Low Skew CMOS PLL Clock Driver With Integrated Loop Filter

QUALITY SEMICONDUCTOR, INC.

FEATURES

- 2xQ output, Q/2 output, $\overline{Q}$ output
- Outputs tri-state while $\overline{RST}$ low
- Internal loop filter RC network
- Low noise TTL level outputs
- < 500ps output skew, Q0-Q4
- PLL disable feature for low frequency testing
- Balanced Drive Outputs ± 24mA
- 132MHz maximum frequency (2xQ output)
- Pin compatible with Motorola MC88915
- ESD > 2000V
- Latch-up > –300mA
- Space saving 28-pin QSOP and PLCC packages

DESCRIPTION

The QS5917T-T Clock Driver uses an internal phase locked loop (PLL) to lock low skew outputs to one of two reference clock inputs. Eight outputs are available: Q0-Q4, 2xQ, Q/2, $\overline{Q5}$. Careful layout and design insures < 500ps skew between the Q4-Q0, and Q/2 outputs. The QS5917T-T includes an internal RC filter which provides excellent jitter characteristics and eliminates the need for external components. In addition, TTL level outputs reduce clock signal noise. Various combinations of feedback and a divide-by-2 in the VCO path allow applications to be customized for linear VCO operation over a wide range of input SYNC frequencies. The VCO can also be disabled by the PLL_EN signal to allow low frequency or DC testing. The LOCK output asserts to indicate when phase lock has been achieved. The QS5917T-T is designed for use in high-performance workstations, multi-board computers, networking hardware, and mainframe systems. Several can be used in parallel or scattered throughout a system for guaranteed low skew, system-wide clock distribution networks.

For more information on PLL clock driver products, see Application Note AN-22A.

3

Figure 1. Functional Block Diagram

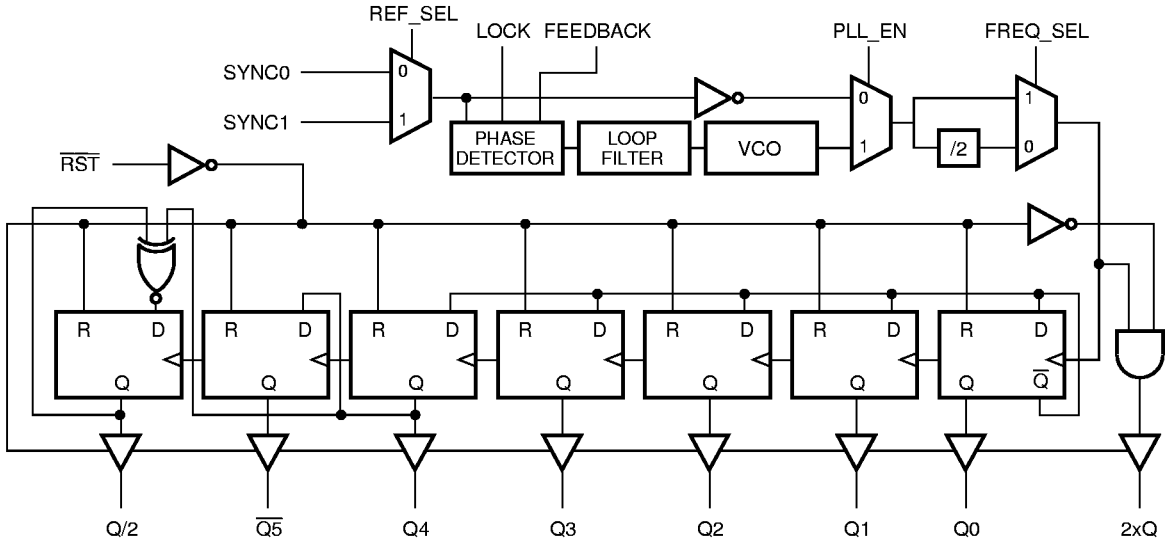


Figure 2. Pin Configuration (All Pins Top View)

