ZL30106

SONET/SDH/PDH Network Interface DPLL

Data Sheet

April 2010

Features

- Synchronizes to clock-and-sync-pair to maintain minimal phase skew between inputs and outputs
- Supports output wander and jitter generation specifications for SONET/SDH and PDH interfaces
- Accepts three input references and synchronizes to any combination of 2 kHz, 8 kHz, 1.544 MHz, 2.048 MHz, 8.192 MHz, 16.384 MHz or 19.44 MHz inputs
- Provides a range of clock outputs:
  - 2.048 MHz (E1), 16.384 MHz and either 4.096 MHz and 8.192 MHz or 32.768 MHz and 65.536 MHz
  - 19.44 MHz (SONET/SDH)
  - 1.544 MHz (DS1) and 3.088 MHz
  - a choice of 6.312 MHz (DS2), 8.448 MHz (E2), 44.736 MHz (DS3) or 34.368 MHz (E3)
- Provides 5 styles of 8 kHz framing pulses and a 2 kHz multi-frame pulse
- Provides automatic entry into Holdover and return from Holdover
- Manual and automatic hitless reference switching between any combination of valid input reference frequencies

Ordering Information

ZL30106QDG1 64 pin TQFP* Trays, Bake & Drypack
*Pb Free Matte Tin

-40°C to +85°C

- Provides lock, holdover and accurate reference fail indication
- Selectable loop filter bandwidth of 29 Hz or 922 Hz
- Less than 24 ps_{rms} intrinsic jitter on the 19.44 MHz output clock, compliant with GR-253-CORE OC-3 and G.813 STM-1 specifications
- Less than 0.6 ns_{pp} intrinsic jitter on all PDH output clocks and frame pulses
- Selectable external master clock source: clock oscillator or crystal
- Simple hardware control interface

Applications

- Line card synchronization for SONET/SDH and PDH systems
- Wireless base-station Network Interface Card
- AdvancedTCA™ and H.110 line cards

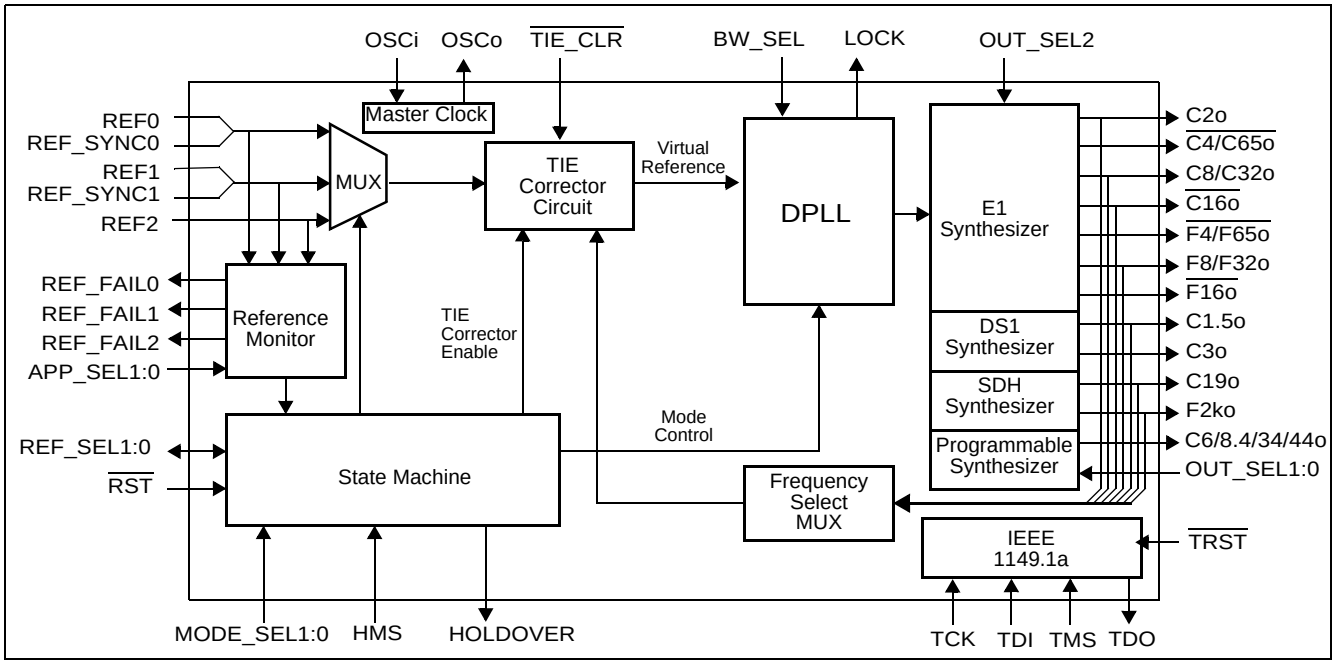


Figure 1 - Functional Block Diagram

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Description

The ZL30106 SONET/SDH/PDH network interface Digital Phase-Locked Loop (DPLL) provides timing and synchronization for SONET/SDH and PDH network interface cards.

The ZL30106 generates SONET/SDH, PDH, ST-BUS and other TDM clock and framing signals that are phase locked to one of three network references. It helps ensure system reliability by monitoring its references for frequency accuracy and stability and by maintaining tight phase alignment between the input reference clock and clock outputs.

The ZL30106 output clocks wander and jitter generation are compliant with the associated transport medium specifications.

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1.0 Change Summary

Changes from November 2005 Issue to April 2010 Issue. Page, section, figure and table numbers refer to this current issue.

Page	Item	Change
1	Ordering Information Box	Leaded part number ZL30106QDG has been obsoleted and replaced by ZL30106QDG1.

Changes from July 2005 Issue to November 2005 Issue. Page, section, figure and table numbers refer to this current issue.

Page	Item	Change
1	Features	Changed description for hitless reference switching.
32	Section 6.1	Removed power supply decoupling circuit and included reference to synchronizer power supply decoupling application note.

Changes from October 2004 Issue to July 2005 Issue. Page, section, figure and table numbers refer to this current issue.

Page	Item	Change
10	$\overline{\text{RST}}$ pin	Specified clock and frame pulse outputs forced to high impedance
15	Figure 7	Corrected middle label in -20 ppm case from -32 to -20
21	Table 1 - “Application Selection and the Out of Range Limits“	Corrected APP_SEL 01 OOR limit from 9.6 to 9.2
35	Table “DC Electrical Characteristics*“	Corrected Schmitt trigger levels
43	Table “Performance Characteristics* - Functional“	Gave more detail on Lock Time conditions

Changes from June 2004 Issue to October 2004 Issue. Page, section, figure and table numbers refer to this current issue.

Page	Item	Change
1	Text	Jitter changed to 24 ps from 20 ps
8	Figure 2	Added note specifying not e-Pad
19	Section 3.3	Changed 200 ns to 20 ns in "HMS=0" section
34	Section 6.4	Corrected time-constant of example reset circuit
35	Table “Absolute Maximum Ratings*“	Corrected package power rating
35	Table “DC Electrical Characteristics*“	Corrected current consumption Corrected Schmitt trigger V_{t-} levels Corrected output voltage note to reflect two pad strengths
38	Table “AC Electrical Characteristics* - Input to output timing for REF0, REF1 and REF2 references when TIE_CLR = 0 (see Figure 23).“	Updated Min. Max. values
39	Section 7.1	Corrected pulse widths
43	Section 7.2	Changed jitter numbers

2.0 Physical Description

2.1 Pin Connections

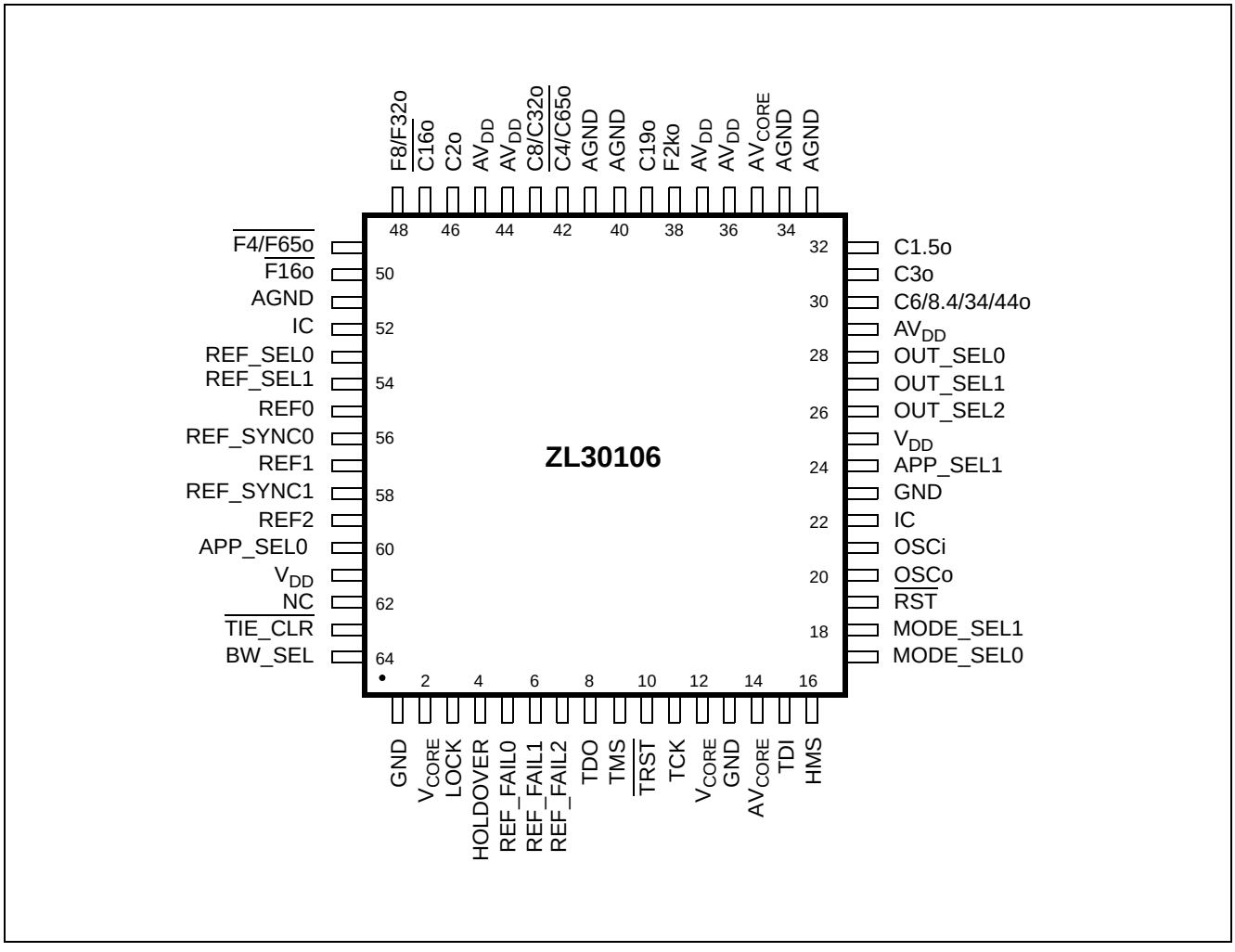


Figure 2 - Pin Connections (64 pin TQFP, please see Note 1)

Note 1: The ZL30106 uses the TQFP shown in the package outline designated with the suffix QD, the ZL30106 does not use the e-Pad TQFP.

2.2 Pin Description

Pin #	Name	Description
1	GND	**Ground.** 0 V
2	V_{CORE}	**Positive Supply Voltage.** +1.8 V_{DC} nominal
3	LOCK	**Lock Indicator (Output).** This output goes to a logic high when the PLL is frequency locked to the selected input reference.
4	HOLDOVER	**Holdover (Output).** This output goes to a logic high whenever the PLL goes into holdover mode.
5	REF_FAIL0	**Reference 0 Failure Indicator (Output).** A logic high at this pin indicates that the REF0 reference frequency has exceeded the out-of-range limit set by the APP_SEL pins or that it is exhibiting abrupt phase or frequency changes.
6	REF_FAIL1	**Reference 1 Failure Indicator (Output).** A logic high at this pin indicates that the REF1 reference frequency has exceeded the out-of-range limit set by the APP_SEL pins or that it is exhibiting abrupt phase or frequency changes.
7	REF_FAIL2	**Reference 2 Failure Indicator (Output).** A logic high at this pin indicates that the REF2 reference frequency has exceeded the out-of-range limit set by the APP_SEL pins or that it is exhibiting abrupt phase or frequency changes.
8	TDO	**Test Serial Data Out (Output).** JTAG serial data is output on this pin on the falling edge of TCK. This pin is held in high impedance state when JTAG scan is not enabled.
9	TMS	**Test Mode Select (Input).** JTAG signal that controls the state transitions of the TAP controller. This pin is internally pulled up to V_{DD}. If this pin is not used then it should be left unconnected.
10	$\overline{TRST}$	**Test Reset (Input).** Asynchronously initializes the JTAG TAP controller by putting it in the Test-Logic-Reset state. This pin should be pulsed low on power-up to ensure that the device is in the normal functional state. This pin is internally pulled up to V_{DD}. If this pin is not used then it should be connected to GND.
11	TCK	**Test Clock (Input):** Provides the clock to the JTAG test logic. If this pin is not used then it should be pulled down to GND.
12	V_{CORE}	**Positive Supply Voltage.** +1.8 V_{DC} nominal
13	GND	**Ground.** 0 V
14	AV_{CORE}	**Positive Analog Supply Voltage.** +1.8 V_{DC} nominal
15	TDI	**Test Serial Data In (Input).** JTAG serial test instructions and data are shifted in on this pin. This pin is internally pulled up to V_{DD}. If this pin is not used then it should be left unconnected.
16	HMS	**Hitless Mode Switching (Input).** The HMS input controls phase accumulation during the transition from Holdover or Freerun mode to Normal mode on the same reference. A logic low at this pin will cause the ZL30106 to maintain the delay stored in the TIE corrector circuit when it transitions from Holdover or Freerun mode to Normal mode. A logic high on this pin will cause the ZL30106 to measure a new delay for its TIE corrector circuit thereby minimizing the output phase movement when it transitions from Holdover or Freerun mode to Normal mode.
17	MODE_SEL0	**Mode Select 0 (Input).** This input combined with MODE_SEL1 determines the mode of operation, see Table 4 on page 22.
18	MODE_SEL1	**Mode Select 1 (Input).** See MODE_SEL0 pin description.

Pin #	Name	Description
19	$\overline{RST}$	**Reset (Input).** A logic low at this input resets the device. On power up, the $\overline{RST}$ pin must be held low for a minimum of 300 ns after the power supply pins have reached the minimum supply voltage. When the RST pin goes high, the device will transition into a Reset state for 3 ms. In the Reset state all clock and frame pulse outputs will be forced into high impedance.
20	OSCo	**Oscillator Master Clock (Output).** For crystal operation, a 20 MHz crystal is connected from this pin to OSCi. This output is not suitable for driving other devices. For clock oscillator operation, this pin must be left unconnected.
21	OSCi	**Oscillator Master Clock (Input).** For crystal operation, a 20 MHz crystal is connected from this pin to OSCo. For clock oscillator operation, this pin must be connected to a clock source.
22	IC	**Internal Connection.** Leave unconnected.
23	GND	**Ground.** 0 V
24	APP_SEL1	**Application Selection 1 (Input).** This input combined with APP_SEL0 selects the application that the ZL30106 is optimized for, see Table 1 on page 21.
25	V_{DD}	**Positive Supply Voltage.** +3.3 V_{DC} nominal
26	OUT_SEL2	**Output Selection 2 (Input).** This input selects the signals on the combined output clock and frame pulse pins, see Table 3 on page 22.
27	OUT_SEL1	**Output Selection 1 (Input).** This input combined with OUT_SEL0 selects the signals on the combined output clock pin C6/8.4/34/44o, see Table 3 on page 22.
28	OUT_SEL0	**Output Selection 0 (Input).** See OUT_SEL1 description.
29	AV_{DD}	**Positive Analog Supply Voltage.** +3.3 V_{DC} nominal
30	C6/8.4/34/44o	**Clock 6.312 MHz, 8.448 MHz, 34.368 MHz or 44.736 MHz (Output).** This output is used in DS2, E2, E3 or DS3 applications. The output frequency is selected via the OUT_SEL1 and OUT_SEL0 pins, see Table 3 on page 22.
31	C3o	**Clock 3.088 MHz (Output).** This output is used in DS1 applications.
32	C1.5o	**Clock 1.544 MHz (Output).** This output is used in DS1 applications. This clock output pad includes a Schmitt input which serves as a PLL feedback path; proper transmission-line termination should be applied to maintain reflections below Schmitt trigger levels.
33	AGND	**Analog Ground.** 0 V
34	AGND	**Analog Ground.** 0 V
35	AV_{CORE}	**Positive Analog Supply Voltage.** +1.8 V_{DC} nominal
36	AV_{DD}	**Positive Analog Supply Voltage.** +3.3 V_{DC} nominal
37	AV_{DD}	**Positive Analog Supply Voltage.** +3.3 V_{DC} nominal
38	F2ko	**Multi Frame Pulse (Output).** This is a 2 kHz 51 ns active high framing pulse, which marks the beginning of a multi frame.
39	C19o	**Clock 19.44 MHz (Output).** This output is used in SONET/SDH applications.
40	AGND	**Analog Ground.** 0 V
41	AGND	**Analog Ground.** 0 V

