



LOW SKEW TTL PLL CLOCK DRIVER WITH INTEGRATED LOOP FILTER

QS5919T

FEATURES:

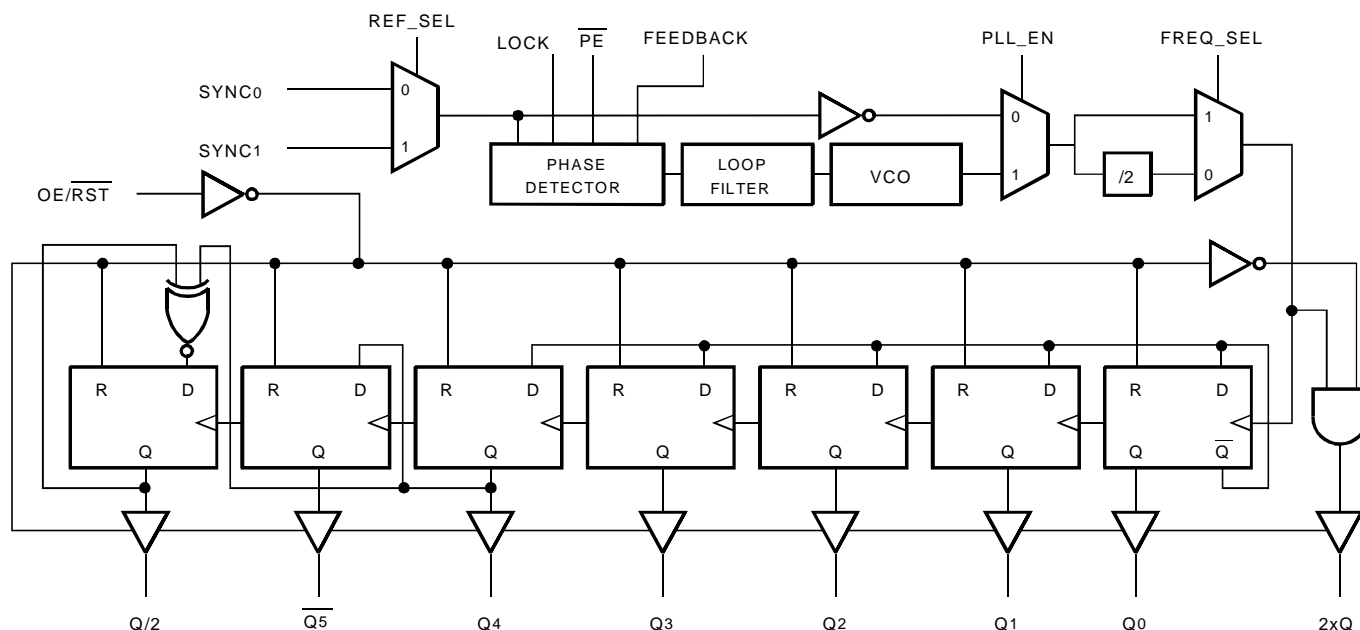
- 5V operation
- Low noise TTL level outputs
- < 350ps output skew, Q0-Q4
- 2xQ output, Q outputs, \overline{Q} output, Q/2 output
- Outputs 3-state and reset while OE/ \overline{RST} low
- PLL disable feature for low frequency testing
- Internal loop filter RC network
- Functional equivalent to Motorola MC88915
- Positive or negative edge synchronization (\overline{PE})
- Balanced drive outputs $\pm 24mA$
- 160MHz maximum frequency (2xQ output)
- Available in QSOP and PLCC packages

