

## Features

### • One, Two or Three DPLL Channels

- Packet and/or physical-layer frequency, phase and time synchronization
- Physical-layer compliance with ITU-T G.8262, G.813, G.812, Telcordia GR-1244, GR-253
- Packet-timing compliance with ITU-T G.8261, G.8263, G.8273.2, G.8273.4
- Enables 5G wireless applications with sub-100ns time/phase alignment requirements
- Programmable bandwidth, 0.1mHz to 470Hz
- Hitless reference switching and mode switching
- High-resolution holdover averaging
- Programmable phase slope limit for transients, down to 1 ns/s
- Per-DPLL phase adjustment, 1ps resolution

### • Input Clocks

- Accepts up to 10 differential or CMOS inputs
- Any input frequency from 0.5Hz to 900MHz
- Per-input activity and frequency monitoring
- Automatic or manual reference switching
- Fast lock to 1 PPS input, <30 seconds
- Any input can be a 1PPS SYNC input for REF+SYNC frequency/phase/time locking
- Any input can be a clock with embedded 1PPS
- Per-input phase adjustment, 1ps resolution

### • Output Clock Frequency Generation

- Any output frequency from <0.5Hz to 1045MHz (180MHz max for Synth0)
- High-resolution fractional frequency conversion with 0ppm error
- Synthesizers 1 & 2 have integer and fractional dividers to make a total of 5 frequency families
- Output jitter from Synths 1 & 2 is <0.3ps RMS
- Output jitter from fractional dividers is typically < 1ps RMS, many frequencies <0.5ps RMS
- Each HPOUTP/N pair can be LVDS, LVPECL, HCSL, 2xCMOS, HSTL or programmable diff.
- Four output banks each with VDDO pin; CMOS output voltages from 1.5V to 3.3V
- Per-synthesizer phase adjust, 1ps resolution

## Ordering Information

ZL30771LFG7	1-Channel	80-lead LGA	Trays
ZL30772LFG7	2-Channel	80-lead LGA	Trays
ZL30773LFG7	3-Channel	80-lead LGA	Trays

Matte Tin

Package size: 11 x 11 mm

-40°C to +85°C

- Per-output programmable duty cycle
- Precise output alignment circuitry and per-output phase adjustment
- Per-output enable/disable and glitchless start/stop (stop high or low)
- **Local Oscillator**
  - Operates from a single TCXO or OCXO: 23.75-25MHz, 47.5-50MHz, 114.285-125MHz
  - Very-low-jitter applications can connect a TCXO or OCXO as the stability reference and a low-jitter XO as the jitter reference
- **General Features**
  - Automatic self-configuration at power-up from internal Flash memory
  - Input-to-output alignment <2ns
  - Internal compensation (1ppt) for local oscillator frequency error in DPLLs and input monitors
  - Numerically controlled oscillator behavior in each DPLL and each fractional output divider
  - Programmable Time of Day counters
  - Easy-to-configure design requires no external VCXO or loop filter components
  - 7 GPIO pins with many possible behaviors
  - SPI or I<sup>2</sup>C processor Interface
  - 1.8V and 3.3V core VDD voltages
  - Power: 1.3W for 2 inputs, 1 synth, 6 LVDS out
  - Easy-to-use evaluation/programming software
  - Factory programmable power-up configuration

## Applications

- Central system timing ICs for SyncE and/or IEEE 1588, SONET/SDH, OTN, wireless base station and other carrier-grade systems
- G.8262/813 EEC/SEC, Telcordia Stratum 2-4