Pin #	Name	Description
42	$\overline{C4}/\overline{C65o}$	**Clock 4.096 MHz or 65.536 MHz (Output).** This output is used for ST-BUS operation at 2.048 Mbit/s, 4.096 Mbit/s or 65.536 MHz (ST-BUS 65.536 Mbit/s). The output frequency is selected via the OUT_SEL2 pin, see Table 3 on page 22.
43	C8/C32o	**Clock 8.192 MHz or 32.768 MHz (Output).** This output is used for ST-BUS and GCI operation at 8.192 Mb/s or for operation with a 32.768 MHz clock. The output frequency is selected via the OUT_SEL2 pin, see Table 3 on page 22. In C8 mode, this clock output pad uses an included Schmitt input as a PLL feedback path; proper transmission-line termination should be applied to maintain reflections below Schmitt trigger levels.
44	AV_{DD}	**Positive Analog Supply Voltage.** +3.3 V_{DC} nominal
45	AV_{DD}	**Positive Analog Supply Voltage.** +3.3 V_{DC} nominal
46	C2o	**Clock 2.048 MHz (Output).** This output is used for standard E1 interface timing and for ST-BUS operation at 2.048 Mbit/s. This clock output pad includes a Schmitt input which serves as a PLL feedback path; proper transmission-line termination should be applied to maintain reflections below Schmitt trigger levels.
47	$\overline{C16o}$	**Clock 16.384 MHz (Output).** This output is used for ST-BUS operation with a 16.384 MHz clock. This clock output pad includes a Schmitt input which serves as a PLL feedback path; proper transmission-line termination should be applied to maintain reflections below Schmitt trigger levels.
48	F8/F32o	**Frame Pulse (Output).** This is an 8 kHz 122 ns active high framing pulse or it is an 8 kHz 31 ns active high framing pulse, which marks the beginning of a frame. The pulse width is selected via the OUT_SEL2 pin, see Table 3 on page 22.
49	$\overline{F4}/\overline{F65o}$	**Frame Pulse ST-BUS 2.048 Mbit/s or ST-BUS at 65.536 MHz clock (Output).** This output is an 8 kHz 244 ns active low framing pulse which marks the beginning of an ST-BUS frame. This is typically used for ST-BUS operation at 2.048 Mbit/s and 4.096 Mbit/s. Or this output is an 8 kHz 15 ns active low framing pulse, typically used for ST-BUS operation with a clock rate of 65.536 MHz. The pulse width is selected via the OUT_SEL2 pin, see Table 3 on page 22.
50	$\overline{F16o}$	**Frame Pulse ST-BUS 8.192 Mbit/s (Output).** This is an 8 kHz 61 ns active low framing pulse, which marks the beginning of an ST-BUS frame. This is typically used for ST-BUS operation at 8.192 Mbit/s.
51	AGND	**Analog Ground.** 0 V
52	IC	**Internal Connection.** Connect this pin to ground.
53	REF_SEL0	**Reference Select 0 (Input/Output).** In the manual mode of operation, REF_SEL0 is an input. As an input REF_SEL0 combined with REF_SEL1 selects the reference input that is used for synchronization, see Table 5 on page 24. In the Automatic mode of operation, REFSEL0 is an output indicating which of the input references is the being selected, see Table 6 on page 26. This pin is internally pulled down to GND.
54	REF_SEL1	**Reference Select 1 (Input/Output)**. See REF_SEL0 pin description.

Pin #	Name	Description
55	REF0	**Reference (Input).** This is one of three (REF0, REF1 and REF2) input reference sources used for synchronization. One of seven possible frequencies may be used: 2 kHz, 8 kHz, 1.544 MHz, 2.048 MHz, 8.192 MHz, 16.384 MHz or 19.44 MHz. This pin is internally pulled down to GND.
56	REF_SYNC0	**REF Synchronization Frame Pulse 0 (Input).** This is the 2 kHz or 8 kHz (multi) frame pulse synchronization input associated with the REF0 reference. While the PLL is locked to the REF0 input reference the output (multi) frame pulses are synchronized to this input. This pin is internally pulled down to GND.
57	REF1	**Reference (Input).** See REF0 pin description.
58	REF_SYNC1	**REF Synchronization Frame Pulse 1 (Input).** This is the 2 kHz or 8 kHz (multi) frame pulse synchronization input associated with the REF1 reference. While the PLL is locked to the REF1 input reference the output (multi) frame pulses are synchronized to this input. This pin is internally pulled down to GND.
59	REF2	**Reference (Input).** See REF0 pin description.
60	APP_SEL0	**Application Selection (Input).** See APP_SEL1 pin description.
61	V_{DD}	**Positive Supply Voltage.** +3.3 V_{DC} nominal
62	NC	**No internal bonding Connection.** Leave unconnected.
63	$\overline{\text{TIE_CLR}}$	**TIE Circuit Reset (Input).** A logic low at this input resets the Time Interval Error (TIE) correction circuit resulting in a realignment of input phase with output phase.
64	BW_SEL	**Filter Bandwidth Selection (Input).** This pin selects the bandwidth of the DPLL loop filter, see Table 2 on page 21.

3.0 Functional Description

The ZL30106 is a SONET/SDH Network Interface DPLL, providing timing (clock) and synchronization (frame) signals to SONET/SDH and PDH network interface cards. The ZL30106 supports the following applications:

- DS1/E1 compliant with ANSI T1.403 and Telcordia GR-1244-CORE Stratum 4/4E
- Derived DS1 compliant with ITU-T G.783
- DS2/DS3/E2/E3 compliant with ANSI T1.102 and ITU-T G.823
- SONET/SDH compliant with ITU-T G.813 option 1 and Telcordia GR-253-CORE

Figure 1 is a functional block diagram which is described in the following sections.

3.1 Reference Select Multiplexer (MUX)

The ZL30106 accepts three simultaneous reference input signals and operates on their rising edges. One of them, the primary reference (REF0), the secondary reference (REF1) or the tertiary reference (REF2) signal, is selected as input to the TIE Corrector Circuit based on the reference selection (REF_SEL1:0) inputs. REF0 and REF1 can be accompanied by a 2 kHz or 8 kHz frame pulse on the REF_SYNC0 and REF_SYNC1 inputs. Input REF_SYNC0 is always associated with input REF0 while input REF_SYNC1 is always associated with input REF1.

The use of the combined REF and REF_SYNC inputs allows for a very accurate phase alignment of the output frame pulses to the 2 kHz or 8 kHz (multi) frame pulse supplied to the REF_SYNC input. This feature supports the implementation of line card clocks where the line card locks to the backplane clock with a filter suitable for good tracking (high bandwidth) yet still provides a (multi) frame locked to the backplane (multi) frame.

3.2 Reference Monitor

The input references are monitored by three independent reference monitor blocks, one for each reference. The block diagram of a single reference monitor is shown in Figure 3. For each reference clock, the frequency is detected and the clock is continuously monitored for three independent criteria that indicate abnormal behavior of the reference signal, for example; long term drift from its nominal frequency or excessive jitter. To ensure proper operation of the reference monitor circuit, the minimum input pulse width restriction of 15 nsec must be observed.

- **Reference Frequency Detector (RFD)**: This detector determines whether the frequency of the reference clock is 2 kHz, 8 kHz, 1.544 MHz, 2.048 MHz, 8.192 MHz, 16.384 MHz or 19.44 MHz and provides this information to the various monitor circuits and the phase detector circuit of the DPLL.
- **Precise Frequency Monitor (PFM)**: This circuit determines whether the frequency of the reference clock is within the selected accuracy range, see Table 1.
- **Coarse Frequency Monitor (CFM)**: This circuit monitors the reference frequency over intervals of approximately 30 μs to quickly detect large frequency changes.
- **Single Cycle Monitor (SCM)**: This detector checks the period of a single clock cycle to detect large phase hits or the complete loss of the clock.

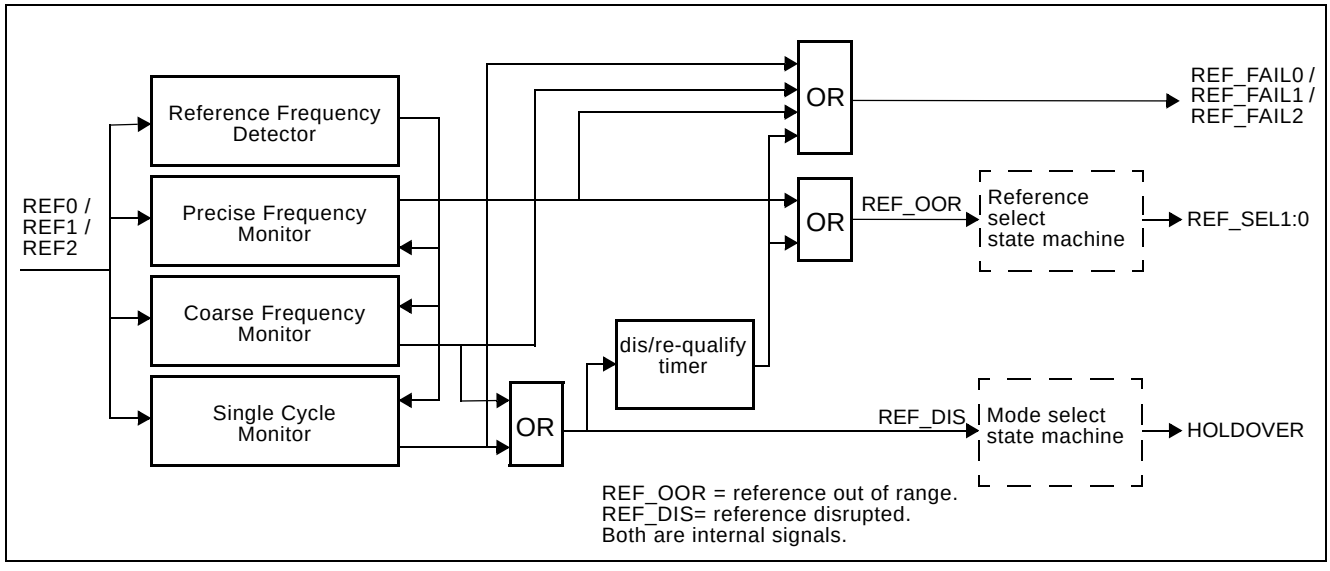


Figure 3 - Reference Monitor Circuit

Exceeding the thresholds of any of the monitors forces the corresponding REF_FAIL pin to go high. The single cycle and coarse frequency failure flags force the DPLL into Holdover mode and feed a timer that disqualifies the reference input signal when the failures are present for more than 50 ms. The single cycle and coarse frequency failures must be absent for 200 ms to let the timer re-qualify the input reference signal as valid. Multiple failures of less than 50 ms each have an accumulative effect and will disqualify the reference eventually. This is illustrated in Figure 4 where REF0 experiences disruptions while REF1 is stable.

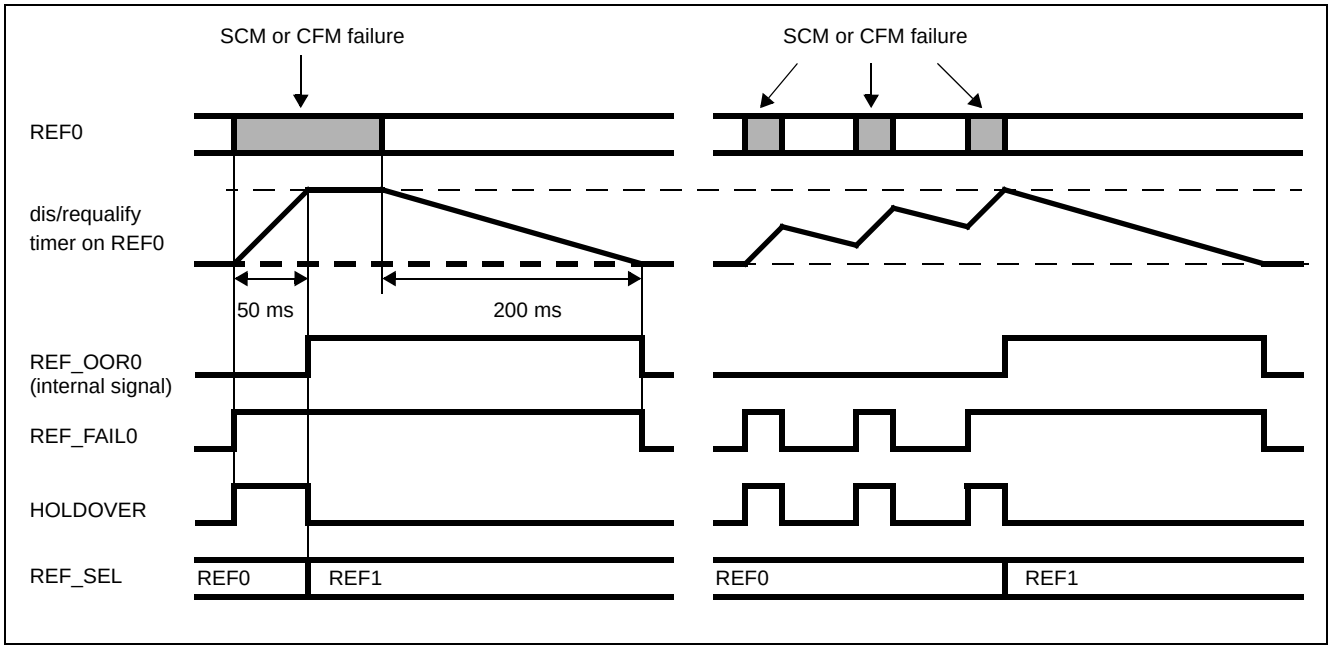


Figure 4 - Behaviour of the Dis/Re-qualify Timer

When the incoming signal returns to normal (REF_FAIL=0), the DPLL returns to Normal mode with the output signal locked to the input signal. Each of the monitors has a built-in hysteresis to prevent flickering of the REF_FAIL status pin at the threshold boundaries. The precise frequency monitor and the timer do not affect the mode (Holdover/Normal) of the DPLL.

If the device is set to Automatic mode (MODE_SEL1:0=11), then the state machine does not immediately switch to another reference. If the single cycle and/or coarse frequency failures persist for more than 50 ms or the precise frequency monitor detects a failure, then the state machine will switch to another valid reference if that is available. If there no other reference available, it stays in Holdover mode.

The precise frequency monitor's failure thresholds are selected with the APP_SEL pins based on the ZL30106 applications. Figure 5, Figure 6 and Figure 7 show the out of range limits for various master clock accuracies. It will take the precise frequency monitor up to 10 s to qualify or disqualify the input reference.