DESCRIPTION

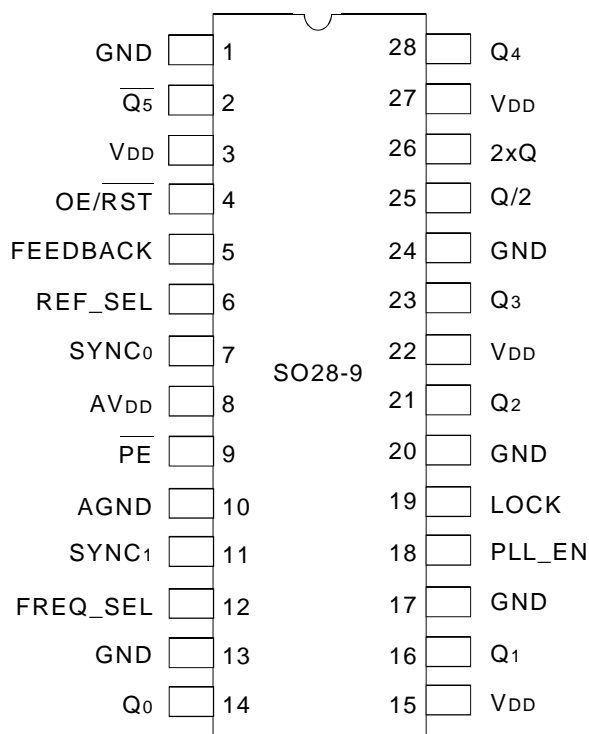
The QS5919T Clock Driver uses an internal phase locked loop (PLL) to lock low skew outputs to one of two reference clock inputs. Eight outputs are available: 2xQ, Q0-Q4, $\overline{Q5}$, Q/2. Careful layout and design ensure < 350ps skew between the Q0-Q4, and Q/2 outputs. The QS5919T includes an internal RC filter which provides excellent jitter characteristics and eliminates the need for external components. 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 PLL 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 QS5919T 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-227.

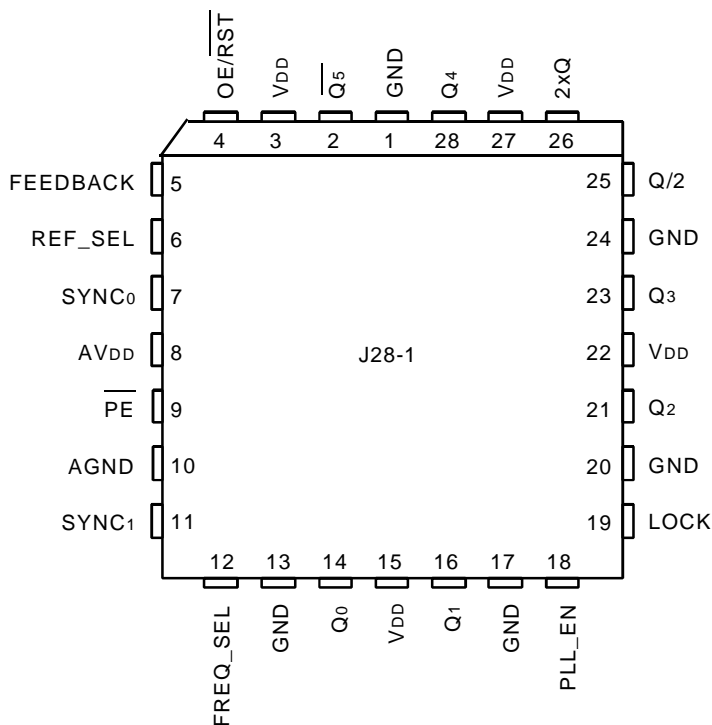
FUNCTIONAL BLOCK DIAGRAM



PIN CONFIGURATION



QSOP
TOP VIEW



PLCC
TOP VIEW

ABSOLUTE MAXIMUM RATINGS (1)

| Symbol | Rating | Max. | Unit |
|------------------------------------|---|-----------------|------|
| V _{DD} , AV _{DD} | Supply Voltage to Ground | -0.5 to +7 | V |
| V _{IN} | DC Input Voltage V _{IN} | -0.5 to +7 | V |
| | Maximum Power Dissipation (T _A = 85°C) | QSOP 655 | mW |
| | | PLCC 770 | mW |
| T _{STG} | Storage Temperature Range | -65°C to +150°C | °C |

NOTE:

- Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and 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 rating conditions for extended periods may affect reliability.

