-Ended Voltage Levels for LVPECL Outputs			

Reg. Addr. (Hex)	Bit(s)	Name	Description
(3F)		(OUT2) (OUT3)	

<3>	<2>	Output Voltage (mV)
0	0	490
0	1	330
1	0	805 (Default)
1	1	650

3C (3D) (3E) (3F)	<7:4>		Not Used
40 (41) (42) (43)	<0>	Power-Down LVDS/CMOS OUT4 (OUT5) (OUT6) (OUT7)	Power-Down Bit for Both Output and LVDS Driver 0 = LVDS/CMOS on (Default) 1 = LVDS/CMOS Power-Down
40 (41) (42) (43)	<2:1>	Output Current Level LVDS OUT4 (OUT5) (OUT6) (OUT7)	

<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>		Not Used
44	<7:0>		Not Used

Reg. Addr. (Hex)	Bit(s)	Name	Description
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>		Not Used
46	<7:0>		Not Used
47	<7:0>		Not Used
	<3:0>	Divider High	Number of Clock Cycles Divider Output Stays High
48		OUT0	
(4A)		(OUT1)	
(4C)		(OUT2)	
(4E)		(OUT3)	
(50)		(OUT4)	
(52)		(OUT5)	
(54)		(OUT6)	
(56)		(OUT7)	
	<7:4>	Divider Low	Number of Clock Cycles Divider Output Stays Low
48		OUT0	
(4A)		(OUT1)	
(4C)		(OUT2)	
(4E)		(OUT3)	
(50)		(OUT4)	
(52)		(OUT5)	
(54)		(OUT6)	
(56)		(OUT7)	
	<3:0>	Phase Offset	Phase Offset (Default = 0000)
49		OUT0	
(4B)		(OUT1)	
(4D)		(OUT2)	
(4F)		(OUT3)	
(51)		(OUT4)	
(53)		(OUT5)	
(55)		(OUT6)	
(57)		(OUT7)	
	<4>	Start	Selects Start High or Start Low (Default = 0)
49		OUT0	
(4B)		(OUT1)	
(4D)		(OUT2)	
(4F)		(OUT3)	
(51)		(OUT4)	
(53)		(OUT5)	
(55)		(OUT6)	
(57)		(OUT7)	
	<5>	Force	Forces Individual Outputs to the State Specified in Start (Above) This Function Requires That Nosync (Below) Also Be Set (Default = 0)

Reg. Addr. (Hex)	Bit(s)	Name	Description
49		OUT0	
(4B)		(OUT1)	
(4D)		(OUT2)	
(4F)		(OUT3)	
(51)		(OUT4)	
(53)		(OUT5)	
(55)		(OUT6)	
(57)		(OUT7)	
	<6>	Nosync	Ignore Chip-Level Sync Signal (Default = 0)
49		OUT0	
(4B)		(OUT1)	
(4D)		(OUT2)	
(4F)		(OUT3)	
(51)		(OUT4)	
(53)		(OUT5)	
(55)		(OUT6)	
(57)		(OUT7)	
	<7>	Bypass Divider	Bypass and Power-Down Divider Logic; Route Clock Directly to Output (Default = 0)
49		OUT0	
(4B)		(OUT1)	
(4D)		(OUT2)	
(4F)		(OUT3)	
(51)		(OUT4)	
(53)		(OUT5)	
(55)		(OUT6)	
(57)		(OUT7)	
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>		Not Used
59	<7:0>		Not Used
5A	<0>	Update Registers	1 written to this bit updates all registers and transfers all serial control port register buffer contents to the control registers on the next rising SCLK edge. This is a self-clearing bit. 0 does not have to be written in order to clear it.
5A	<7:1>		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 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. Figure 35 shows the required sampling clock jitter as a function of the analog frequency and effective number of bits (ENOB)

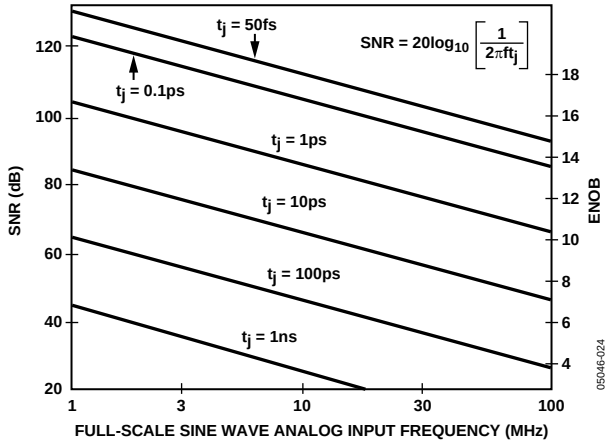

Figure 35. ENOB and SNR vs. Analog Input Frequency

See Application Note AN-501 at www.analog.com.