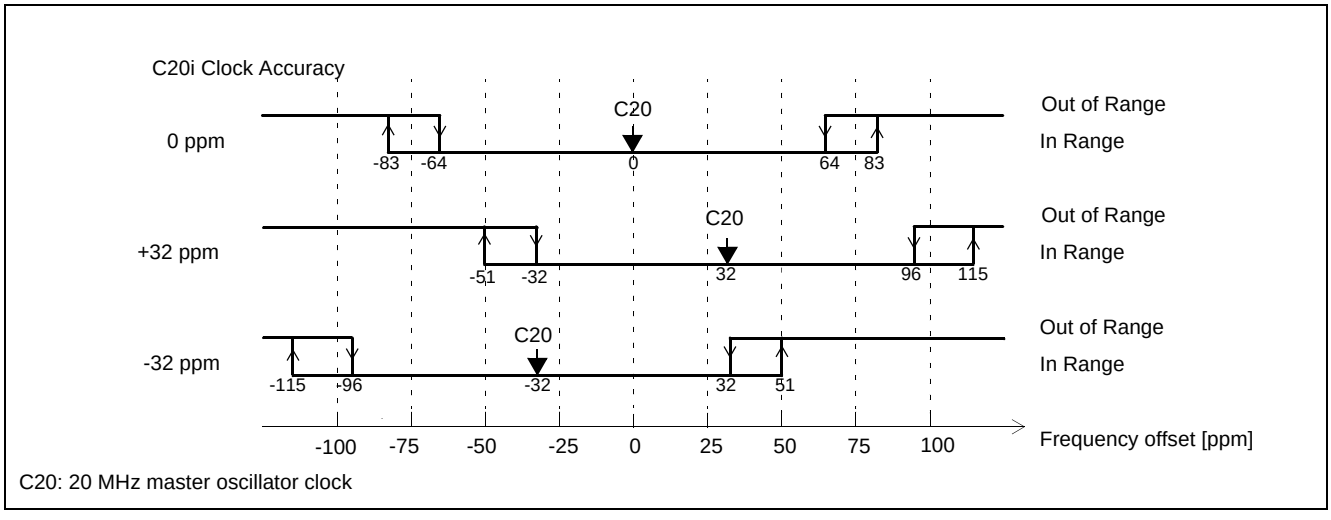


Figure 5 - Out-of-Range Thresholds for APP_SEL1:0=00

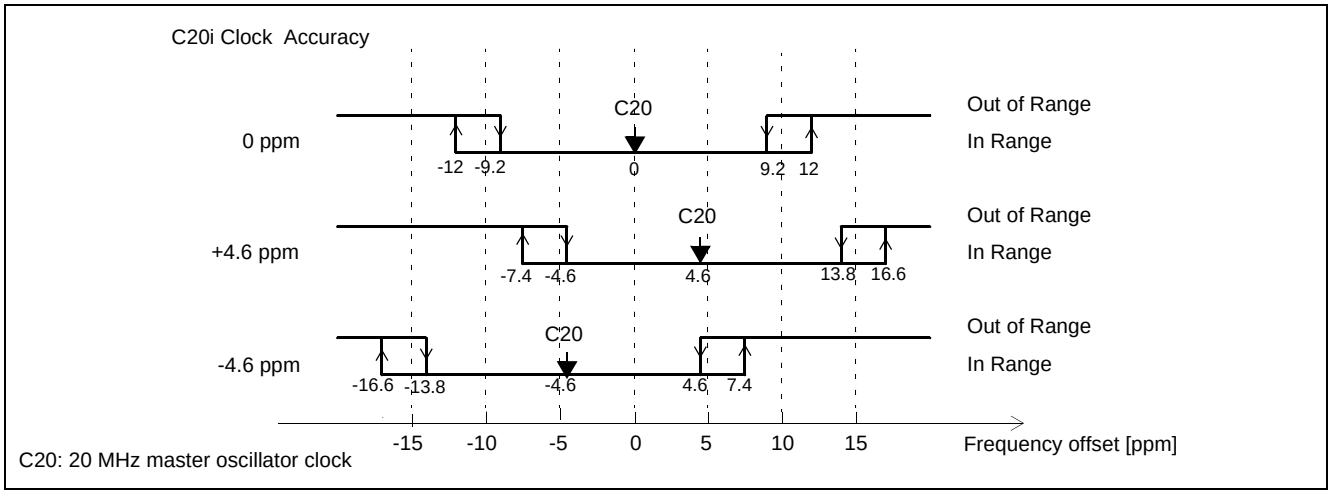


Figure 6 - Out-of-Range Thresholds for APP_SEL1:0=01

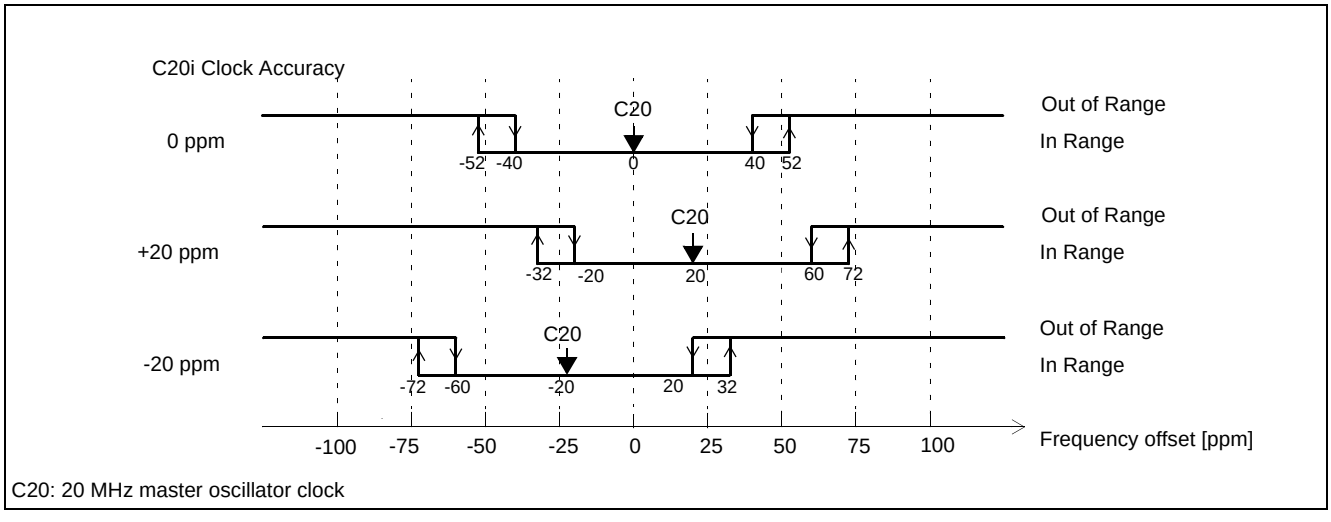


Figure 7 - Out-of-Range Thresholds for APP_SEL1:0=10 or APP_SEL1:0=11

In addition to the monitoring of the REF reference signals the companion REF_SYNC input signals are also monitored for failure (see Figure 8).

- **REF_SYNC Frequency Detector (RSFD)**: This detector determines whether the frequency of the REF_SYNC frame pulse is 2 kHz or 8 kHz and provides this information to the REF/SYNC ratio monitor circuits and the phase detector circuit of the DPLL.
- **REF_SYNC Ratio Monitor (RSRM)**: This monitor checks the number of REF reference clock cycles in a single associated REF_SYNC frame pulse period to determine the integrity of the REF_SYNC signal, for example there must be exactly 256 clock cycles of a 2.048 MHz REF reference clock in a single 8 kHz REF_SYNC frame pulse period to validate the REF_SYNC signal. If the REF and REF_SYNC inputs are selected for synchronization and the Sync Ratio Monitor detects a failure, the DPLL will abandon the mechanism of aligning the output frame pulse to the REF_SYNC pulse. Instead only the REF reference will be used for synchronization.

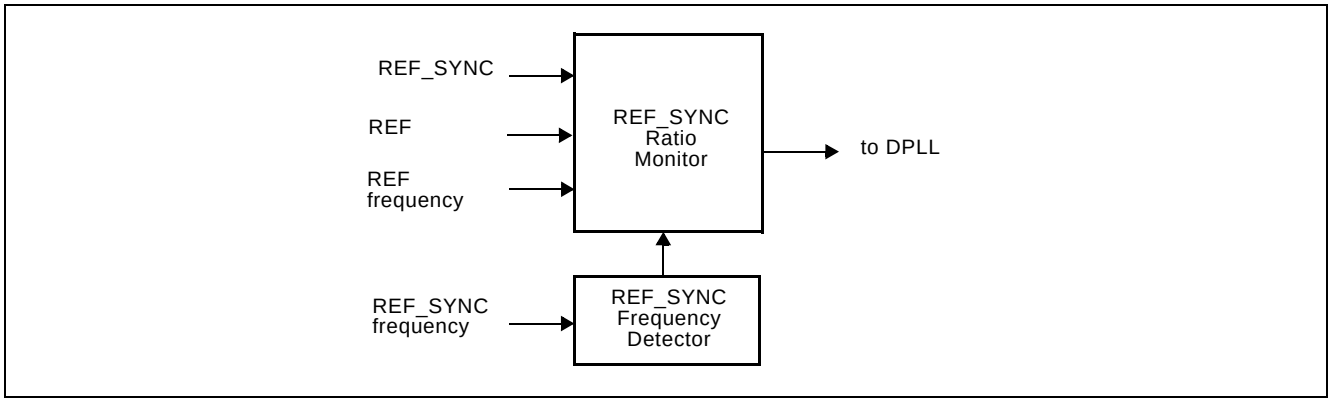


Figure 8 - REF_SYNC Monitor Circuit

3.3 Time Interval Error (TIE) Corrector Circuit

The TIE Circuit eliminates phase transients on the output clock that may occur during reference switching or the recovery from Holdover mode to Normal mode.

On recovery from Holdover mode (dependent on the HMS pin) or when switching to another reference input, the TIE corrector circuit measures the phase delay between the current phase (feedback signal) and the phase of the selected reference signal. This delay value is stored in the TIE corrector circuit. This circuit creates a new virtual reference signal that is at the same phase position as the feedback signal. By using the virtual reference, the PLL minimizes the phase transient it experiences when it recovers from Holdover mode.

The delay value can be reset by setting the TIE Corrector Circuit Clear pin ($\overline{\text{TIE_CLR}}$) low for at least 15 ns. This results in a phase alignment between the input reference signal and the output clocks and frame pulses as shown in Figure 23. The speed of the phase alignment correction is limited by the loop filter bandwidth. Convergence is always in the direction of least phase travel. TIE_CLR can be kept low continuously. In that case the output clocks will always align with the selected input reference. This is illustrated in Figure 9.

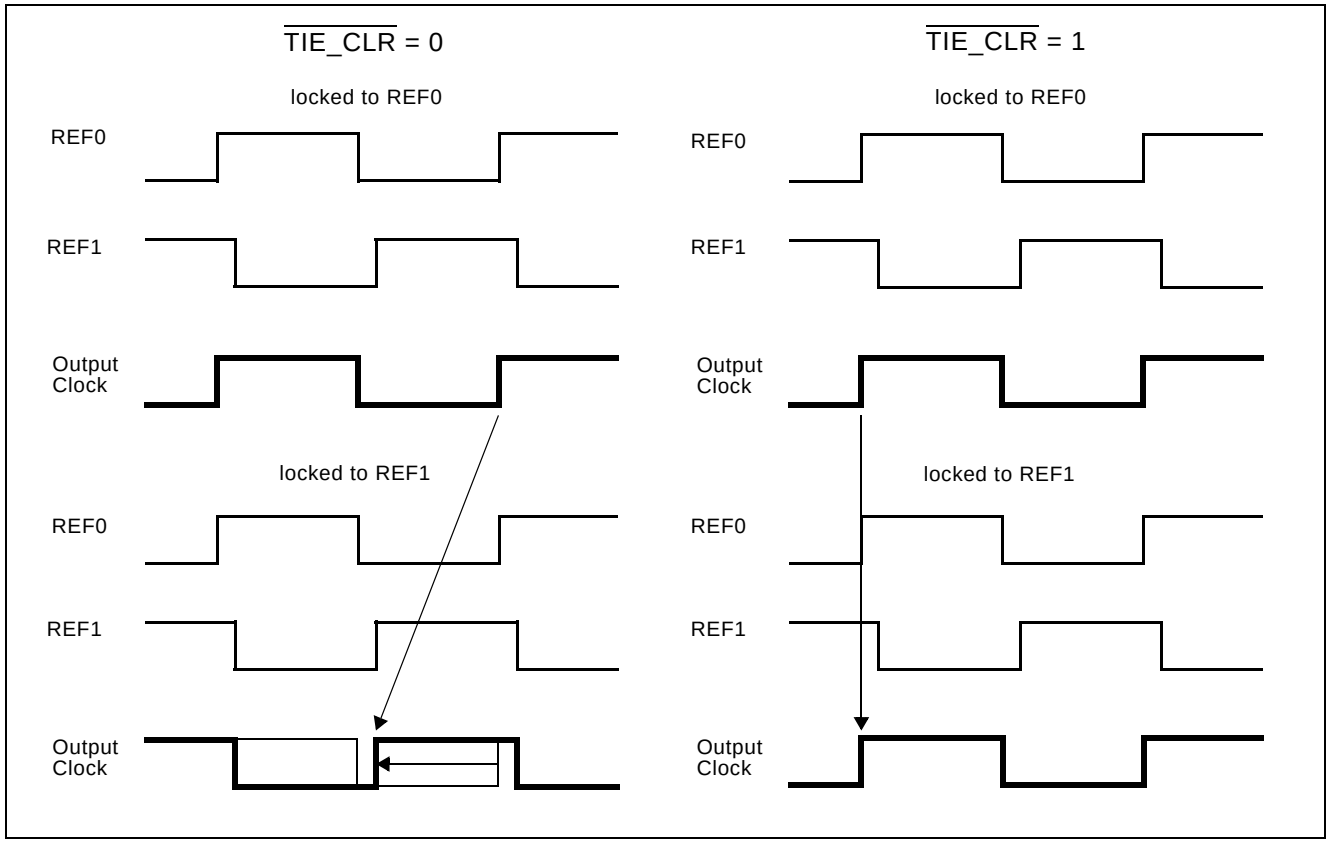


Figure 9 - Timing Diagram of Hitless Reference Switching

The Hitless Mode Switching (HMS) pin enables phase hitless returns from Freerun and Holdover modes to Normal mode in a single reference operation. A logic low at the HMS input disables the TIE circuit updating the delay value thereby forcing the output of the PLL to gradually move back to the original point before it went into Holdover mode (see Figure 10). This prevents accumulation of phase in network elements. A logic high (HMS=1) enables the TIE circuit to update its delay value thereby preventing a large output phase movement after return to Normal mode. This causes accumulation of phase in network elements. In both cases the PLL's output can be aligned with the input reference by setting $\overline{\text{TIE_CLR}}$ low. Regardless of the HMS pin state, reference switching in the ZL30106 is always hitless unless $\overline{\text{TIE_CLR}}$ is kept low continuously.

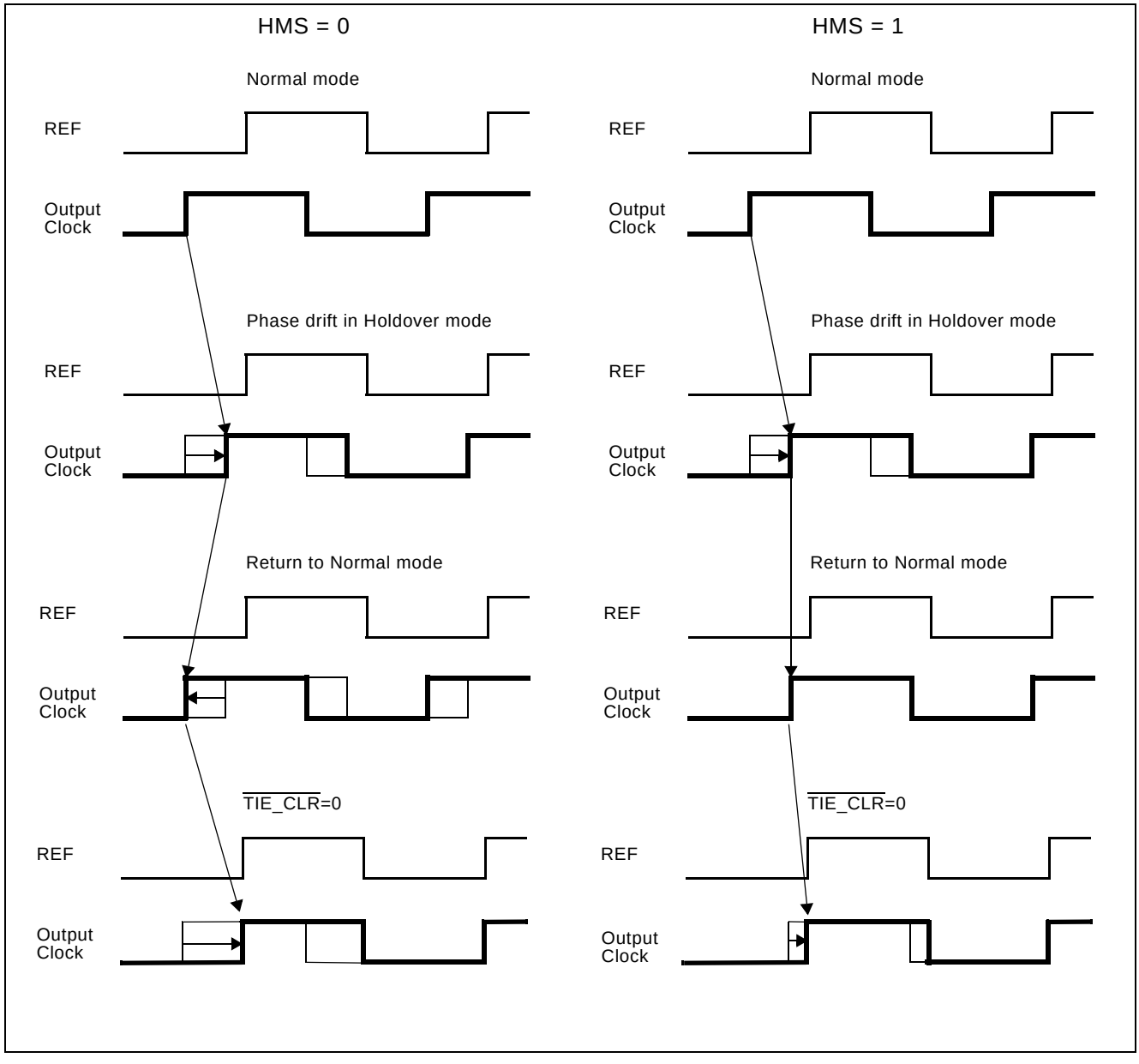


Figure 10 - Timing Diagram of Hitless Mode Switching

Examples:

HMS=1: When ten Normal to Holdover to Normal mode transitions occur and in each case the Holdover mode was entered for 2 seconds then the accumulated phase change (MTIE) could be as large as 330 ns.

- $Phase_{holdover_drift}$ = 0.01 ppm x 2 s = 20 ns
- $Phase_{mode_change}$ = 0 ns + 13 ns = 13 ns
- $Phase_{10\ changes}$ = 10 x (20 ns + 13 ns) = 330 ns

where:

- 0.01 ppm is the accuracy of the Holdover mode
- 0 ns is the maximum phase discontinuity in the transition from the Normal mode to the Holdover mode
- 13 ns is the maximum phase discontinuity in the transition from the Holdover mode to the Normal mode when a new TIE corrector value is calculated

HMS=0: When the same ten Normal to Holdover to Normal mode changes occur and in each case Holdover mode was entered for 2 seconds, then the overall MTIE would be 20 ns. As the delay value for the TIE corrector circuit is not updated, there is no 13 ns measurement error at this point. The phase can still drift for 20 ns when the PLL is in Holdover mode but when the PLL enters Normal mode again, the phase moves back to the original point so the phase is not accumulated.

3.4 Digital Phase Lock Loop (DPLL)

The DPLL of the ZL30106 consists of a phase detector, a limiter, a loop filter and a digitally controlled oscillator as shown in Figure 11. The data path from the phase detector to the limiter is tapped and routed to the lock detector that provides a lock indication which is output at the LOCK pin.