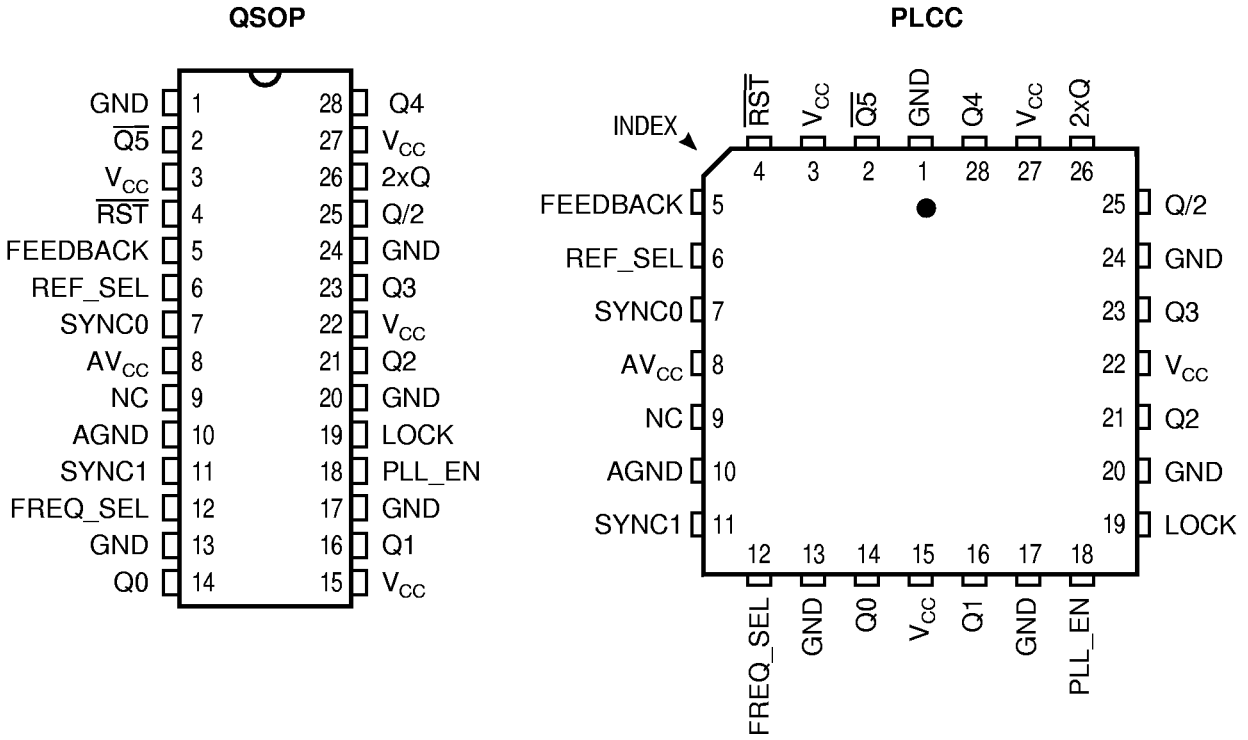


Table 1. Pin Descriptions

Pin Name	I/O	Functional Description
SYNC0	I	Reference clock input
SYNC1	I	Reference clock input
REF_SEL	I	Reference clock select. When 1, selects SYNC1. When 0, selects SYNC0.
FREQ_SEL	I	VCO frequency select. For choosing optimal VCO operating frequency depending on input frequency.
FEEDBACK	I	PLL feedback input which is connected to a user selected output pin. External feedback provides flexibility for different output frequency relationships. See the Frequency Selection Table for more information.
Q0-Q4	O	Clock outputs
$\overline{Q5}$	O	Clock output. Matched in frequency, but inverted with respect to Q.
2xQ	O	Clock output. Matched in phase, but frequency is double the Q frequency.
Q/2	O	Clock output. Matched in phase, but frequency is half the Q frequency.
LOCK	O	PLL lock indication signal. 1 indicates positive lock. 0 indicates that the PLL is not locked and outputs may not be synchronized to the inputs.
$\overline{RST}$	I	Asynchronous reset. Resets all output registers. When 0, all outputs are held in a tri-stated condition. When 1, outputs are enabled (normal operation).
PLL_EN	I	PLL enable. When 1, PLL is enabled (normal operation). When 0, PLL is disabled (for testing purposes).
NC	—	No Connection

Table 2. Absolute Maximum Ratings

Supply Voltage to Ground	–0.5V to +7.0V
DC Input Voltage V_{IN}	–0.5V to +7.0V
AC Input Voltage (for a pulse width ≤ 20ns)	–3.0V
Maximum Power Dissipation	1.2 watts
T_{STG} Storage Temperature	–65° to +150°C

Note: Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to QSI devices that result in functional or reliability type failures.