## 1. Block Diagram

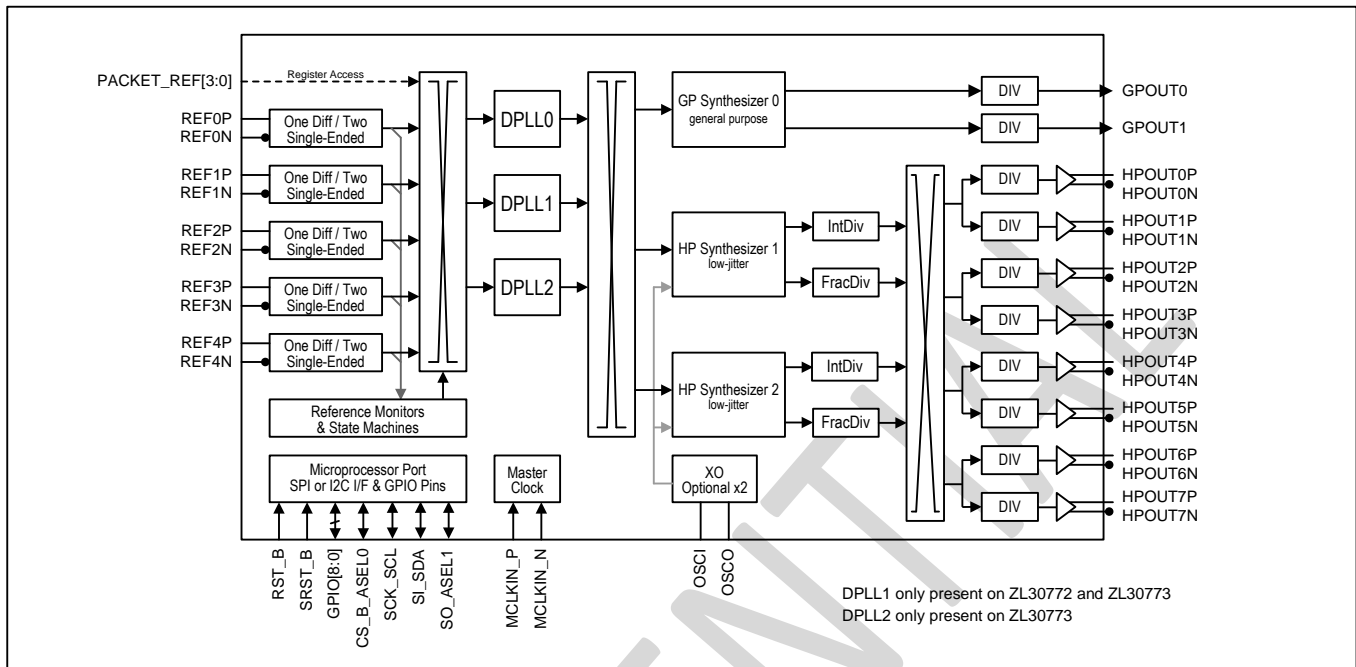


Figure 1 - Functional Block Diagram

## 2. Application Example

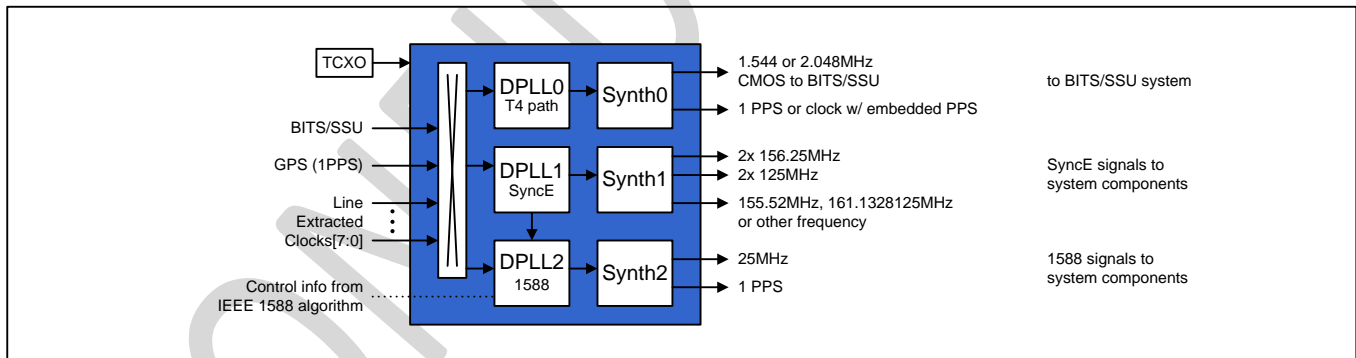


Figure 2 - Synchronous Ethernet and IEEE 1588 Central Timing Application

### 3. Detailed Features

#### 3.1 Input Block Features

- Ten input reference pins; each can accept a CMOS signal or the POS side of a differential pair; or two can be paired to accept both sides of a differential pair
- Any input can be a SYNC signal for REF+SYNC frequency/phase/time locking
- Any input can be a clock signal with embedded PPS signal (duty cycle distortion indicates PPS location)
- Input clocks can be any frequency from 0.5Hz up to 900MHz (180MHz max for CMOS inputs)
- Supported telecom frequencies include PDH, SDH, Synchronous Ethernet, OTN, wireless
- Inputs constantly monitored by programmable frequency and single-cycle monitors
- Single-cycle monitor can quickly disqualify a reference when measured period is incorrect
- Frequency measurement (ppb or Hz) and monitoring (coarse, fine, and frequency-step monitors)
- Optional input clock invalidation on GPIO assertion to react to LOS signals from PHYs
- Input-to-input phase measurement, 1ps resolution
- Input-to-DPLL phase measurement, 1ps resolution
- Per-input phase adjustment, 1ps resolution

#### 3.2 DPLL Features

- One, two or three full-featured DPLLs
- Very high-resolution DPLL architecture
- State machine automatically transitions among freerun, tracking and holdover states
- Revertive or nonrevertive reference selection algorithm
- Programmable bandwidth from 0.1mHz to 470Hz
- Less than 0.1dB gain peaking
- Fast frequency/phase/time lock capability for PPS and clock+PPS input references
- Programmable phase-slope limiting (PSL)
- Programmable frequency rate-of-change limiting (FCL)
- Programmable tracking range (i.e. hold-in range)
- Truly hitless reference switching and mode switching
  - Physical-to-physical reference switching
  - Physical-to-packet reference switching
  - Packet-to-physical reference switching
  - Packet-to-packet reference switching
- Per-DPLL phase adjustment, 1ps resolution
- High-resolution frequency and phase measurement
- Fast detection of input clock failure and transition to holdover mode