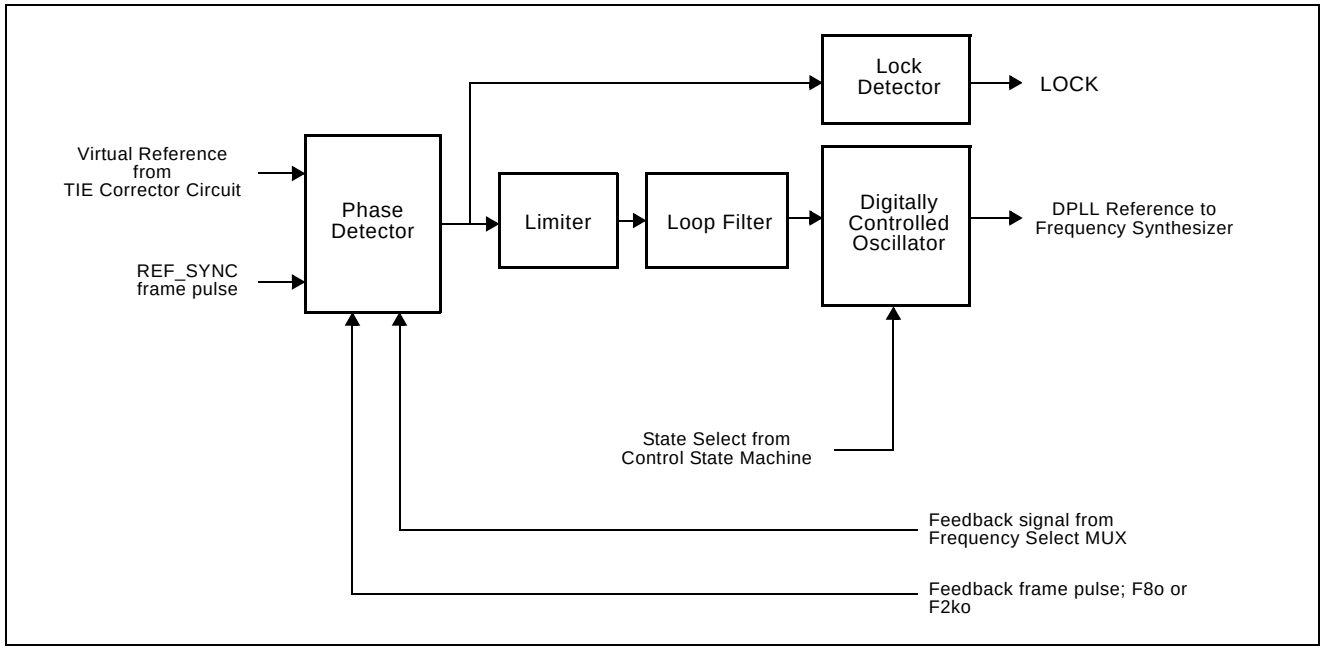


Figure 11 - DPLL Block Diagram

Phase Detector - the phase detector compares the virtual reference signal from the TIE corrector circuit with the feedback signal and provides an error signal corresponding to the phase difference between the two. This error signal is passed to the limiter circuit.

Limiter - the limiter receives the error signal from the phase detector and ensures that the DPLL responds to all input transient conditions with a maximum output phase slope compliant with the applicable standards. The phase slope limit is dependent on the APP_SEL1:0 and BW_SEL pins and is listed in Table 2.

Loop Filter - the loop filter is similar to a first order low pass filter with a bandwidth selected by the BW_SEL pin, suitable to provide timing and synchronization for SONET/SDH and PDH network interface cards. For stability reasons, the loop filter bandwidth for 2 kHz references is always 14 Hz and the loop filter bandwidth for 8 kHz references is limited to a maximum of 58 Hz.

Digitally Controlled Oscillator (DCO) - the DCO receives the limited and filtered signal from the Loop Filter, and based on its value, generates a corresponding digital output signal. The synchronization method of the DCO is dependent on the state of the ZL30106.

In Normal Mode, the DCO provides an output signal which is frequency and phase locked to the selected input reference signal.

In Holdover Mode, the DCO is free running at a frequency equal to the frequency that the DCO was generating in Normal Mode. The frequency in Holdover mode is calculated from frequency samples stored 26 ms to 52 ms before the ZL30106 entered Holdover mode. This ensures that the coarse frequency monitor and the single cycle monitor have time to disqualify a bad reference before it corrupts the holdover frequency.

In Freerun Mode, the DCO is free running with an accuracy equal to the accuracy of the OSCi 20 MHz source.

Lock Indicator - the lock detector monitors if the output value of the phase detector is within the phase-lock-window for a certain time. The selected phase-lock-window guarantees the stable operation of the LOCK pin with maximum network jitter and wander on the reference input. If the DPLL goes into Holdover mode (auto or manual), the LOCK pin will initially stay high for 0.1 s. If at that point the DPLL is still in holdover mode, the LOCK pin will go low. In Freerun mode the LOCK pin will go low immediately.

3.5 Frequency Synthesizers

The output of the DCO is used by the frequency synthesizers to generate the output clocks and frame pulses which are synchronized to one of three reference inputs (REF0, REF1 or REF2). The frequency synthesizer uses digital techniques to generate output clocks and advanced noise shaping techniques to minimize the output jitter. The clock and frame pulse outputs have limited driving capability and should be buffered when driving high capacitance loads.

3.6 State Machine

As shown in Figure 1, the state machine controls the TIE Corrector Circuit and the DPLL. The control of the ZL30106 is based on the inputs MODE_SEL1:0, REF_SEL1:0 and HMS.

3.7 Master Clock

The ZL30106 can use either a clock or crystal as the master timing source. For recommended master timing circuits, see the Applications - Master Clock section.

4.0 Control and Modes of Operation

4.1 Application Selection

Table 1 lists the applications that are supported by the ZL30106 with the corresponding frequency out of range limits.

APP_SEL	Application	Applicable Standard	Out Of Range Limits
00	DS1/E1	ANSI T1.403 Telcordia GR-1244-CORE Stratum 4/4E	64 - 83 ppm
01	Derived DS1	ITU-T G.783	9.2 - 12 ppm
10	DS2/E2/DS3/E3	ANSI T1.102 ITU-T G.823	40 - 52 ppm
11	SONET/SDH	ITU-T G.813 Option 1 Telcordia GR-253-CORE	40 - 52 ppm

Table 1 - Application Selection and the Out of Range Limits

4.2 Loop Filter and Limiter Selection

The loop filter and limiter settings are selected through the APP_SEL and BW_SEL pins, see Table 2. The maximum loop filter bandwidth is also dependent on the frequency of the currently selected reference (REF0/1/2).

APP_SEL1:0	BW_SEL	Detected REF Frequency	Loop Filter Bandwidth	Phase Slope Limiting
00 or 10 (DS1/E1 or DS2/E2/DS3/E3)	0	2 kHz	14 Hz	61 µs/s
		8 kHz, 1.544 MHz, 2.048 MHz, 8.192 MHz, 16.384 MHz, 19.44 MHz	29 Hz	
01 (Derived DS1)	0	2 kHz	14 Hz	9.5 ms /s
		8 kHz, 1.544 MHz, 2.048 MHz, 8.192 MHz, 16.384 MHz, 19.44 MHz	29 Hz	
11 (SONET/SDH)	0	2 kHz	14 Hz	7.5 µs/s
		8 kHz, 1.544 MHz, 2.048 MHz, 8.192 MHz, 16.384 MHz, 19.44 MHz	29 Hz	
00, 01, 10 or 11 (all applications)	1	2 kHz	14 Hz	9.5 ms /s
		8 kHz	58 Hz	
		1.544 MHz, 2.048 MHz, 8.192 MHz, 16.384 MHz, 19.44 MHz	922 Hz	

Table 2 - Loop Filter and Limiter Settings

4.3 Output Clock and Frame Pulse Selection

The output of the DCO is used by the frequency synthesizers to generate the output clocks and frame pulses which are synchronized to one of three reference inputs (REF0, REF1 or REF2). These signals are available in two groups controlled by the OUT_SEL2:0 pins, see Table 3.

OUT_SEL2	Generated Clocks	Generated Frame Pulses
0	C2o, $\overline{\text{C4o}}$, C8o, $\overline{\text{C16o}}$	$\overline{\text{F4o}}$, F8o, $\overline{\text{F16o}}$
1	C2o, $\overline{\text{C16o}}$, C32, $\overline{\text{C65o}}$	$\overline{\text{F16o}}$, F32o, $\overline{\text{F65o}}$
OUT_SEL1:0		
00	C6o	
01	C8.4o	
10	C34o	
11	C44o	

Table 3 - Clock and Frame Pulse Selection with OUT_SEL Pin

4.4 Modes of Operation

The ZL30106 has three possible manual modes of operation; Normal, Holdover and Freerun. These modes are selected with mode select pins MODE_SEL1 and MODE_SEL0 as is shown in Table 4. Transitioning from one mode to the other is controlled by an external controller. The ZL30106 can be configured to automatically select a valid input reference under control of its internal state machine by setting MODE_SEL1:0 = 11. In this mode of operation, a state machine controls selection of references (REF0 or REF1) used for synchronization.

MODE_SEL1	MODE_SEL0	Mode
0	0	Normal (with automatic Holdover)
0	1	Holdover
1	0	Freerun
1	1	Automatic (Normal with automatic Holdover and automatic reference switching)

Table 4 - Operating Modes

4.4.1 Freerun Mode

Freerun mode is typically used when an independent clock source is required or immediately following system power-up before network synchronization is achieved.

In Freerun mode, the ZL30106 provides timing and synchronization signals which are based on the master clock frequency (supplied to OSCi pin) only and are not synchronized to the reference input signals.

The accuracy of the output clock is equal to the accuracy of the master clock (OSCi). So if a ±32 ppm output clock is required, the master clock must also be ±32 ppm. See Applications - Section 6.2, “Master Clock“.

4.4.2 Holdover Mode

Holdover Mode is typically used for short durations while system synchronization is temporarily disrupted.

In Holdover Mode, the ZL30106 provides timing and synchronization signals, which are not locked to an external reference signal, but are based on storage techniques. The storage value is determined while the device is in Normal Mode and locked to an external reference signal.

When in Normal Mode, and locked to the input reference signal, a numerical value corresponding to the ZL30106 output reference frequency is stored alternately in two memory locations every 26 ms. When the device is switched into Holdover Mode, the value in memory from between 26 ms and 52 ms is used to set the output frequency of the device. The frequency accuracy of Holdover Mode is 0.01 ppm.

Two factors affect the accuracy of Holdover mode. One is drift on the master clock while in Holdover mode, drift on the master clock directly affects the Holdover mode accuracy. Note that the absolute master clock (OSCi) accuracy does not affect Holdover accuracy, only the *change* in OSCi accuracy while in Holdover. For example, a ±32 ppm master clock may have a temperature coefficient of ±0.1 ppm per °C. So a ±10 °C change in temperature, while the ZL30106 is in Holdover mode may result in an additional offset (over the 0.01 ppm) in frequency accuracy of ±1 ppm. Which is much greater than the 0.01 ppm of the ZL30106. The other factor affecting the accuracy is large jitter on the reference input prior to the mode switch.

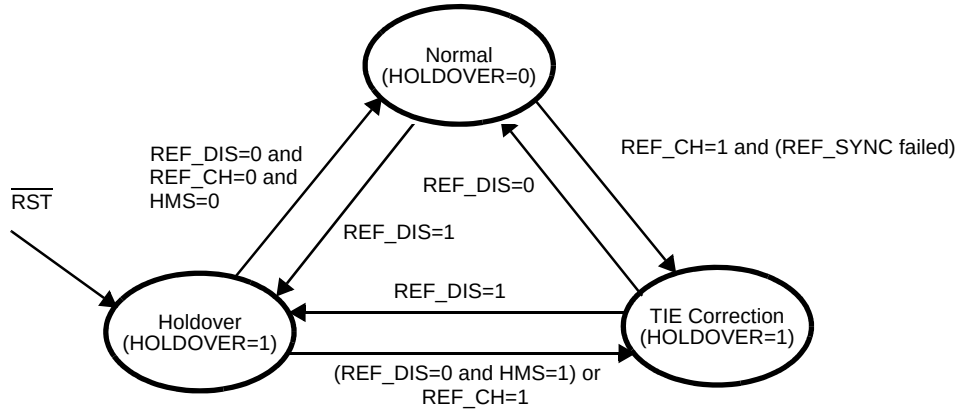
4.4.3 Normal Mode

Normal mode is typically used when a system clock source, synchronized to the network is required. In Normal mode, the ZL30106 provides timing and frame synchronization signals, which are synchronized to one of three reference inputs (REF0, REF1 or REF2). The input reference signal may have a nominal frequency of 2 kHz, 8 kHz, 1.544 MHz, 2.048 MHz, 8.192 MHz, 16.384 MHz or 19.44 MHz. The frequency of the reference inputs are automatically detected by the reference monitors.

When the ZL30106 comes out of RESET while Normal mode is selected by its MODE_SEL pins then it will initially go into Holdover mode and generate clocks with the accuracy of its freerunning local oscillator (see Figure 12). If the ZL30106 determines that its selected reference is disrupted (see Figure 3), it will remain in Holdover until the selected reference is no longer disrupted or the external controller selects another reference that is not disrupted. If the ZL30106 determines that its selected reference is not disrupted (see Figure 3) then the state machine will cause the DPLL to recover from Holdover via one of two paths depending on the logic level at the HMS pin. If HMS=0 then the ZL30106 will transition directly to Normal mode and it will align its output signals with its selected input reference (see Figure 10). If HMS=1 then the ZL30106 will transition to Normal mode via the TIE correction state and the phase difference between the output signals and the selected input reference will be maintained.

When the ZL30106 is operating in Normal mode, if it determines that its selected reference is disrupted (Figure 3) then its state machine will cause it to automatically go to Holdover mode. When the ZL30106 determines that its selected reference is not disrupted then the state machine will cause the DPLL to recover from Holdover via one of two paths depending on the logic level at the HMS pin (see Figure 12). If HMS=0 then the ZL30106 will transition directly to Normal mode and it will align its output signals with its input reference (see Figure 10). If HMS=1 then the ZL30106 will transition to Normal mode via the TIE correction state and the phase difference between the output signals and the input reference will be maintained.

If the reference selection changes because the value of the REF_SEL1:0 pins changes or because the reference selection state machine selected a different reference input, the ZL30106 goes into Holdover mode and returns to Normal mode through the TIE correction state regardless of the logic value on HMS pin.



REF_DIS=1: Current selected reference disrupted (see Figure 3)

REF_CH= 1: Reference change, a transition in the reference selection (see Figure 14) or a change in the REF_SEL pins.

Figure 12 - Mode Switching in Normal Mode

4.4.4 Automatic Mode

The Automatic mode combines the functionality of the Normal mode (automatic Holdover) with automatic reference switching. The automatic reference switching is described in more detail in section 4.5.2, “Automatic Reference Switching“.

4.5 Reference Switching

4.5.1 Manual Reference Switching

In the manual modes of operation (MODE_SEL1:0 ≠ 11) the active reference input (REF0, REF1 or REF2) is selected by the REF_SEL1 and REF_SEL0 pins as shown in Table 5. When the logic value of the REF_SEL pins is changed when the DPLL is in Normal mode, the ZL30106 will perform a hitless reference switch.

REF_SEL1	REF_SEL0	Input Reference Selected
0	0	REF0
0	1	REF1
1	0	REF2
1	1	REF2

Table 5 - Manual Reference Selection

When the REF_SEL inputs are used in Normal mode to force a change from the currently selected reference to another reference, the action of the LOCK output will depend on the relative frequency and phase offset of the old and new references. Where the new reference has enough frequency offset and/or TIE-corrected phase offset to force the output outside the phase-lock-window, the LOCK output will de-assert, the lock-qualify timer is reset, and LOCK will stay de-asserted for the full lock-time duration. Where the new reference is close enough in frequency and TIE-corrected phase for the output to stay within the phase-lock-window, the LOCK output will remain asserted through the reference-switch process.

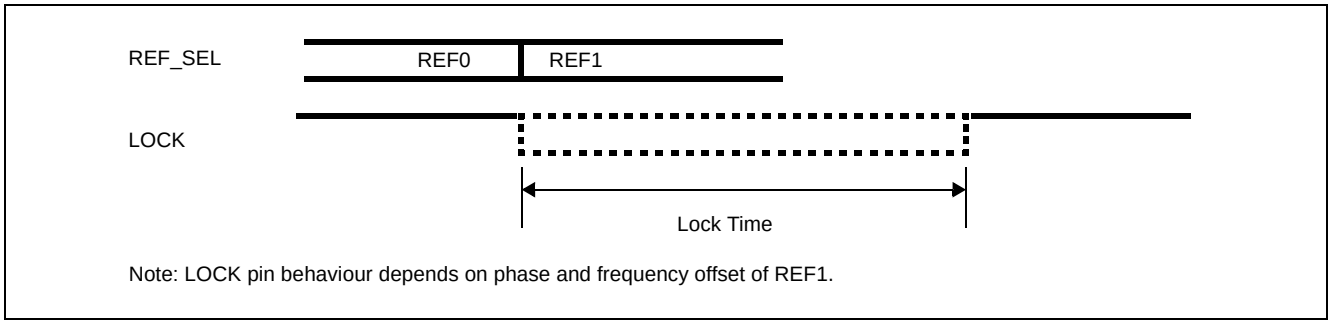


Figure 13 - Reference Switching in Normal Mode

4.5.2 Automatic Reference Switching

In the automatic mode of operation (MODE_SEL1:0 = 11), the ZL30106 automatically selects a reference input that is not out-of-range (REF_OOR=0, see Figure 3). The state machine can only select REF0 or REF1. REF2 cannot be selected in the Automatic mode. See Figure 14.