CAPACITANCE (T_A = 25°C, f = 1MHz, V_{IN} = 0V)

| Parameter | QSOP | | PLCC | | Unit |
|-----------------|------|------|------|------|------|
| | Typ. | Max. | Typ. | Max. | |
| C _{IN} | 3 | 4 | 4 | 6 | pF |

PIN DESCRIPTION

| Pin Name | I/O | Description |
|--------------------------------|-----|---|
| SYNC ₀ | I | Reference clock input |
| SYNC ₁ | I | Reference clock input |
| REF_SEL | I | Reference clock select. When 1, selects SYNC ₁ . When 0, selects SYNC ₀ . |
| 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. |
| Q ₀ -Q ₄ | O | Clock outputs |
| $\overline{Q_5}$ | 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. |
| OE/ \overline{RST} | I | Output enable/asynchronous reset. Resets all output registers. When 0, all outputs are held in a tri-stated condition. When 1, outputs are enabled. |
| PLL_EN | I | PLL enable. Enables and disables the PLL. Useful for testing purposes. |
| \overline{PE} | I | When \overline{PE} is LOW, outputs are synchronized with the positive edge of SYNC. When HIGH, outputs are synchronized with the negative edge of SYNC. |
| V _{DD} | — | Power supply for output buffers. |
| AV _{DD} | — | Power supply for phase lock loop and other internal circuitries. |
| GND | — | Ground supply for output buffers. |
| AGND | — | Ground supply for phase lock loop and other internal circuitries. |

OUTPUT FREQUENCY SPECIFICATIONS

Industrial: T_A = -40°C to +85°C, AV_{DD} / V_{DD} = 5.0V ± 10%

| Symbol | Description | - 55 | - 70 | - 100 | - 133 | - 160 | Units |
|----------------------|---|-------|------|-------|-------|-------|-------|
| F _{MAX_2XQ} | Max Frequency, 2xQ | 55 | 70 | 100 | 133 | 160 | MHz |
| F _{MAX_Q} | Max Frequency, Q ₀ - Q ₄ , $\overline{Q_5}$ | 27.5 | 35 | 50 | 66.5 | 80 | MHz |
| F _{MAX_Q/2} | Max Frequency, Q/2 | 13.75 | 17.5 | 25 | 33.25 | 40 | MHz |
| F _{MIN_2XQ} | Min Frequency, 2xQ | 20 | 20 | 20 | 20 | 20 | MHz |
| F _{MIN_Q} | Min Frequency, Q ₀ - Q ₄ , $\overline{Q_5}$ | 10 | 10 | 10 | 10 | 10 | MHz |
| F _{MIN_Q/2} | Min Frequency, Q/2 | 5 | 5 | 5 | 5 | 5 | MHz |

FREQUENCY SELECTION TABLE

| FREQ_SEL | Output Used for Feedback | SYNC (MHz) (allowable range) ⁽¹⁾ | | Output Frequency Relationships ⁽²⁾ | | | |
|----------|---------------------------------|--|--------------------------|---|------------------|---------------------------------|------------|
| | | Min. | Max | Q/2 | $\overline{Q_5}$ | Q ₀ - Q ₄ | 2XQ |
| HIGH | Q/2 | F _{MIN_Q/2} | F _{MAX_Q/2} | SYNC | – SYNC X 2 | SYNC X 2 | SYNC X 4 |
| HIGH | Q ₀ - Q ₄ | F _{MIN_Q} | F _{MAX_Q} | SYNC / 2 | – SYNC | SYNC | SYNC X 2 |
| HIGH | $\overline{Q_5}$ | F _{MIN_Q} | F _{MAX_Q} | – SYNC / 2 | SYNC | – SYNC | – SYNC X 2 |
| HIGH | 2xQ | F _{MIN_2XQ} | F _{MAX_2XQ} | SYNC / 4 | – SYNC / 2 | SYNC / 2 | SYNC |
| LOW | Q/2 | F _{MIN_Q/2 / 2} | F _{MAX_Q/2 / 2} | SYNC | – SYNC X 2 | SYNC X 2 | SYNC X 4 |
| LOW | Q ₀ - Q ₄ | F _{MIN_Q / 2} | F _{MAX_Q / 2} | SYNC / 2 | – SYNC | SYNC | SYNC X 2 |
| LOW | $\overline{Q_5}$ | F _{MIN_Q / 2} | F _{MAX_Q / 2} | – SYNC / 2 | SYNC | – SYNC | – SYNC X 2 |
| LOW | 2xQ | F _{MIN_2XQ / 2} | F _{MAX_2XQ / 2} | SYNC / 4 | – SYNC / 2 | SYNC / 2 | SYNC |

NOTES:

- Operation in the specified SYNC frequency range guarantees that the VCO will operate in its optimal range of 20MHz to F_{MAX_2xQ}. Operation with Sync inputs outside specified frequency ranges may result in out-of-lock outputs. FREQ_SEL only affects VCO frequency and does not affect output frequencies.
- The lock output pin (LOCK) may not indicate reliably for VCO frequencies below 30MHz.

DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE

Following Conditions Apply Unless Otherwise Specified:

Industrial: T_A = –40°C to +85°C, AV_{DD} / V_{DD} = 5.0V ± 10%

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|-----------------|---|--|------|------|------|------|
| V _{IH} | Input HIGH Voltage | Guaranteed Logic HIGH Level | 2 | — | — | V |
| V _{IL} | Input LOW Voltage | Guaranteed Logic LOW Level | — | — | 0.8 | V |
| V _{OH} | Output HIGH Voltage | V _{DD} = Min., I _{OH} = –24mA | 2.4 | — | — | V |
| | | V _{DD} = Min., I _{OH} = –100μA | 3 | — | — | V |
| V _{OL} | Output LOW Voltage | V _{DD} = Min., I _{OL} = 24mA | — | — | 0.45 | V |
| | | V _{DD} = Min., I _{OL} = 100μA | — | — | 0.2 | V |
| V _H | Input Hysteresis | — | — | 100 | — | mV |
| I _{oZ} | Output Leakage Current | V _{OUT} = V _{DD} or GND, V _{DD} = Max. | — | — | 5 | μA |
| I _{IN} | Input Leakage Current | V _{IN} = AV _{DD} or GND, AV _{DD} = Max. | — | — | 5 | μA |
| I _{PD} | Input Pull-Down Current (\overline{PE}) | AV _{DD} = Max., V _{IN} = AV _{DD} | — | — | 100 | μA |

POWER SUPPLY CHARACTERISTICS

| Symbol | Parameter | Test Conditions | Typ. | Max. | Unit |
|------------------|---|--|------|------|--------|
| I _{DDQ} | Quiescent Power Supply Current | V _{DD} = Max., OE/ \overline{RST} = LOW, SYNC = LOW, All outputs unloaded | | 1.5 | mA |
| ΔI _{DD} | Power Supply Current per Input HIGH | V _{DD} = Max., V _{IN} = 3.4V | 0.5 | 1.5 | mA |
| I _{DDD} | Dynamic Power Supply Current ⁽¹⁾ | V _{DD} = Max., C _L = 0pF | 0.2 | 0.4 | mA/MHz |

NOTE:

- Relative to the frequency of Q outputs.

INPUT TIMING REQUIREMENTS

| Symbol | Description ⁽¹⁾ | Min. | Max. | Unit |
|---------------------------------|---|------|----------------------|------|
| t _R , t _F | Maximum input rise and fall times, 0.8V to 2V | — | 3 | ns |
| F _I | Input Clock Frequency, SYNC ₀ , SYNC ₁ ⁽¹⁾ | 2.5 | F _{MAX_2XQ} | MHz |
| t _{PWC} | Input clock pulse, HIGH or LOW ⁽²⁾ | 2 | — | ns |
| D _H | Input duty cycle ⁽²⁾ | 25 | 75 | % |

NOTES:

- See Output Frequency and Frequency Selection tables for more detail on allowable SYNC input frequencies for different speed grades with different FEEDBACK and FREQ_SEL combinations.
- Where pulse width implied by D_H is less than t_{PWC} limit, t_{PWC} limit applies