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) that 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 has one receiver only on the net, if possible. This allows for simple termination schemes and minimizes 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 the 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 37. 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.

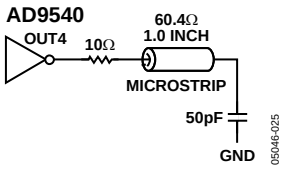

Figure 36. Series Termination of CMOS Output

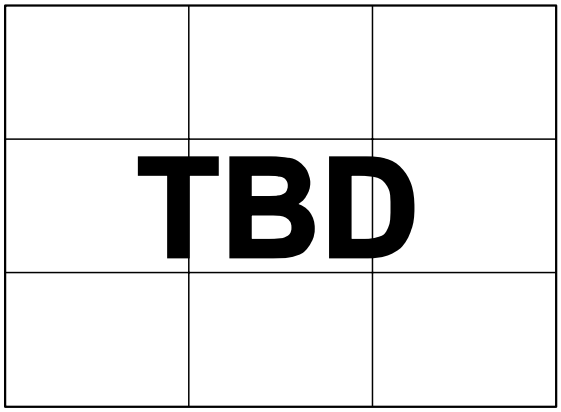

Figure 37. CMOS Output Waveforms

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 39. 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.

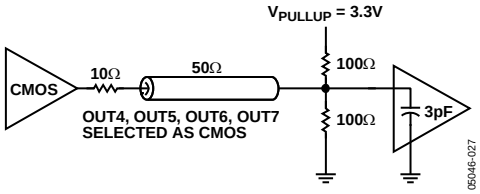

Figure 38. CMOS Output with Far-End Termination

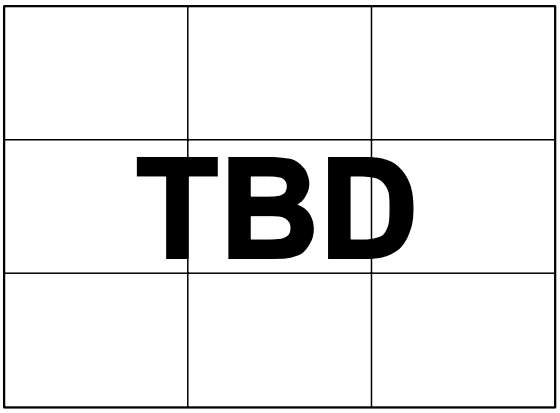

Figure 39. Far-End Termination of CMOS Output Waveform

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 24 shows the LVPECL output stage.

In most applications, a standard LVPECL far-end termination is recommended, as shown in Figure 40. The resistor network is designed to match the transmission line impedance (50 Ω) and the desired switching threshold (1.3 V). Figure 42 shows a typical LVPECL clock waveform.

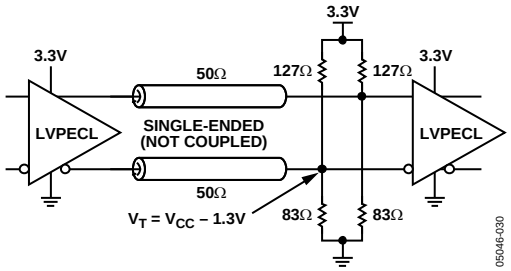

Figure 40. LVPECL Far-End Termination

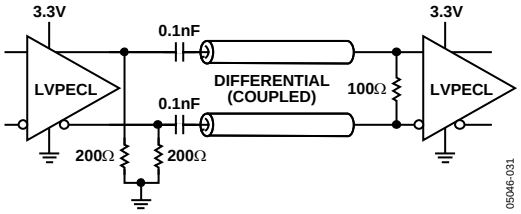

Figure 41 LVPECL with Parallel Transmission Line

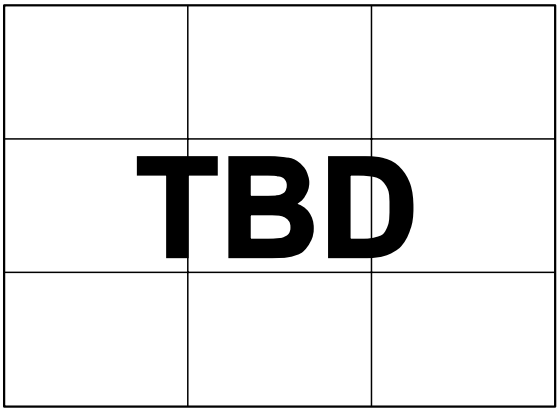

Figure 42. Typical LVPECL Outputs

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 for the LVDS outputs is shown in Figure 43.