If the current reference (REF0 or REF1) used for synchronization fails, the state machine will switch to the other reference. If both references fail then the ZL30106 enters the Holdover mode without switching to another reference. When the ZL30106 comes out of reset or when REF2 is the current reference when the ZL30106 is put in the Automatic mode, then REF0 has priority over REF1. Otherwise there is no preference for REF0 or REF1 which is referred to as non-revertive reference selection.

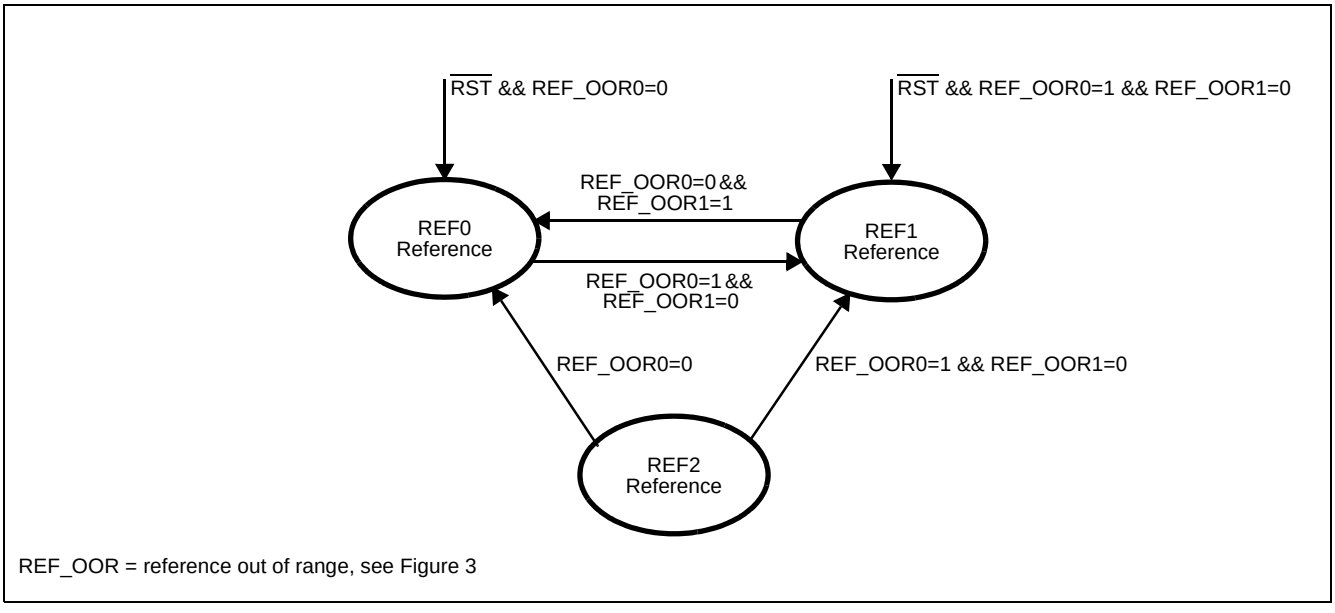


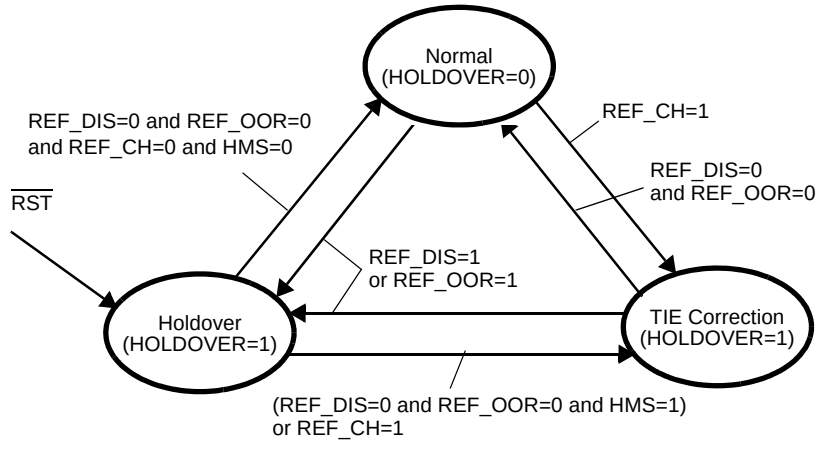
Figure 14 - Reference Selection in Automatic Mode (MODE_SEL=11)

In the automatic mode of operation, both pins REF_SEL1 and REF_SEL0 are configured as outputs. The logic level on the REF_SEL0 output indicates the current input reference being selected for synchronization (see Table 6).

REF_SEL1 (output pin)	**REF_SEL0** (output pin)	**Input Reference**
0	0	REF0
0	1	REF1

Table 6 - The Reference Selection Pins in the Automatic Mode

The mode selection state machine behaves differently in Automatic mode in that when both reference REF0 and reference REF1 are out of range (REF_OOR=1), the state machine will select the Holdover state. In Normal mode the reference out of range (REF_OOR) status is ignored by the state machine. This is illustrated in Figure 15.



REF_DIS=1: Current selected reference disrupted (see Figure 3). REF_DIS is an internal signal.

REF_OOR=1: Current selected reference out of range (see Figure 3). REF_OOR is an internal signal.

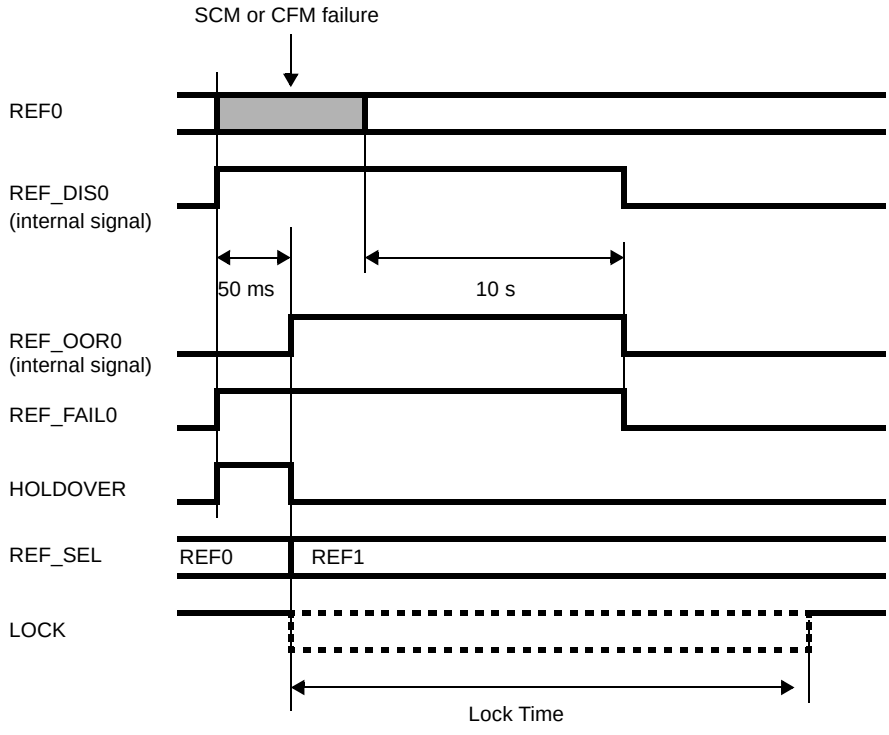
REF_CH= 1: Reference change, a transition in the reference selection (see Figure 14). REF_CH is an internal signal.

Figure 15 - Mode Switching in Automatic Mode

4.5.2.1 Automatic Reference Switching - Coarse Reference Failure

When the currently-active input reference in Automatic mode fails in a coarse manner, the REF_DIS internal signal places the device in holdover, with the HOLDOVER pin and the REF_FAIL pin asserted. This can occur through triggering the Single Cycle Monitor, or the Coarse Frequency Monitor, in the Reference Monitor block. If the reference does not correct itself within the reference-disqualify duration (50 milliseconds) the HOLDOVER pin is de-asserted and the REF_SEL outputs indicate that the device has switched to the other reference. Where the new reference is close enough in frequency and TIE-corrected phase for the output to stay within the phase-lock-window, the LOCK output will remain asserted through the reference-switch process. Where the new reference has enough frequency offset and/or TIE-corrected phase offset to force the output outside the phase-lock-window, the LOCK output will de-assert, the lock-qualify timer is reset, and LOCK will stay de-asserted for the full lock-time duration. Figure 16 illustrates this process.

If the reference corrects itself within the reference-disqualify duration (< 50 milliseconds) the HOLDOVER pin is de-asserted, the REF_FAIL pin is de-asserted, and the REF_SEL outputs indicate that the device has remained locked to the old reference. The LOCK pin remains asserted.



Note: This scenario is based on REF1 remaining good throughout the duration.
LOCK pin behaviour depends on phase and frequency offset of REF1.

Figure 16 - Automatic Reference Switching - Coarse Reference Failure

4.5.2.2 Automatic Reference Switching - Reference Frequency Out-of-Range

When the currently-active input reference in Automatic mode fails through a subtle frequency offset, the REF_FAIL output is asserted as soon as the Precise Frequency Monitor indicates an out-of-range reference (10 to 20 seconds). The HOLDOVER output is briefly asserted (approximately three reference input cycles) and the REF_SEL outputs indicate that the device has switched to the other reference. Where the new reference is close enough in frequency and TIE-corrected phase for the output to stay within the phase-lock-window, the LOCK output will remain asserted through the reference-switch process. Where the new reference has enough frequency offset and/or TIE-corrected phase offset to force the output outside the phase-lock-window, the LOCK output will de-assert, the lock-qualify timer is reset, and LOCK will stay de-asserted for the full lock-time duration. Figure 17 illustrates this process.

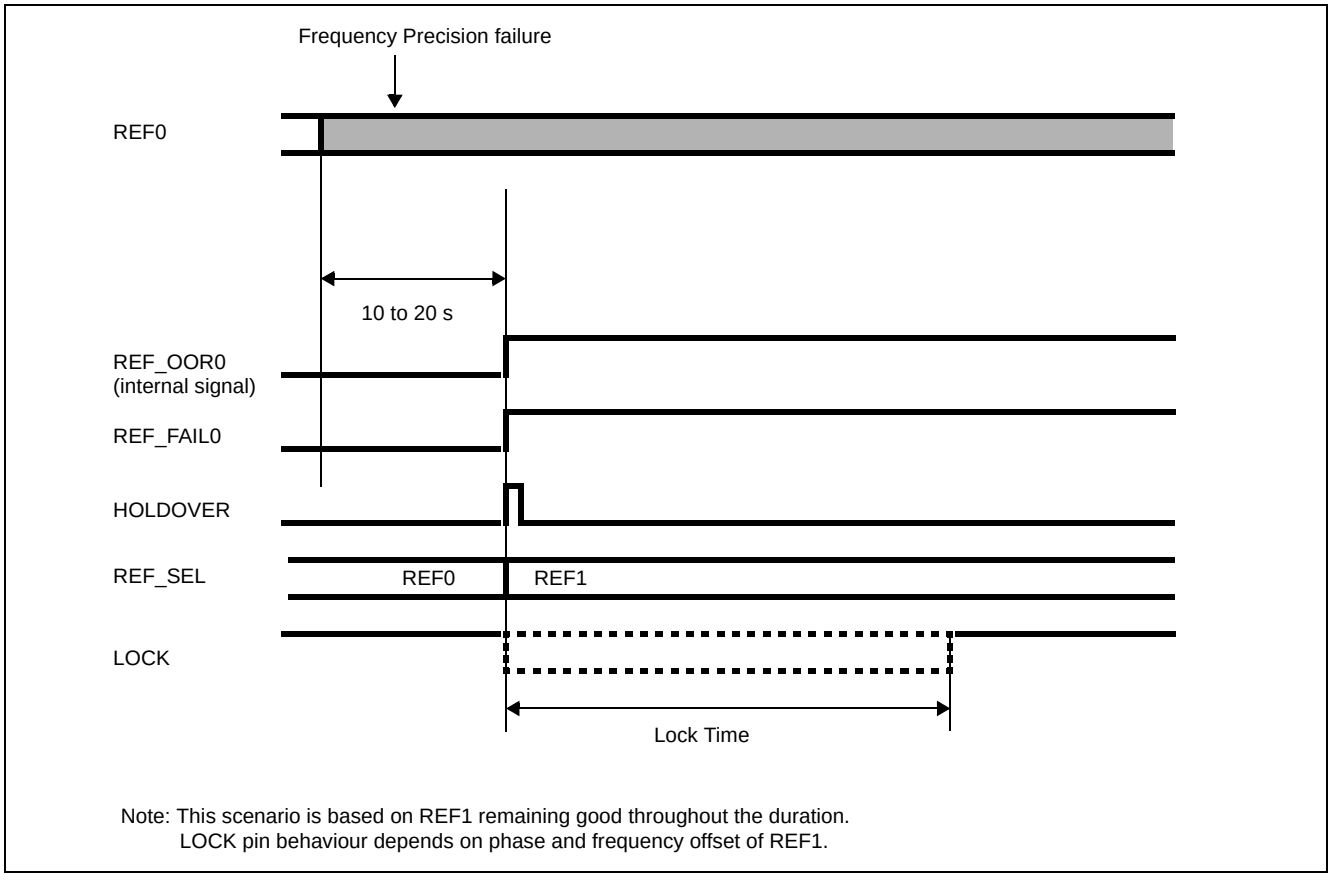


Figure 17 - Automatic Reference Switching - Out-of-Range Reference Failure

4.6 Clock-and-Sync Pair Synchronization

The ZL30106 can lock directly to a 2 kHz reference or an 8 kHz reference, but the low frequency of these references restricts the value of the highest loop filter that can be used. The clock-and-sync pair synchronization technique enables the ZL30106 to align its output 2 kHz and 8 kHz frame pulses with 2 kHz and 8 kHz references without restricting the loop filter. Therefore the output clocks and frame pulses will track the input clock and frame pulse pair closely even in the presence of jitter on the reference input.

The clock-and-sync pair mechanism is enabled as soon as a valid 2 kHz or 8 kHz frame pulse is detected on the REF_SYNC input. The REF_SYNC pulse must be generated from the clock that is present on the REF input. The ZL30106 checks the number of REF cycles in the REF_SYNC period. If this is not the nominal number of cycles, the REF_SYNC pulse is considered invalid. For example, if REF is a 8.192 MHz clock then there must be exactly 1024 REF cycles in a REF_SYNC period. If a valid REF_SYNC pulse is detected, the ZL30106 will align the rising edges of the REF clock and the corresponding output clock such that the rising edge of the F2ko or F8o/F32o output frame pulse is aligned with the frame boundary indicated by the REF_SYNC signal. The rising edges of the REF and the corresponding output clock that are aligned, are the ones that lag the rising edges of the REF_SYNC and the F8o pulses respectively. This is illustrated in Figure 18. If an ST_BUS clock and frame pulse pair is used as the REF and REF_SYNC inputs, the ST-BUS frame pulse must be inverted first before it can be used as the REF_SYNC pulse.

If a clock and frame pulse pair is used for synchronization, the TIE correction value should be cleared by keeping the TIE_CLR pin low for at least 15 ns. Otherwise a static phase offset may remain between the output frame pulse and the REF_SYNC frame pulse. Reference switching from one REF- REF_SYNC pair to the other REF- REF_SYNC pair does not activate the TIE correction circuit and the ZL30106 will align the output frame pulse to the new REF_SYNC frame pulse. In that case the MTIE can be as large as 250 µs for a 2 kHz REF_SYNC signal and 62.5 µs for an 8 kHz REF_SYNC signal. Reference switching from a REF- REF_SYNC pair to a single REF input however, is hitless unless the TIE_CLR pin is kept low.

If a REF - REF_SYNC pair is used as the reference then if the ZL30106 transitions from Holdover to Normal mode, the TIE correction circuit will not be activated and the PLL will align its output clock and frame pulse with the input REF and REF_SYNC pair.