Table 3. Output Frequency Specifications

Industrial: T_A = –40°C to +85°C, V_{CC} = 5.0V ± 5%.

Symbol	Description	–70	–100	–132	Units
F2xQ	Maximum frequency, 2xQ output	70	100	132	MHz
FQ	Maximum frequency, Q0-Q4, $\overline{Q5}$ outputs	35	50	66	MHz
FQ/2	Maximum frequency, Q/2 output	17.5	25	33	MHz

3

Table 4. Frequency Selection Table

FREQ_SEL	Output Used for Feedback	Allowable SYNC[1] Range (MHz) Min	Max	Output Frequency Relationships Q/2	$\overline{Q5}$	Q Outputs	2xQ
1	Q/2	5	F2xQ ÷ 4	SYNC	–(SYNC x 2)	SYNC x 2	SYNC x 4
1	Q4-Q0	10	F2xQ ÷ 2	SYNC ÷ 2	–SYNC	SYNC	SYNC x 2
1	$\overline{Q5}$	10	F2xQ ÷ 2	–SYNC ÷ 2	SYNC	–SYNC	–SYNC x 2
1	2xQ	20	F2xQ[2]	SYNC ÷ 4	–(SYNC ÷ 2)	SYNC ÷ 2	SYNC
0	Q/2	2.5	F2xQ ÷ 8	SYNC	–(SYNC x 2)	SYNC x 2	SYNC x 4
0	Q4-Q0	5	F2xQ ÷ 4	SYNC ÷ 2	–SYNC	SYNC	SYNC x 2
0	$\overline{Q5}$	5	F2xQ ÷ 4	–SYNC ÷ 2	SYNC	–SYNC	–SYNC x 2
0	2xQ	10	F2xQ ÷ 2	SYNC ÷ 4	–(SYNC ÷ 2)	SYNC ÷ 2	SYNC

Notes:
1. Operation in the specified SYNC frequency range guarantees that the VCO will operate in optimal range of 20MHz to F_{2XQMAX}. Operation with Sync inputs outside specified frequency ranges may result in invalid or out-of-lock outputs. FREQ_SEL only affects VCO frequency and does not affect output frequencies.
2. For the –132 speed grade, maximum input frequency is restricted to 100MHz.

Table 5. Capacitance

T_A = 25°C, f = 1MHz, V_{IN} = 0V, V_{OUT} = 0V

Pins	QSOP Typ	QSOP Max	PLCC Typ	PLCC Max	Unit
C_{IN}	3	4	4	6	pF
C_{OUT}	7	9	8	10	pF

Note: Capacitance is characterized but not tested.

Table 6. DC Electrical Characteristics Over Operating Range

Industrial: T_A = –40°C to +85°C, V_{CC} = 5.0V ± 5%

Symbol	Parameter	Test Conditions	Min	Max	Unit
V_{IH}	Input HIGH Voltage	Guaranteed Logic HIGH Level	2.0	—	V
V_{IL}	Input LOW Voltage	Guaranteed Logic LOW Level	—	0.8	V
V_{OH}	Output HIGH Voltage	V_{CC} = Min., I_{OH} = –24mA(1)	2.4	—	V
		V_{CC} = Min., I_{OH} = –100µA	3.0	—	V
V_{OL}	Output LOW Voltage	V_{CC} = Min., I_{OL} = 24mA(1)	—	0.55	V
		V_{CC} = Min., I_{OL} = 100µA	—	0.2	V
$\|I_{OZ}\|$	Output Leakage Current	V_{OUT} = V_{CC} or V_{OUT} = GND, V_{CC} = Max.	—	5	µA
$\|I_{IN}\|$	Input Leakage Current	V_{CC} = Max., V_{IN} = V_{CC} or V_{IN} = GND	—	5	µA

Notes:
1. I_{OL} and I_{OH} are 12mA and –12mA, respectively, for the LOCK output.