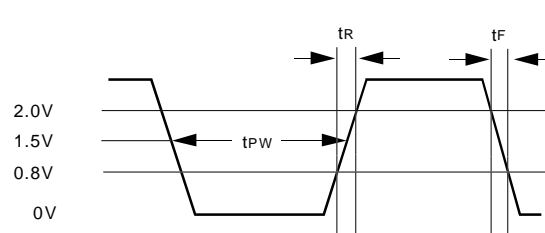
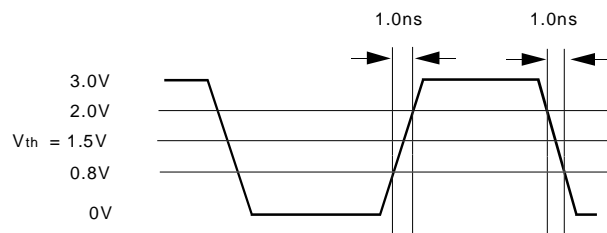
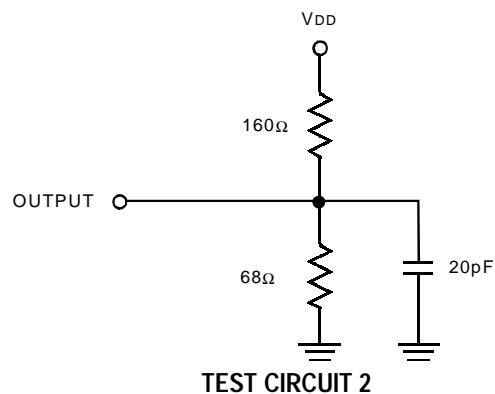
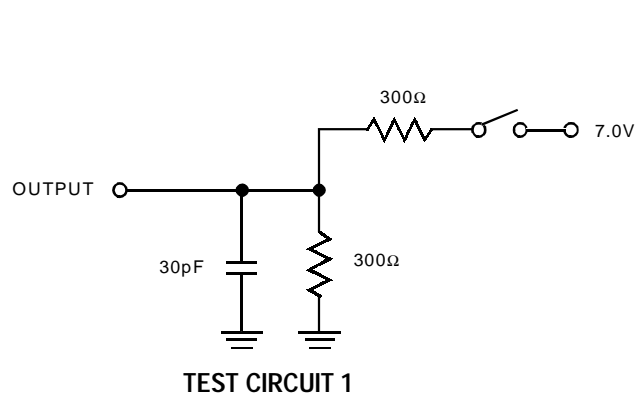
SWITCHING CHARACTERISTICS OVER OPERATING RANGE

| Symbol | Parameter ⁽¹⁾ | Min. | Max. | Unit |
|--------------------------------------|--|--------------------------|--------------------------|------|
| t _{SKR} | Output Skew Between Rising Edges, Q ₀ -Q ₄ and Q/2 ⁽²⁾ | — | 350 | ps |
| t _{SKF} | Output Skew Between Falling Edges, Q ₀ -Q ₄ and Q/2 ⁽²⁾ | — | 350 | ps |
| t _{SKALL} | Output Skew, All Outputs ^(2,5) | — | 500 | ps |
| t _{PW} | Pulse Width, 2xQ output, >40MHz | T _{cy} /2 – 0.4 | T _{cy} /2 + 0.4 | ns |
| t _{PW} | Pulse Width, Q ₀ -Q ₄ , Q ₅ , Q/2 outputs, 80MHz | T _{cy} /2 – 0.4 | T _{cy} /2 + 0.4 | ns |
| t _J | Cycle-to-Cycle Jitter ⁽⁴⁾ | – 0.15 | 0.15 | ns |
| t _{PD} | SYNC Input to Feedback Delay ⁽⁶⁾ | – 500 | 0 | ps |
| t _{LOCK} | SYNC to Phase Lock | — | 10 | ms |
| t _{PZH} t _{PZL} | Output Enable Time, OE/ $\overline{\text{RST}}$ LOW to HIGH ⁽³⁾ | 0 | 7 | ns |
| t _{PHZ} t _{PLZ} | Output Enable Time, OE/ $\overline{\text{RST}}$ HIGH to LOW ⁽³⁾ | 0 | 6 | ns |
| t _R , t _F | Output Rise/Fall Times, 0.8V ~ 2V | 0.3 | 1.5 | ns |

NOTES:

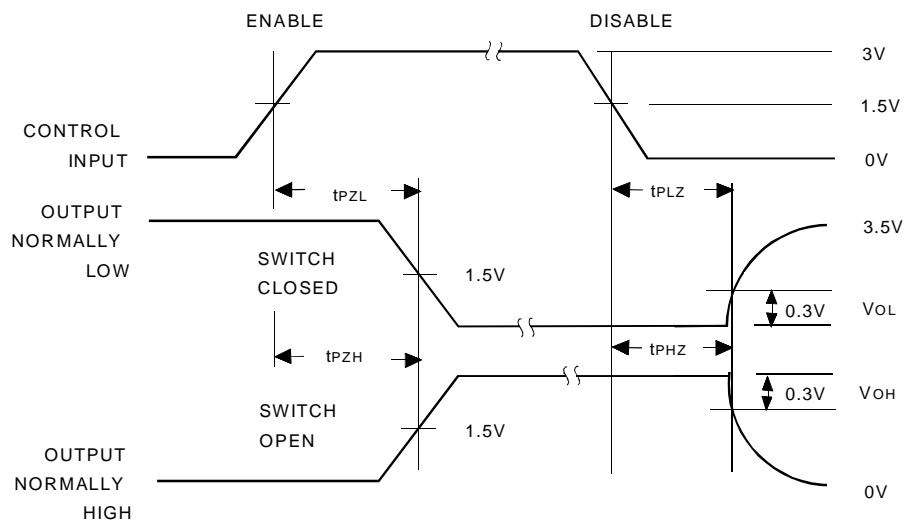
- See Test Loads and Waveforms for test load and termination. Test circuit 1 is used for output enable/disable parameters. Test circuit 2 is used for all other timing parameters.
- Skew specifications apply under identical environments (loading, temperature, VCC, device speed grade).
- Measured in open loop mode PLL_EN = 0.
- Jitter is characterized with Q output at 20MHz. See FREQUENCY SELECTION TABLE for information on proper FREQ_SEL level for specified input frequencies.
- Skew measured at selected synchronization edge.
- t_{PD} measured at device inputs at 1.5V, Q output at 80MHz.