- High-resolution holdover frequency averaging, better than 0.01ppb when using <10mHz filter
- Time-of-Day registers: 48-bit seconds, 32-bit nanoseconds, writeable on input PPS edge

#### 3.3 Synthesizer Features

- Any-to-any frequency conversion with 0ppm error
- Two low-jitter synthesizers (Synth1, Synth2) with very high-resolution fractional scaling (i.e. non-integer multiplication)
- Two output dividers per low-jitter synthesizer: one integer (4 to 15 plus half divides 4.5 to 7.5) and one 40-bit fractional
- One general-purpose synthesizer (Synth0)
- A total of five output frequency families
- Easy-to-configure, completely encapsulated design requires no external VCXO or loop filter components

#### 3.4 Low-Jitter Output Clock Features

- Up to 16 single-ended outputs (up to 8 differential outputs) from Synth1 and Synth2
- Each output can be one differential output or two CMOS outputs
- Output clocks can be any frequency from 0.5Hz to 1045MHz (250MHz max for CMOS and HSTL)

- Output jitter from Synth1 and Synth2 integer dividers is <0.3ps RMS
- Output jitter from fractional dividers is <1ps RMS, many frequencies <0.5ps RMS
- In CMOS mode, the HPOUTxN frequency can be an integer divisor of the HPOUTxP frequency (Example 1: HPOUT3P 125MHz, HPOUT3N 25MHz. Example 2: HPOUT2P 25MHz, HPOUT2N 1Hz)
- Outputs directly interface (DC coupled) with LVDS, LVPECL, HSTL, HCSL and CMOS components
- Supported telecom frequencies include PDH, SDH, Synchronous Ethernet, OTN
- Can produce clock frequencies for microprocessors, ASICs, FPGAs and other components
- Can produce PCIe clocks
- Sophisticated output-to-output phase alignment
- Per-synthesizer phase adjustment, 1ps resolution
- Per-output phase adjustment
- Per-output duty cycle / pulse width configuration
- Per-output enable/disable
- Per-output glitchless start/stop (stop high or low)

### 3.5 General-Purpose Output Clock Features

- Two CMOS outputs from Synth0
- Any frequency from 0.5Hz to 180MHz
- Output jitter is typically 20-30ps
- Useful for applications where the component or system receiving the signal has low bandwidth such as a central timing IC
- Can output a clock signal with embedded PPS (ePPS) (duty cycle distortion indicates PPS location)