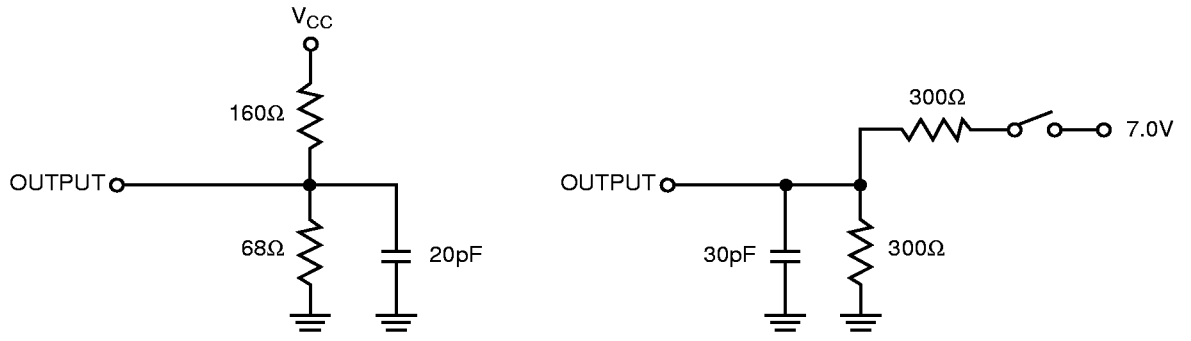
Table 7. Power Supply Characteristics

Symbol	Parameter	Test Conditions(1)	Typ	Max	Unit
ΔI_{CC}	Input Power Supply Current per TTL Input HIGH(2)	V_{CC} = Max., V_{IN} = 3.4V	0.4	1.5	mA
I_{CCD}	Dynamic Power Supply Current(3)	V_{CC} = Max.	—	0.4	mA/ MHz

Notes:
1. For conditions shown as Min. or Max., use the appropriate values specified under DC specifications.
2. This specification does not apply to the PLL_EN input.
3. Guaranteed but not tested.
4. For all DC parameters, test conditions also assume no output loading.

Figure 2. Test Load

Test Circuit #2 is used for output enable/disable parameters.
Test Circuit #1 is used for all other timing parameters.



TEST CIRCUIT 1 TEST CIRCUIT 2

Table 8. Switching Characteristics Over Operating Range

Industrial: T_A = –40°C to +85°C, V_{CC} = 5.0V ± 5%

Symbol	Description[1]	QS5917T-T Min	QS5917T-T Max	Unit
t_{SKR}	Output Skew Between Rising Edges, Q0-Q4 and Q/2[2,3]	—	350	ps
t_{SKF}	Output Skew Between Falling Edges, Q0-Q4[2,3]	—	350	ps
t_{SKALL}	Output Skew, All Outputs[2,3]	—	500	ps
t_{PW}	Pulse Width, 2xQ Outputs[2]	T_{CY}/2–0.5	T_{CY}/2+0.5	ns
t_{PW}	Pulse Width, Q0-Q4, $\overline{Q5}$, Q/2 Outputs[2]	T_{CY}/2–0.5	T_{CY}/2+0.5	ns
t_J	Cycle to Cycle Jitter, 33MHz[2,5]	—	0.25	ns
t_{PD}	SYNC Input to Feedback Delay, 10MHz	–100	400	ps
t_{PD}	SYNC Input to Feedback Delay, 33MHz, 50Ω to 1.5V[2]	–100	400	ps
t_{LOCK}	SYNC to Phase Lock	—	10	ms
t_{PZH} t_{PZL}	Output Enable Time, $\overline{RST}$ LOW to HIGH[4]	0	7	ns
t_{PHZ} t_{PLZ}	Output Disable Time, $\overline{RST}$ HIGH to LOW[2,4]	0	6	ns
t_R, t_F	Output Rise and Fall Times, 0.8V to 2.0V[2]	0.4	1.5	ns