AC TEST LOADS AND WAVEFORMS



TTL INPUT TEST WAVEFORM

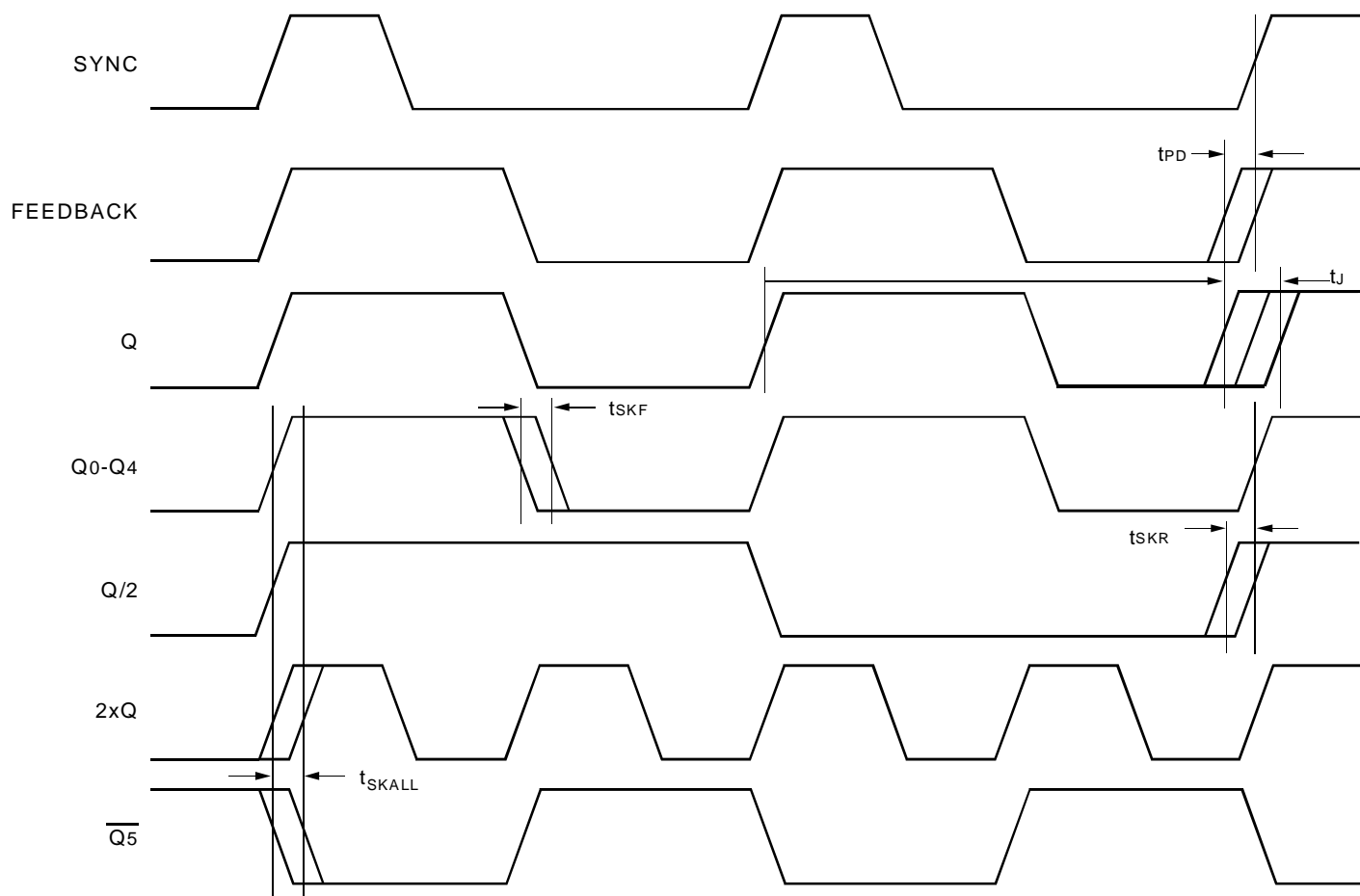
TTL OUTPUT WAVEFORM



ENABLE AND DISABLE TIMES

TEST CIRCUIT 1 is used for output enable/disable parameters.
TEST CIRCUIT 2 is used for all other timing parameters.

AC TIMING DIAGRAM



NOTES:

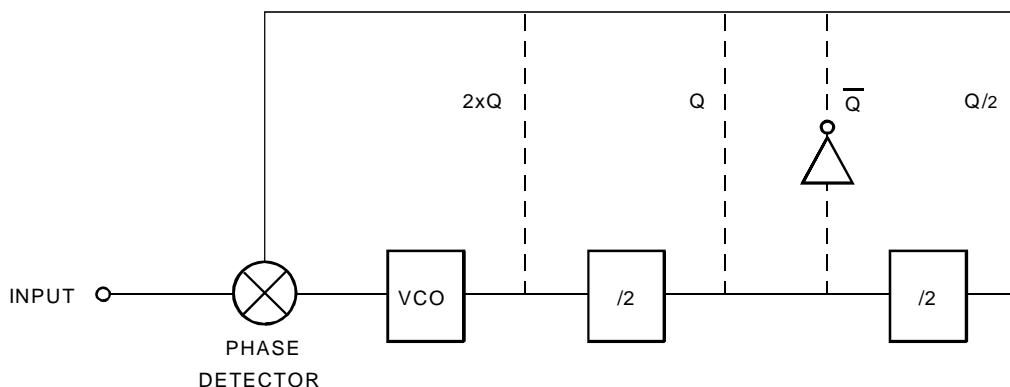
1. AC Timing Diagram applies to Q output connected to FEEDBACK and $\overline{PE} = \text{GND}$. For $\overline{PE} = V_{DD}$, the negative edge of FEEDBACK aligns with the negative edge of SYNC input, and the negative edges of the multiplied and divided outputs align with the negative edge of SYNC.
2. All parameters are measured at 1.5V.

PLL OPERATION

The Phase Locked Loop (PLL) circuit included in the QS5919T provides for replication of incoming SYNC clock signals. Any manipulation of that signal, such as frequency multiplying 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 feedback path, 'propagation delay' can even be negative! A simplified schematic of the QS5919T PLL circuit is shown below.

SIMPLIFIED DIAGRAM OF QS5919T 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 QS5919T 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 respective 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.

ORDERING INFORMATION

| QS | XXXX | XX | X | | |
|-------------|------|-------|---------|---|--|
| Device Type | | Speed | Package | | |
| | | | Q | Quarter Size Outline Package (SO28-9) | |
| | | | | Plastic Leaded Chip Carrier (J28-1) | |
| | | | 55 | 55MHz Max. Frequency | |
| | | | | 70MHz Max. Frequency | |
| | | | | 100MHz Max. Frequency | |
| | | | | 133MHz Max. Frequency | |
| | | | 160 | 160MHz Max. Frequency | |
| | | | 5919T | Low Skew TTL PLL Clock Driver with Integrated Loop Filter | |



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