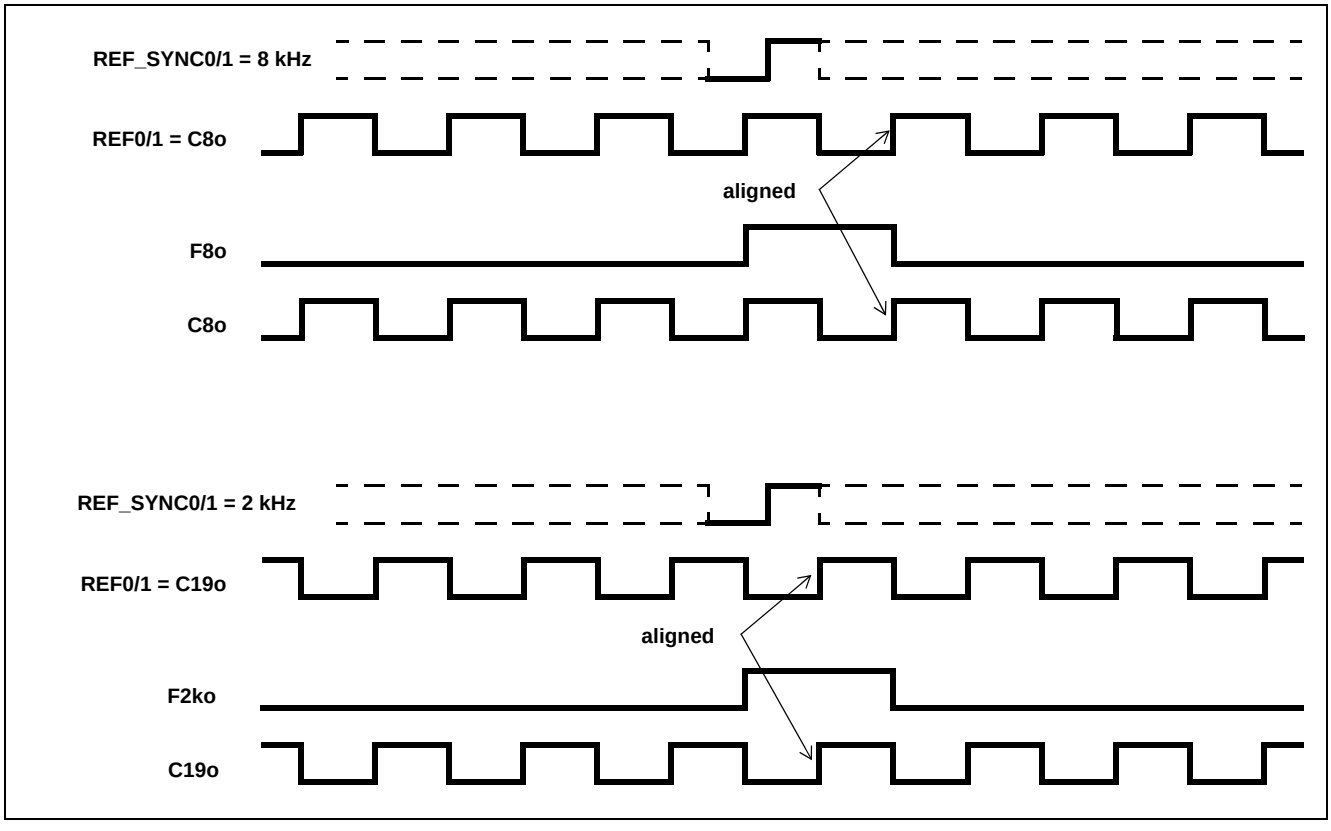


Figure 18 - Examples of REF & REF_SYNC to Output Alignment

5.0 Measures of Performance

The following are some PLL performance indicators and their corresponding definitions.

5.1 Jitter

Timing jitter is defined as the high frequency variation of the clock edges from their ideal positions in time. Wander is defined as the low-frequency variation of the clock edges from their ideal positions in time. High and low frequency variation imply phase oscillation frequencies relative to some demarcation frequency. (Often 10 Hz or 20 Hz for DS1 or E1, higher for SONET/SDH clocks.) Jitter parameters given in this data sheet are total timing jitter numbers, not cycle-to-cycle jitter.

5.2 Jitter Generation (Intrinsic Jitter)

Jitter generation is the measure of the jitter produced by the PLL and is measured at its output. It is measured by applying a reference signal with no jitter to the input of the device, and measuring its output jitter. Jitter generation may also be measured when the device is in a non-synchronizing mode, such as free running or holdover, by measuring the output jitter of the device. Jitter is usually measured with various bandlimiting filters depending on the applicable standards.

5.3 Jitter Tolerance

Jitter tolerance is a measure of the ability of a PLL to operate properly (i.e., remain in lock and or regain lock in the presence of large jitter magnitudes at various jitter frequencies) when jitter is applied to its reference. The applied jitter magnitude and jitter frequency depends on the applicable standards.

5.4 Jitter Transfer

Jitter transfer or jitter attenuation refers to the magnitude of jitter at the output of a device for a given amount of jitter at the input of the device. Input jitter is applied at various amplitudes and frequencies, and output jitter is measured with various filters depending on the applicable standards.

For the Zarlink digital PLLs two internal elements determine the jitter attenuation; the internal low pass loop filter and the phase slope limiter. The phase slope limiter limits the output phase slope to, for example, 61 μs/s. Therefore, if the input signal exceeds this rate, such as for very large amplitude low frequency input jitter, the maximum output phase slope will be limited (i.e., attenuated).

Since intrinsic jitter is always present, jitter attenuation will appear to be lower for small input jitter signals than for large ones. Consequently, accurate jitter transfer function measurements are usually made with large input jitter signals (for example 75% of the specified maximum tolerable input jitter).

5.5 Frequency Accuracy

The Frequency accuracy is defined as the absolute accuracy of an output clock signal when it is not locked to an external reference, but is operating in a free running mode.

5.6 Holdover Accuracy

Holdover accuracy is defined as the absolute accuracy of an output clock signal, when it is not locked to an external reference signal, but is operating using storage techniques. For the ZL30106, the storage value is determined while the device is in Normal Mode and locked to an external reference signal.

5.7 Pull-in Range

Also referred to as capture range. This is the input frequency range over which the PLL must be able to pull into synchronization.

5.8 Lock Range

This is the input frequency range over which the synchronizer must be able to maintain synchronization.

5.9 Phase Slope

Phase slope is measured in seconds per second and is the rate at which a given signal changes phase with respect to an ideal signal. The given signal is typically the output signal. The ideal signal is of constant frequency and is nominally equal to the value of the final output signal or final input signal. Another way of specifying the phase slope is as the fractional change per time unit. For example; a phase slope of 61 μs/s can also be specified as 61 ppm.

5.10 Time Interval Error (TIE)

TIE is the time delay between a given timing signal and an ideal timing signal.

5.11 Maximum Time Interval Error (MTIE)

MTIE is the maximum peak to peak delay between a given timing signal and an ideal timing signal within a particular observation period.

5.12 Phase Continuity

Phase continuity is the phase difference between a given timing signal and an ideal timing signal at the end of a particular observation period. Usually, the given timing signal and the ideal timing signal are of the same frequency. Phase continuity applies to the output of the PLL after a signal disturbance due to a reference switch or a mode change. The observation period is usually the time from the disturbance, to just after the synchronizer has settled to a steady state.

5.13 Lock Time

This is the time it takes the PLL to frequency lock to the input signal. Phase lock occurs when the input signal and output signal are aligned in phase with respect to each other within a certain phase distance (not including jitter). Lock time is affected by many factors which include:

- initial input to output phase difference
- initial input to output frequency difference
- PLL loop filter bandwidth
- PLL phase slope limiter
- in-lock phase distance

The presence of input jitter makes it difficult to define when the PLL is locked as it may not be able to align its output to the input within the required phase distance, dependent on the PLL bandwidth and the input jitter amplitude and frequency.

Although a short lock time is desirable, it is not always possible to achieve due to other synchronizer requirements. For instance, better jitter transfer performance is achieved with a lower frequency loop filter which increases lock time. And better (smaller) phase slope performance (limiter) results in longer lock times.

6.0 Applications

This section contains ZL30106 application specific details for power supply decoupling, reset operation, clock and crystal operation.

6.1 Power Supply Decoupling

Jitter levels on the ZL30106 output clocks may increase if the device is exposed to excessive noise on its power pins. For optimal jitter performance, the ZL30106 device should be isolated from noise on power planes connected to its 3.3 V and 1.8 V supply pins. For recommended common layout practices, refer to Zarlink Application Note ZLAN-178.

6.2 Master Clock

The ZL30106 can use either a clock or crystal as the master timing source. Zarlink application note ZLAN-68 lists a number of applicable oscillators and crystals that can be used with the ZL30106.

6.2.1 Clock Oscillator

When selecting a clock oscillator, numerous parameters must be considered. This includes absolute frequency, frequency change over temperature, output rise and fall times, output levels, duty cycle and phase noise.

The output clock should be connected directly (not AC coupled) to the OSCi input of the ZL30106, and the OSCo output should be left open as shown in Figure 19.

1	Frequency	20 MHz
2	Tolerance	as required
3	Rise & fall time	< 10 ns
4	Duty cycle	40% to 60%

Table 7 - Typical Clock Oscillator Specification

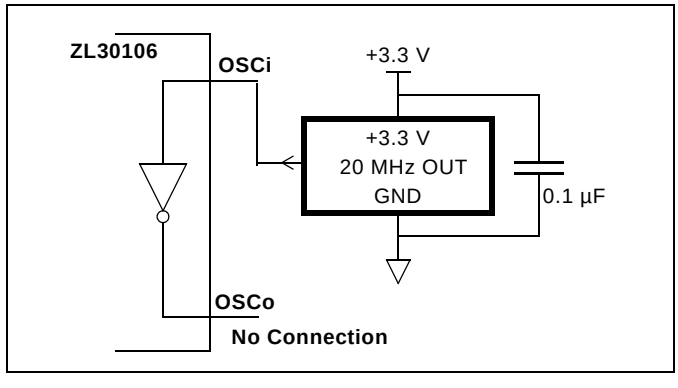


Figure 19 - Clock Oscillator Circuit

6.2.2 Crystal Oscillator

Alternatively, a Crystal Oscillator may be used. A complete oscillator circuit made up of a crystal, resistor and capacitors is shown in Figure 20.

The accuracy of a crystal oscillator depends on the crystal tolerance as well as the load capacitance tolerance. Typically, for a 20 MHz crystal specified with a 32 pF load capacitance, each 1 pF change in load capacitance

contributes approximately 9 ppm to the frequency deviation. Consequently, capacitor tolerances and stray capacitances have a major effect on the accuracy of the oscillator frequency.

The crystal should be a fundamental mode type - not an overtone. The fundamental mode crystal permits a simpler oscillator circuit with no additional filter components and is less likely to generate spurious responses. A typical crystal oscillator specification and circuit is shown in Table 8 and Figure 20 respectively.

1	Frequency	20 MHz
2	Tolerance	as required
3	Oscillation mode	fundamental
4	Resonance mode	parallel
5	Load capacitance	as required
6	Maximum series resistance	50 Ω

Table 8 - Typical Crystal Oscillator Specification

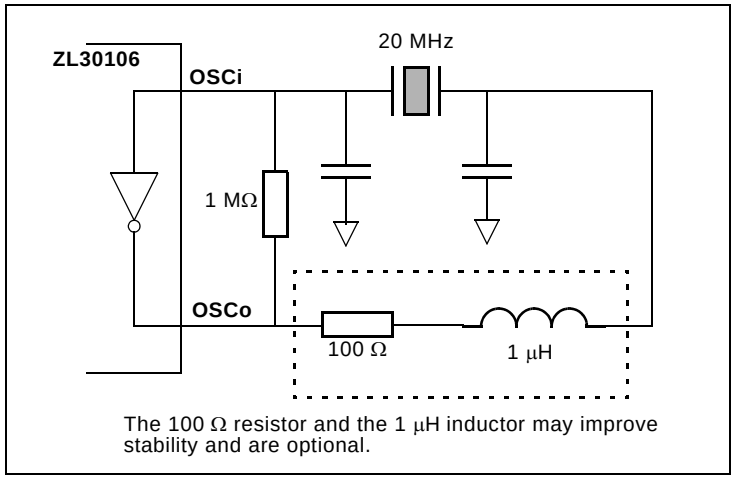


Figure 20 - Crystal Oscillator Circuit

6.3 Power Up Sequence

The ZL30106 requires that the 3.3 V supply is not powered up after the 1.8 V supply. This is to prevent the risk of latch-up due to the presence of parasitic diodes in the IO pads.

Two options are given:

1. Power-up the 3.3 V supply fully first, then power up the 1.8 V supply

2. Power up the 3.3 V supply and the 1.8 V supply simultaneously, ensuring that the 3.3 V supply is never lower than a few hundred millivolts below the 1.8 V supply (e.g., by using a schottky diode or controlled slew rate)

6.4 Reset Circuit

A simple power up reset circuit with about a 60 μs reset low time is shown in Figure 21. Resistor R_P is for protection only and limits current into the $\overline{RST}$ pin during power down conditions. The reset low time is not critical but should be greater than 300 ns.

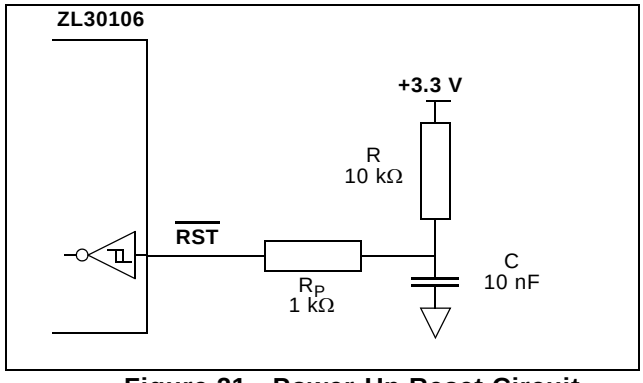


Figure 21 - Power-Up Reset Circuit

7.0 Characteristics

7.1 AC and DC Electrical Characteristics

Absolute Maximum Ratings*

	Parameter	Symbol	Min.	Max.	Units
1	Supply voltage	V_{DD_R}	-0.5	4.6	V
2	Core supply voltage	V_{CORE_R}	-0.5	2.5	V
3	Voltage on any digital pin	V_{PIN}	-0.5	6	V
4	Voltage on OSCi and OSCo pin	V_{OSC}	-0.3	V_{DD} + 0.3	V
5	Current on any pin	I_{PIN}		30	mA
6	Storage temperature	T_{ST}	-55	125	°C
7	TQFP 64 pin package power dissipation	P_{PD}		500	mW
8	ESD rating	V_{ESD}		2	kV

* Exceeding these values may cause permanent damage. Functional operation under these conditions is not implied.
* Voltages are with respect to ground (GND) unless otherwise stated.

Recommended Operating Conditions*

	Characteristics	Sym.	Min.	Typ.	Max.	Units
1	Supply voltage	V_{DD}	2.97	3.30	3.63	V
2	Core supply voltage	V_{CORE}	1.62	1.80	1.98	V
3	Operating temperature	T_A	-40	25	85	°C

* Voltages are with respect to ground (GND) unless otherwise stated.

DC Electrical Characteristics*

	Characteristics	Sym.	Min.	Max.	Units	Notes
1	Supply current with: OSCi = 0 V	I_{DDS}	1	8	mA	outputs loaded with 30 pF
2	OSCi = Clock, OUT_SEL=000	I_{DD}	30	60	mA	
3	OSCi = Clock, OUT_SEL=111	I_{DD}	45	78	mA	
4	Core supply current with: OSCi = 0 V	I_{CORES}	0	28	µA	
5	OSCi = Clock	I_{CORE}	14	20	mA	
6	Schmitt trigger Low to High threshold point	V_{t+}	1.43	1.85	V	All device inputs are Schmitt trigger type.
7	Schmitt trigger High to Low threshold point	V_{t-}	0.80	1.10	V	
8	Input leakage current	I_{IL}	-105	105	µA	$V_I = V_{DD}$ or 0 V
9	High-level output voltage	V_{OH}	2.4		V	I_{OH} = 8 mA for clock and frame-pulse outputs, 4 mA for status outputs

DC Electrical Characteristics*

	Characteristics	Sym.	Min.	Max.	Units	Notes
10	Low-level output voltage	V_{OL}		0.4	V	I_{OL} = 8 mA for clock and frame-pulse outputs, 4 mA for status outputs

* Supply voltage and operating temperature are as per Recommended Operating Conditions.
* Voltages are with respect to ground (GND) unless otherwise stated.

AC Electrical Characteristics* - Timing Parameter Measurement Voltage Levels (see Figure 22).

	Characteristics	Sym.	CMOS	Units
1	Threshold Voltage	V_T	$0.5 \cdot V_{DD}$	V
2	Rise and Fall Threshold Voltage High	V_{HM}	$0.7 \cdot V_{DD}$	V
3	Rise and Fall Threshold Voltage Low	V_{LM}	$0.3 \cdot V_{DD}$	V

* Supply voltage and operating temperature are as per Recommended Operating Conditions.
* Voltages are with respect to ground (GND) unless otherwise stated.

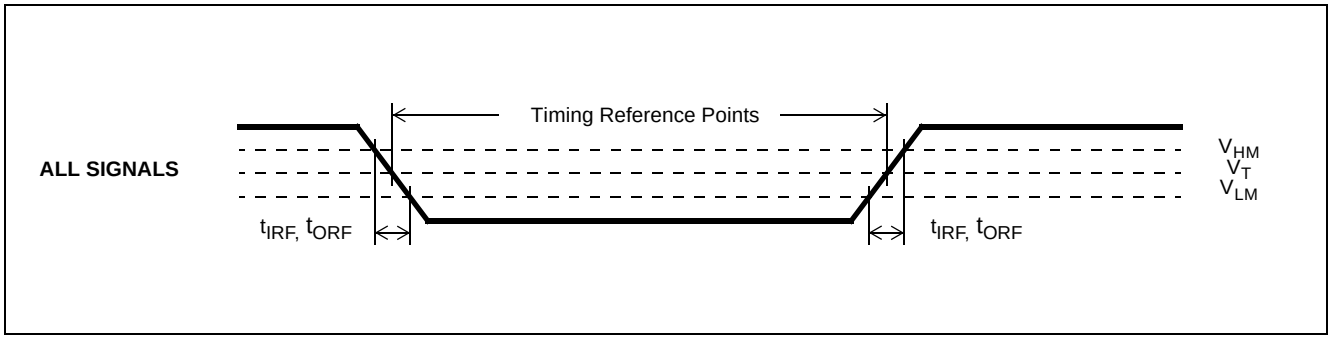


Figure 22 - Timing Parameter Measurement Voltage Levels

AC Electrical Characteristics* - Input timing for REF0, REF1 and REF2 references (see Figure 23).