Notes:
1. See Test Circuit and Waveforms. Minimums guaranteed but not tested.
2. This parameter is guaranteed by design but not tested.
3. Skew specifications apply under identical environments (loading, temperature, V_{CC}, device speed grade).
4. Measured in open loop mode PLL_EN = 0.
5. Jitter is characterized using an oscilloscope. Measurement is taken one cycle after jitter. Jitter is characterized but not tested. See FREQUENCY SELECTION TABLE for information on proper FREQ_SEL level for specified input frequencies.

Table 9. Input Timing Requirements

Industrial: T_A = –40°C to +85°C, V_{CC} = 5.0V ± 5%

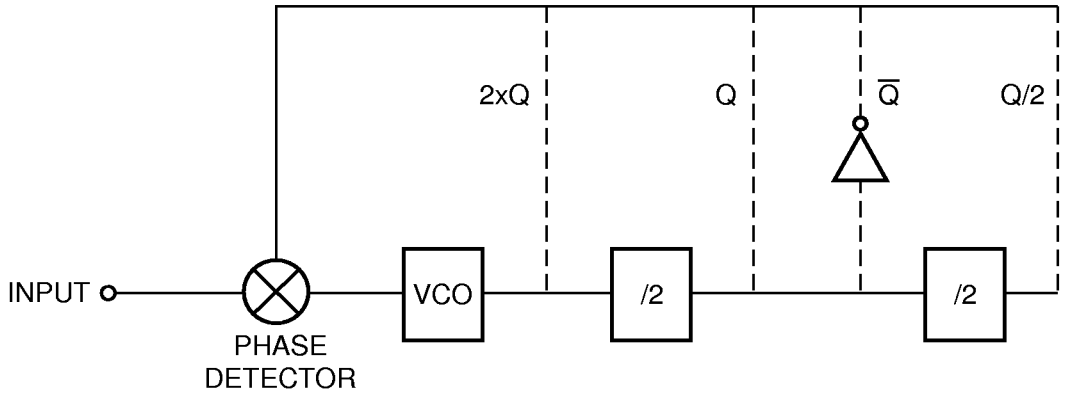
Symbol	Description[1]	QS5917T-T Min	QS5917T-T Max	Unit
t_R, t_F	Maximum Input Rise and Fall Times, 0.8V to 2.0V	—	3.0	ns
F_I	Input Clock Frequency, SYNC0, SYNC1[2]	5	F2xQ	MHz
t_{PWC}	Input Clock Pulse, HIGH or LOW	2	—	ns
D_H	Duty Cycle, SYNC0, SYNC1	25%	75%	%

Notes:
1. See Test Circuit and Waveforms. Minimums guaranteed but not tested.
2. The F_I specification is based on Q output feedback. See FREQUENCY SELECTION TABLE for more detail on allowable SYNC input frequencies for different feedback combinations.

PLL Operation

The Phase Locked Loop (PLL) circuit included in the QS5917T-T provides for replication of incoming SYNC clock signals. Any manipulation of that signal, such as frequency mulitplying or inversion is performed by digital logic following the PLL (see the block diagram). The key advantage of the PLL circuit is to provide an effective zero propagation delay between the output and input signals. In fact, adding delay circuits in the feeback path, 'propagation delay' can even be negative! Figure 3 shows a simplified schematic of the QS5917T-T PLL circuit:

Figure 3. Simplified diagram of QS5917T-T feedback



The phase difference between the output and the input frequencies feeds the VCO which drives the outputs. Whichever output is fed back, it will stabilize at the same frequency as the input. Hence, this is a true negative feedback closed loop system. In most applications, the output will optimally have zero phase shift with respect to the input. In fact, the internal loop filter on the QS5917T-T typically provides within 150ps of phase shift between input and output.

If the user wishes to vary the phase difference (typically to compensate for backplane delays), this is most easily accomplished by adding delay circuits to the feedback path. The repective output used for feedback will be advanced by the amount of delay in the feedback path. All other outputs will retain their proper relationships to that output.