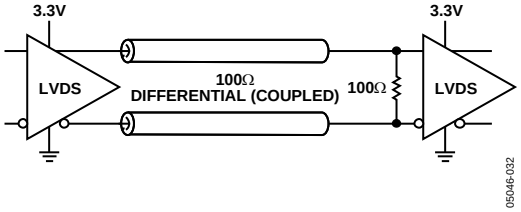

Figure 43. LVDS Output Termination

A typical LVDS output waveform is shown in Figure 44.

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

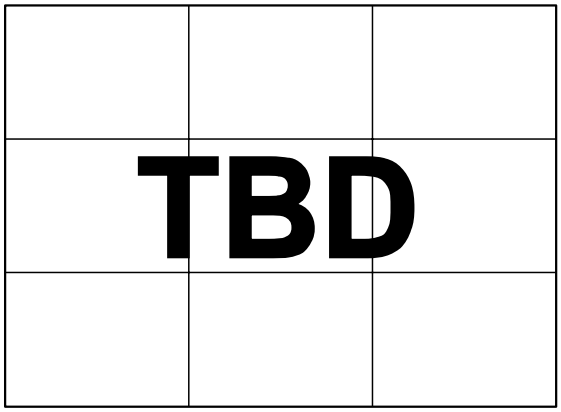

Figure 44. Typical LVDS Output Waveforms

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.

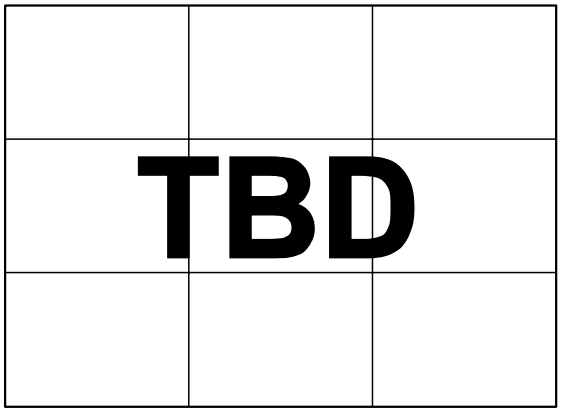

Figure 45. Differential LC Filter for Single 3.3 V Applications

OUTLINE DIMENSIONS

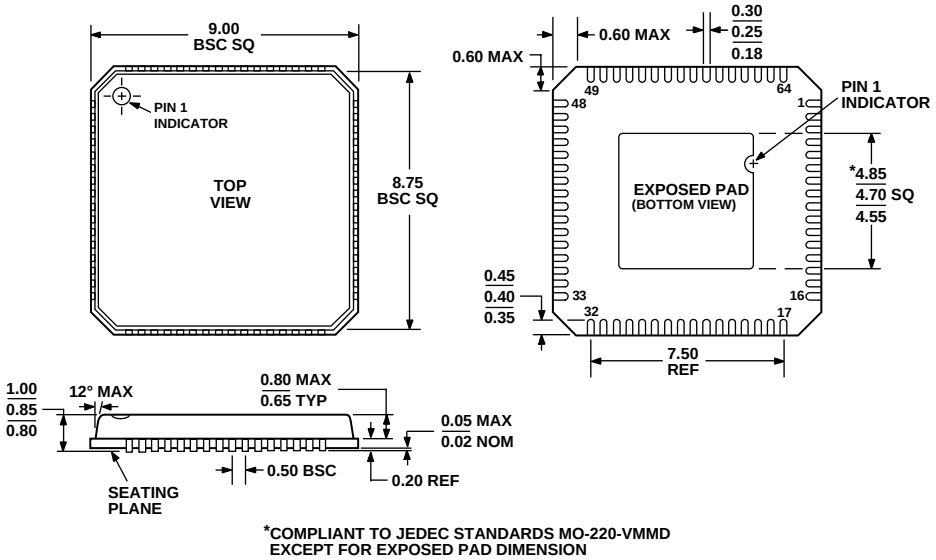

Figure 46. 64-Lead Lead Frame Chip Scale Package [LFCSP_VQ]
9 mm × 9 mm Body, Very Thin Quad (CP-64-1)
Dimensions shown in millimeters

ORDERING GUIDE

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

NOTES

PR05046–0–2/05(PrB)