	Characteristics	Symbol	Min.	Typ.	Max.	Units
1	2 kHz reference period	t_{REF2kP}	484	500	515	µs
2	8 kHz reference period	t_{REF8kP}	121	125	128	µs
3	1.544 MHz reference period	$t_{REF1.5P}$	338	648	950	ns
4	2.048 MHz reference period	t_{REF2P}	263	488	712	ns
5	8.192 MHz reference period	t_{REF8P}	63	122	175	ns
6	16.384 MHz reference period	t_{REF16P}	38	61	75	ns
7	19.44 MHz reference period	t_{REF8kP}	38	51	75	ns
8	reference pulse width high or low	t_{REFW}	15			ns

* Supply voltage and operating temperature are as per Recommended Operating Conditions.
* Period Min/Max values are the limits to avoid a single-cycle fault detection. Short-term and long-term average periods must be within Out-of-Range limits.

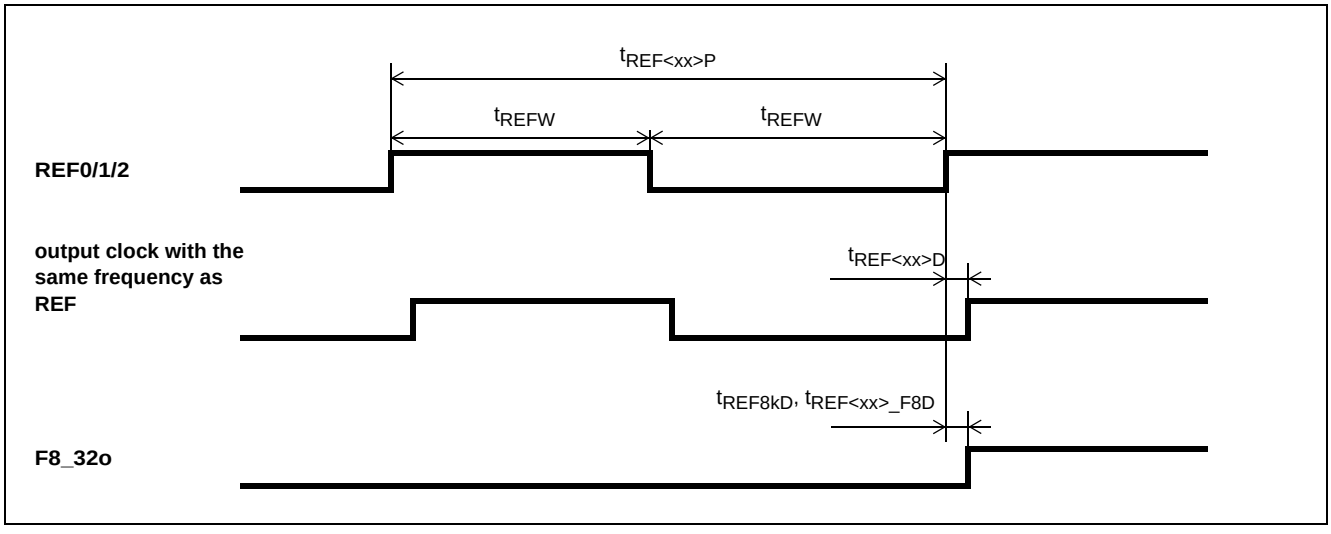
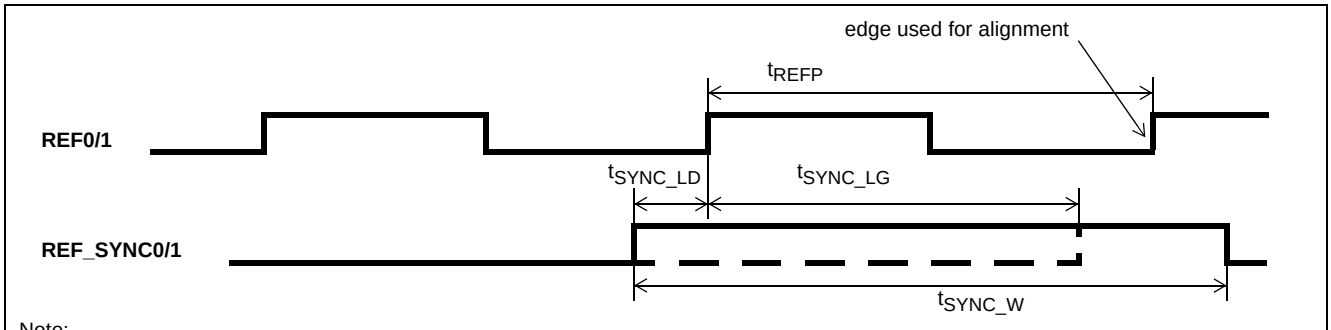


Figure 23 - REF0/1/2 Input Timing and Input to Output Timing

AC Electrical Characteristics* - Input timing for REF_SYNC0/1 (see Figure 24).

	Characteristics	REF_SYNC0/1 frequency	Symbol	Min.	Max.	Units	Notes
1	REF_SYNC0/1 lead time	2 kHz	t_{SYNC_LD}		0	ns	
2		8 kHz	t_{SYNC_LD}		12	ns	
3	REF_SYNC0/1 lag time	2 kHz	t_{SYNC_LG}		t_{REFP} - 15	ns	t_{REFP} = minimum period of REF0/1 clock
4		8 kHz	t_{SYNC_LG}		t_{REFP} - 28	ns	t_{REFP} = minimum period of REF0/1 clock
5	REF_SYNC0/1 pulse width high or low	2 kHz, 8 kHz	t_{SYNC_W}	15		ns	

* Supply voltage and operating temperature are as per Recommended Operating Conditions.
* See Figure 18, “Examples of REF & REF_SYNC to Output Alignment” on page 29 for further explanation.



Note:
REF0/1 can be 1.544 MHz, 2.048 MHz, 8.192 MHz, 16.384 MHz or 19.44 MHz.
REF_SYNC0/1 can be 2 kHz or 8 kHz.

Figure 24 - REF_SYNC0/1 Timing

AC Electrical Characteristics* - Input to output timing for REF0, REF1 and REF2 references when TIE_CLR = 0 (see Figure 23).

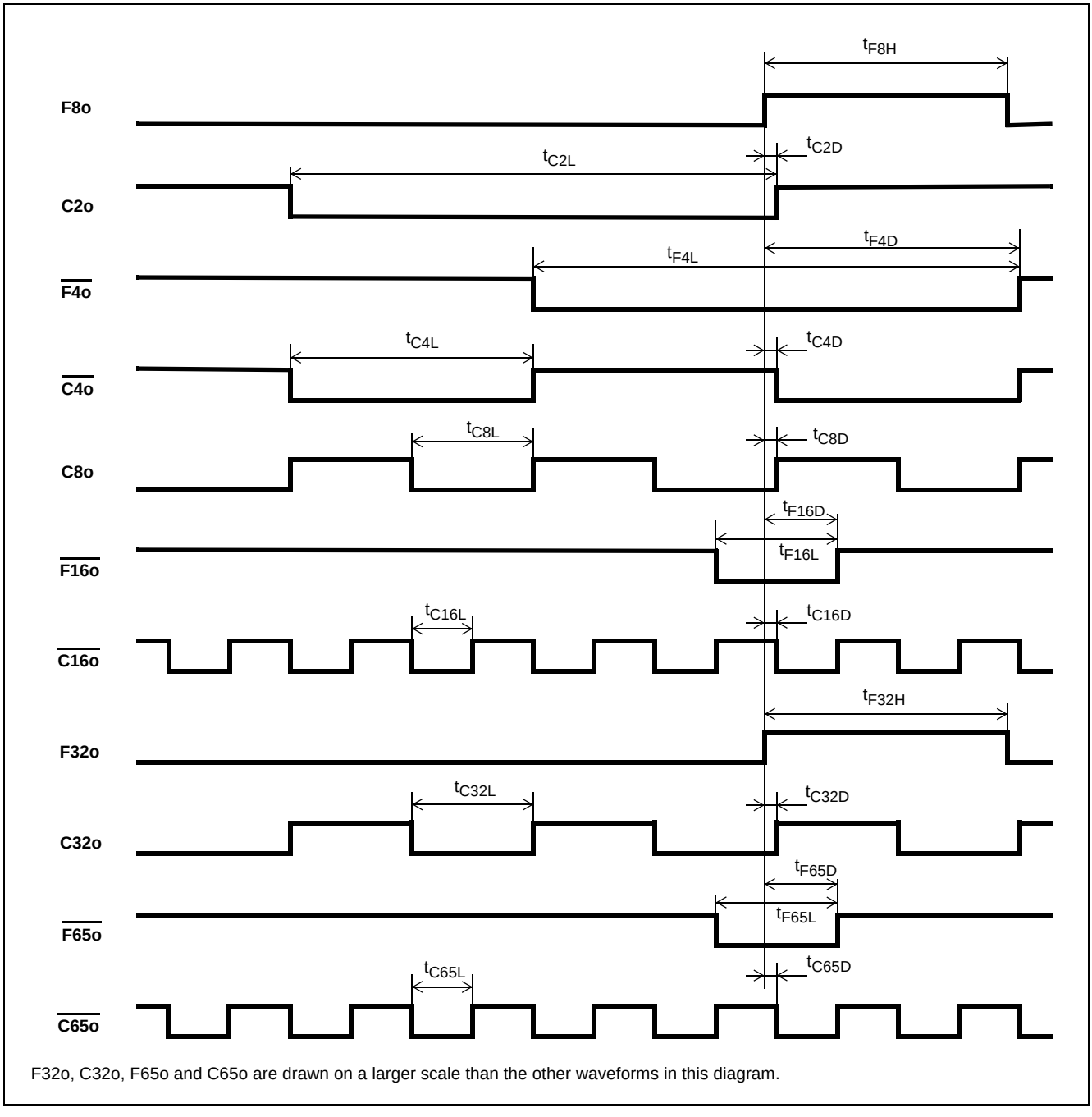
	Characteristics	Symbol	Min.	Max.	Units
1	2 kHz reference input to F2ko delay	t_{REF2kD}	0	1.2	ns
2	2 kHz reference input to F8/F32o delay	t_{REF2k_F8D}	-27.2	-26.5	ns
3	8 kHz reference input to F8/F32o delay	t_{REF8kD}	-0.3	2.0	ns
4	1.544 MHz reference input to C1.5o delay	$t_{REF1.5D}$	-1.2	0.2	ns
5	1.544 MHz reference input to F8/F32o delay	$t_{REF1.5_F8D}$	-1.1	0.9	ns
6	2.048 MHz reference input to C2o delay	t_{REF2D}	-1.2	0	ns
7	2.048 MHz reference input to F8/F32o delay	t_{REF2_F8D}	-0.6	0.8	ns
8	8.192 MHz reference input to C8o delay	t_{REF8D}	-2.0	0.1	ns
9	8.192 MHz reference input to F8/F32o delay	t_{REF8_F8D}	-1.0	1.8	ns
10	16.384 MHz reference input to $\overline{C16o}$ delay	t_{REF16D}	-1.1	1.9	ns
11	16.384 MHz reference input to F8/F32o delay	t_{REF16_F8D}	29.0	30.6	ns
12	19.44 MHz reference input to C19o delay	t_{REF19D}	0.2	1.1	ns
13	19.44 MHz reference input to F8/F32o delay	t_{REF19_F8D}	-1.7	-1.0	ns

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

AC Electrical Characteristics* - E1 output timing (see Figure 25).

	Characteristics	Sym.	Min.	Max.	Units	Notes
1	C2o delay	t_{C2D}	-0.4	0.3	ns	outputs loaded with 30 pF
2	C2o pulse width low	t_{C2L}	243.0	244.1	ns	
3	$\overline{\text{F4o}}$ pulse width low	t_{F4L}	243.3	244.3	ns	
4	$\overline{\text{F4o}}$ delay	t_{F4D}	121.5	122.2	ns	
5	$\overline{\text{C4o}}$ pulse width low	t_{C4L}	121.0	122.4	ns	
6	$\overline{\text{C4o}}$ delay	t_{C4D}	-0.3	1.1	ns	
7	F8o pulse width high	t_{F8H}	121.6	123.5	ns	
8	C8o pulse width low	t_{C8L}	60.3	61.3	ns	
9	C8o delay	t_{C8D}	-0.4	0.3	ns	
10	$\overline{\text{F16o}}$ pulse with low	t_{F16L}	60.3	61.2	ns	
11	$\overline{\text{F16o}}$ delay	t_{F16D}	29.9	30.8	ns	
12	$\overline{\text{C16o}}$ pulse width low	t_{C16L}	28.7	30.8	ns	
13	$\overline{\text{C16o}}$ delay	t_{C16D}	-0.5	1.5	ns	
14	F32o pulse width high	t_{F32H}	30.0	32.1	ns	
15	C32o pulse width low	t_{C32L}	14.7	15.5	ns	
16	C32o delay	t_{C32D}	-0.5	0.5	ns	
17	$\overline{\text{F65o}}$ pulse with low	t_{F65L}	14.7	15.5	ns	
18	$\overline{\text{F65o}}$ delay	t_{F65D}	7.1	8.0	ns	
19	$\overline{\text{C65o}}$ pulse width low	t_{C65L}	7.2	8.1	ns	
20	$\overline{\text{C65o}}$ delay	t_{C65D}	-1.0	1.0	ns	
21	Output clock and frame pulse rise time	t_{OR}	1.1	2.0	ns	
22	Output clock and frame pulse fall time	t_{OF}	1.2	2.3	ns	

* Supply voltage and operating temperature are as per Recommended Operating Conditions.



F32o, C32o, F65o and C65o are drawn on a larger scale than the other waveforms in this diagram.

Figure 25 - E1 Output Timing Referenced to F8/F32o

AC Electrical Characteristics* - DS1 output timing (see Figure 26).

	Characteristics	Sym.	Min.	Max.	Units	Notes
1	C1.5o delay	$t_{C1.5D}$	-0.6	0.6	ns	outputs loaded with 30 pF
2	C1.5o pulse width low	$t_{C1.5L}$	323.1	324.0	ns	
3	C3o delay	t_{C3D}	-0.7	0.5	ns	
4	C3o pulse width low	t_{C3L}	161.1	162.0	ns	
5	Output clock and frame pulse rise time	t_{OR}	1.1	2.0	ns	
6	Output clock and frame pulse fall time	t_{OF}	1.2	2.3	ns	

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

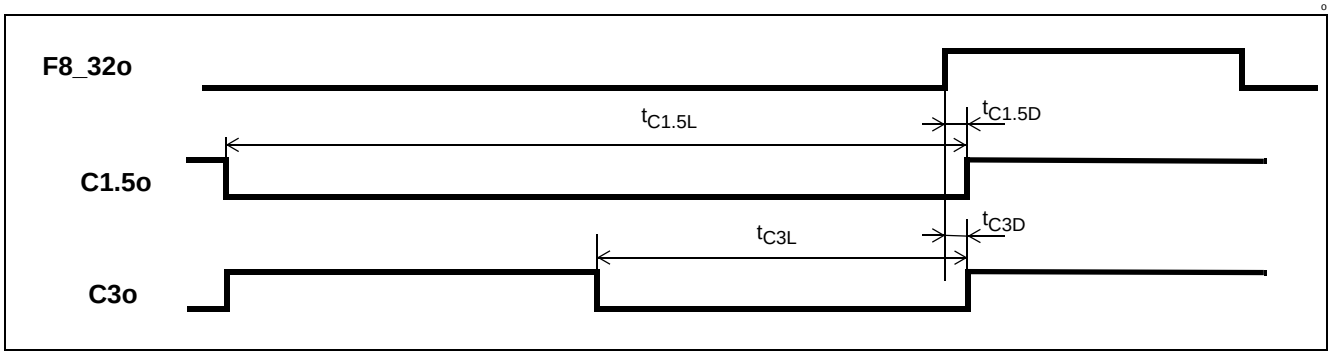


Figure 26 - DS1 Output Timing Referenced to F8/F32o

AC Electrical Characteristics* - SDH output timing (see Figure 27).

	Characteristics	Sym.	Min.	Max.	Units	Notes
1	C19o delay	t_{C19D}	-1.0	0.5	ns	outputs loaded with 30 pF
2	C19o pulse width low	t_{C19L}	25.0	25.8	ns	
3	F2ko delay	t_{F2kD}	25.0	26.6	ns	
4	F2ko pulse width high	t_{F2kH}	51.1	51.8	ns	
5	Output clock and frame pulse rise time	t_{OR}	1.1	2.0	ns	
6	Output clock and frame pulse fall time	t_{OF}	1.2	2.3	ns	

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

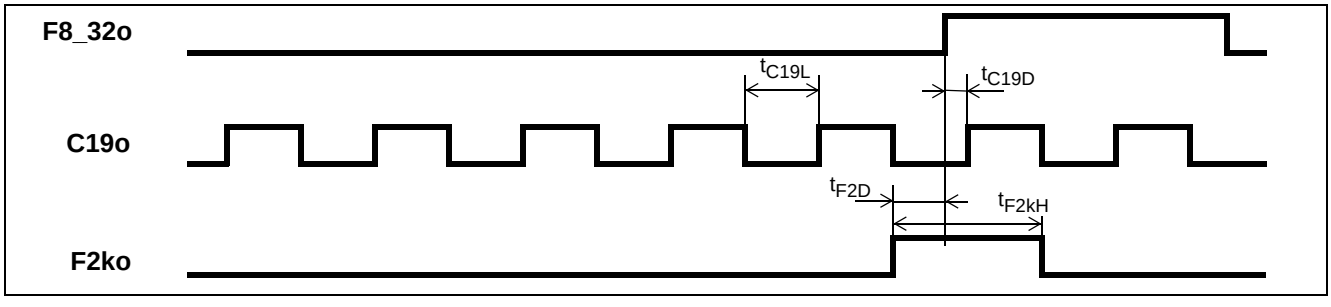


Figure 27 - SDH Output Timing Referenced to F8/F32o

AC Electrical Characteristics* - DS2, E2, E3 and DS3 Output Timing (see Figure 28).

	Characteristics	Sym.	Min.	Max.	Units	Notes
1	C6o delay	t_{C6D}	-0.70	0.70	ns	outputs loaded with 30 pF
2	C6o pulse width low	t_{C6L}	78.5	79.3	ns	
3	C8.4o delay	$t_{C8.4D}$	-0.8	0.8	ns	
4	C8.4o pulse width low	$t_{C8.4L}$	58.4	59.2	ns	
5	C34o delay	t_{C34D}	-0.5	0.5	ns	
6	C34o pulse width low	t_{C34L}	13.5	14.6	ns	
7	C44o delay	t_{C44D}	-1.0	0.5	ns	
8	C44o pulse width low	t_{C44L}	10.4	11.2	ns	
9	Output clock and frame pulse rise time	t_{OR}	1.1	2.0	ns	
10	Output clock and frame pulse fall time	t_{OF}	1.2	2.3	ns	

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

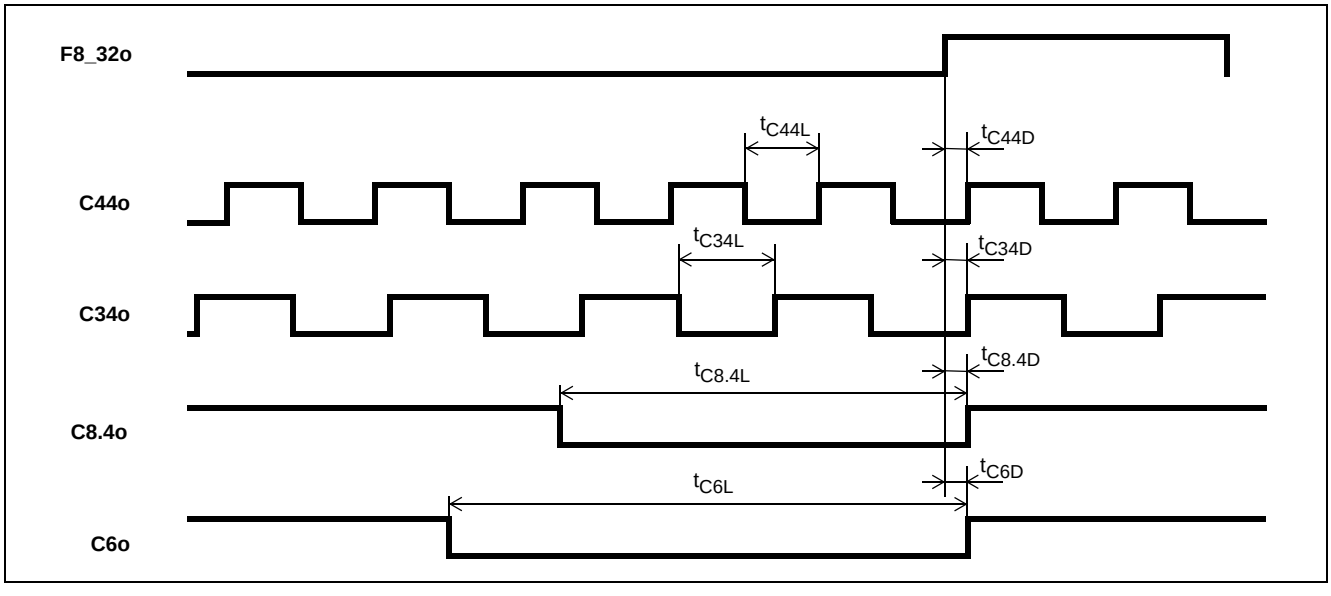


Figure 28 - DS3, E3, E2 and DS2 Output Timing Referenced to F8/F32o

AC Electrical Characteristics* - OSCi 20 MHz Master Clock Input

	Characteristics	Min.	Max.	Units	Notes
1	Oscillator Tolerance - DS1/E1	-32	+32	ppm	
2	Oscillator Tolerance - Derived DS1	-4.6	+4.6	ppm	
3	Oscillator Tolerance - DS2/DS3/E2/E3 SONET/SDH	-20	+20	ppm	
4	Duty cycle	40	60	%	
5	Rise time		10	ns	
6	Fall time		10	ns	

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

7.2 Performance Characteristics

Performance Characteristics* - Functional

	Characteristics	Min.	Max.	Units	Notes
1	Holdover accuracy		0.01	ppm	
2	Holdover stability		0	ppm	Determined by stability of the 20 MHz master clock oscillator
3	Freerun accuracy		0	ppm	Determined by accuracy of the 20 MHz master clock oscillator
4	Capture Range	-130	+130	ppm	The 20 MHz master clock oscillator set at 0 ppm
Reference Out of Range Threshold (including hysteresis)					
5	DS1/E1 (APP_SEL=00)	-64 -83	+64 +83	ppm	The 20 MHz master clock oscillator set at 0 ppm
6	Derived DS1 (APP_SEL=01)	-9.2 -12	+9.2 +12	ppm	The 20 MHz master clock oscillator set at 0 ppm
7	DS2/DS3/E2/E3 (APP_SEL=10), SONET/SDH (APP_SEL=11)	-40 -52	+40 +52	ppm	The 20 MHz master clock oscillator set at 0 ppm
Lock Time					
8	All Application modes, 2 kHz reference (14 Hz filter)	1.5	1.5	s	±9.2 to ±64 ppm frequency offset, HMS=1, TIE_CLR=1 and BW_SEL=0
9	DS1/E1 (APP_SEL=00) 8 kHz and greater reference frequencies (29 Hz filter)	1	1	s	±64 ppm frequency offset, HMS=1, TIE_CLR=1 and BW_SEL=0.
10	Derived DS1 (APP_SEL=01) 8 kHz and greater reference frequencies (29 Hz filter)	1	1	s	±9.2 ppm frequency offset, HMS=1, TIE_CLR=1 and BW_SEL=0

Performance Characteristics* - Functional (continued)

	Characteristics	Min.	Max.	Units	Notes
11	DS2/DS3/E2/E3 (APP_SEL=10) 8 kHz and greater reference frequencies (29 Hz filter)	1	1	s	±40 ppm frequency offset, HMS=1, TIE_CLR=1 and BW_SEL=0
12	SONET/SDH (APP_SEL=11) 8 kHz and greater reference frequencies (29 Hz filter)	1	1	s	±9.2 ppm frequency offset, HMS=1, TIE_CLR=1 and BW_SEL=0
13	BW_SEL=1, all Application modes, all reference frequencies	1	1	s	Up to ±64 ppm frequency offset, HMS=1, TIE_CLR=1 and BW_SEL=1
	Output Phase Continuity (MTIE)				
14	Reference switching		13	ns	TIE_CLR=1
15	Switching from Normal mode to Holdover mode		0	ns	
16	Switching from Holdover mode to Normal mode		13	ns	TIE_CLR=1 and HMS=1
	Output Phase Slope				
17	DS1/E1 (APP_SEL=00), DS2/DS3/E2/E3 (APP_SEL=10)		61	µs/s	
18	SONET/SDH (APP_SEL=11)		7.5	µs/s	
19	Derived DS1 (APP_SEL=01)		9.5	ms/s	

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

Performance Characteristics*: Input Wander and Jitter Tolerance Conformance

	Input reference frequency	Standard	Interface
1	1.544 MHz	Telcordia GR-1244-CORE	DS1 Line timing, DS1 External timing
2	2.048 MHz	ITU-T G.823	2048 kbit/s
3	19.44 MHz	ITU-T G.813	Option 1

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

Performance Characteristics*: Output Jitter Generation - ANSI T1.403 conformance

	Signal	ANSI T1.403 Jitter Generation Requirements			ZL30106 maximum jitter generation	Units
		Jitter measurement filter	Limit in UI	Equivalent limit in the time domain		
DS1 Interface						
1	C1.5o (1.544 MHz)	8 kHz to 40 kHz	0.07 UI_{pp}	45.3	0.30	ns_{pp}
2		10 Hz to 40 kHz	0.5 UI_{pp}	324	0.32	ns_{pp}

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

Performance Characteristics*: Output Jitter Generation - ITU-T G.747 conformance

	Signal	ITU-T G.747 Jitter Generation Requirements			ZL30106 maximum jitter generation	Units
		Jitter measurement filter	Limit in UI	Equivalent limit in the time domain		
DS2 Interface						
1	C6o (6.312 MHz)	10 Hz to 60 kHz	0.05 UI_{pp}	7.92	0.20	ns_{pp}

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

Performance Characteristics*: Output Jitter Generation - ITU-T G.812 conformance

	Signal	ITU-T G.812 Jitter Generation Requirements			ZL30106 maximum jitter generation	Units
		Jitter measurement filter	Limit in UI	Equivalent limit in the time domain		
E1 Interface						
1	C2o (2.048 MHz)	20 Hz to 100 kHz	0.05 UI_{pp}	24.4	0.36	ns_{pp}

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

Performance Characteristics*: Measured Output Jitter - GR-253-CORE and T1.105.03 conformance

	Signal	Telcordia GR-253-CORE and ANSI T1.105.03 Jitter Generation Requirements			ZL30106 maximum jitter generation	Units
		Jitter Measurement Filter	Limit in UI (1 UI = 6.4 ns)	Equivalent limit in time domain		
OC-3 Interface						
1	C19o	65 kHz to 1.3 MHz	0.15 UI_{pp}	0.96	0.22	ns_{pp}
2		12 kHz to1.3 MHz (Category II)	0.1 UI_{pp}	0.64	0.22	ns_{pp}
			0.01 UI_{rms}	64	24	ps_{rms}
3		500 Hz to 1.3 MHz	1.5 UI_{pp}	9.65	0.22	ns_{pp}

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

Performance Characteristics*: Measured Output Jitter - G.813 conformance (Option 1 and Option 2)

	Signal	ITU-T G.813 Jitter Generation Requirements			ZL30106 maximum jitter generation	Units
		Jitter Measurement Filter	Limit in UI (1 UI = 6.4 ns)	Equivalent limit in time domain		
STM-1 Option 1 Interface						
1	C19o	65 kHz to 1.3 MHz	0.1 UI_{pp}	0.64	0.22	ns_{pp}
2		500 Hz to 1.3 MHz	0.5 UI_{pp}	3.22	0.22	ns_{pp}
STM-1 Option 2 Interface						
3	C19o	12 kHz to1.3 MHz	0.1 UI_{pp}	0.64	0.22	ns_{pp}

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

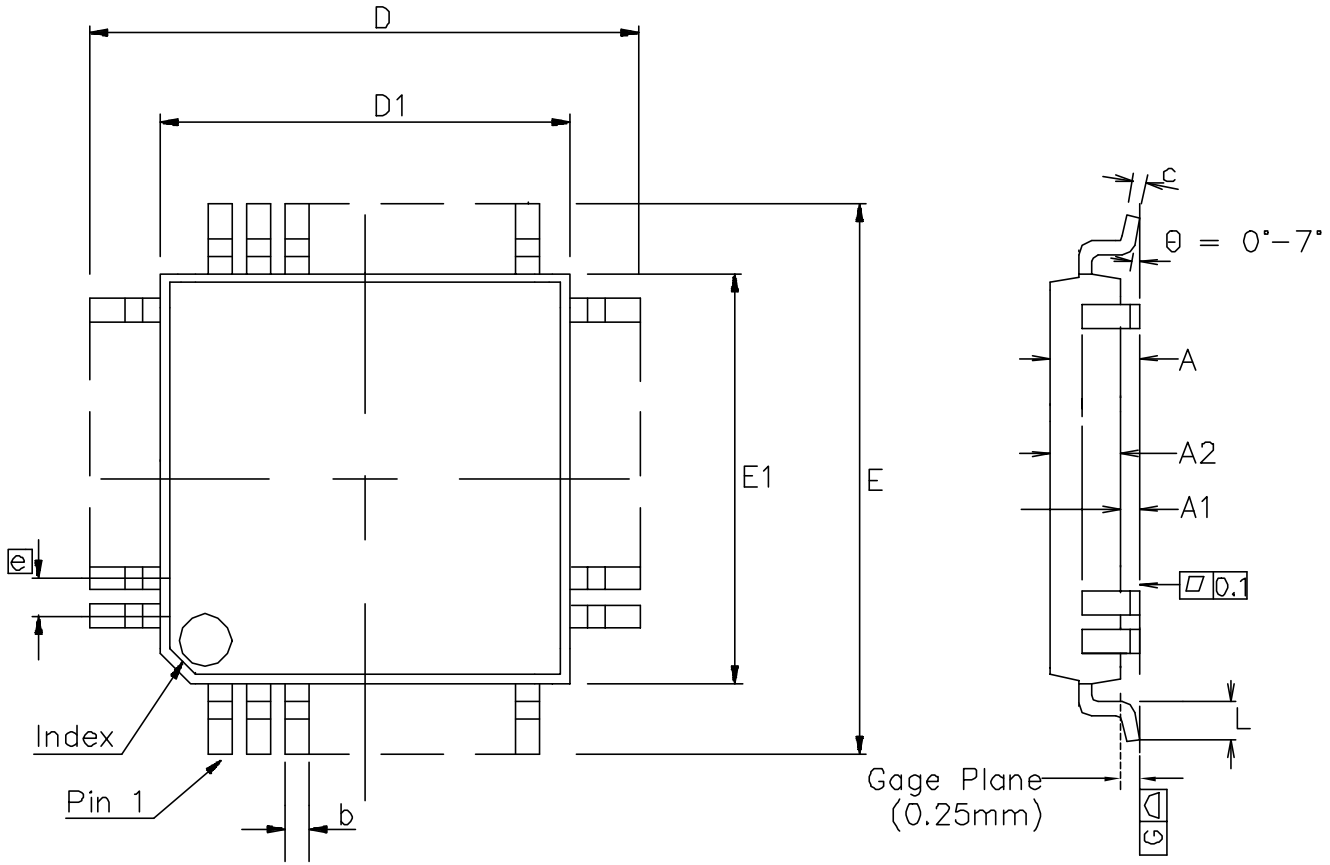
Performance Characteristics* - Unfiltered Jitter Generation

	Characteristics	Max. [ns_{pp}]	Notes
1	C1.5o (1.544 MHz)	0.45	
2	C2o (2.048 MHz)	0.47	
3	C3o (3.088 MHz)	0.53	
4	$\overline{C4o}$ (4.096 MHz)	0.42	
5	C6o (6.312 MHz)	0.58	
6	C8o (8.192 MHz)	0.42	
7	C8.4o (8.448 MHz)	0.55	
8	$\overline{C16o}$ (16.384 MHz)	0.56	
9	C19o (19.44 MHz)	0.42	
10	C32o (32.768 MHz)	0.46	
11	C34o (34.368 MHz)	0.56	
12	C44o (44.736 MHz)	0.60	
13	$\overline{C65o}$ (65.536 MHz)	0.49	
14	F2ko (2 kHz)	0.40	
15	$\overline{F4o}$ (8 kHz)	0.43	
16	F8o (8 kHz)	0.43	
17	$\overline{F16o}$ (8 kHz)	0.44	
18	F32o (8 kHz)	0.43	
19	$\overline{F65o}$ (8 kHz)	0.46	

* Supply voltage and operating temperature are as per Recommended Operating Conditions.

8.0 References

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Symbol	Control Dimensions in millimetres			Altern. Dimensions in inches	
	MIN	MAX		MIN	MAX
A	---	1.20		---	0.047
A1	0.05	0.15		0.002	0.006
A2	0.95	1.05		0.037	0.041
D	12.00 BSC			0.472 BSC	
D1	10.00 BSC			0.394 BSC	
E	12.00 BSC			0.472 BSC	
E1	10.00 BSC			0.394 BSC	
L	0.45	0.75		0.018	0.030
e	0.50 BSC			0.020 BSC	
b	0.17	0.27		0.007	0.011
c	0.09	0.20		0.004	0.008
	Pin features				
N	64				
ND	16				
NE	16				
NOTE	SQUARE				

Conforms to JEDEC MS-026 ACD Iss. C

Notes:

1. Pin 1 indicator may be a corner chamfer, dot or both.
2. Controlling dimensions are in millimeters.
3. The top package body size may be smaller than the bottom package body size by a max. of 0.15 mm.
4. Dimension D1 and E1 do not include mould protrusion.
5. Dimension b does not include dambar protusion.
6. Coplanarity, measured at seating plane G, to be 0.08 mm max.

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ZARLINK SEMICONDUCTOR

Previous package codes

TP/TH

Package Code QD/QG

Package Outline for 64 Lead TQFP 10x10x1.0mm, +2.0mm (footprint)

GPD00450



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