### 3.6 Local Oscillator

- Operates from a single low-cost XO (jitter reference for the device). Acceptable frequencies: 23.75MHz to 25MHz, 47.5MHz to 50MHz, 114.285MHz to 125MHz. Best jitter:  $\geq 48$ MHz.
- Very-low-jitter applications can connect a TCXO or OCXO (any frequency, any output jitter) as the stability reference and a low-cost low-jitter XO as the jitter reference
- This ability to have separate jitter and stability references greatly reduces the cost of the TCXO or OCXO (no jitter requirement, no high-frequency-requirement) and allows reuse of already-qualified TCXO and OCXO components
- Supports redundant TCXOs connected to two REF pins

### 3.7 General Features

- Automatic self-configuration at power-up from internal Flash memory
- Input-to-output alignment <200ps with external feedback
- Fast REF+SYNC locking for frequency and 1PPS phase alignment with lower-cost oscillator
- Generates output SYNC signals: 1PPS (IEEE 1588), 2kHz or 8kHz (SONET/SDH) or other frequency
- Internal compensation for local oscillator frequency error in DPLLs and input monitors, 1ppt resolution
- Numerically controlled oscillator (NCO) behavior allows system software to steer DPLL frequency or fractional output divider frequency with resolution better than 0.005ppt
- Spread-spectrum modulation available in each fractional output divider (PCIe compliant)
- Seven general-purpose I/O pins each with many possible status and control options
- SPI or I<sup>2</sup>C serial microprocessor interface

### 3.8 Evaluation Software

- Simple, intuitive Windows-based graphical user interface
- Supports all device features and register fields
- Makes lab evaluation of the device quick and easy
- Generates configuration scripts to be stored in internal Flash memory
- Generates full or partial configuration scripts to be run on a system processor
- Works with or without an evaluation board

### 3.9 Packet Time Synchronization

The Time Synchronization Algorithm is suitable for use in a wide variety of markets and applications, including the following IEEE 1588-2008 Profiles:

- Annex J.3 Delay Request-Response Default Profile
- Annex J.4 Peer-to-peer Default Profile
- ITU-T G.8265.1 Telecom Profile for Frequency Synchronization
- ITU-T G.8275.1 Telecom Profile for Phase with Full Timing Support Networks
- ITU-T G.8275.2 Telecom Profile for Phase with Partial Timing Support Networks
- CableLabs CM-SP-RDTI Remote DTI Profile
- SMPTE ST-2059-2 Professional Broadcast Environment Profile
- IEEE C37.238 Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications.
- IEC 61850-9-3 Power Utility Automation Profile
- IEEE802.1as AVB-TSN gPTP
- IEEE 1588-2017 Annex J.5 High Accuracy Profile (based on White Rabbit)
- IETF TICTOC Enterprise Profile

#### 3.9.1 Application Targets

The Time Synchronization Algorithm is suitable for many end application targets:

- Frequency accuracy performance for GSM, WCDMA-FDD, LTE-FDD femtocell, small cell (residential, urban, rural, enterprise), picocell and macrocell applications, with target performance less than  $\pm 15$  ppb.
- Frequency performance for ITU-T G.823 and G.824 synchronization interface, as well as G.8261 PNT EEC, PNT PEC and CES interface specifications.
- Phase Synchronization performance for WCDMA-TDD, Mobile WiMAX, TD-SCDMA, CDMA2000, LTE-TDD and LTE-A femtocell, small cell (residential, urban, rural, enterprise), picocell and macrocell applications with target performance less than  $\pm 1$   $\mu$ s phase alignment.
- Time Synchronization for TAI, UTC-traceability and GNSS/GPS replacement.

#### 3.9.2 Packet Networks

The Time Synchronization Algorithm is suitable for high performance over a variety of packet networks:

- ITU-T G.8261 Appendix VI
- ITU-T G.8261.1 network limit compliant
- ITU-T G.8271.1 network limit compliant
- ITU-T G.8271.2 (draft) network limit compliant
- Native Ethernet (switched) & IP (routed) networks
- xDSL
- Microwave
- Fully aware, partially aware and unaware timing supported networks
- Networks including intermediate Boundary Clocks and Transparent Clocks
- Networks with and without SyncE or frequency physical layer support

#### 3.9.3 Clock Specifications

The Time Synchronization Algorithm is suitable to address a variety of standardized clock specifications, including:

- ITU-T G.8263 PEC-S
- ITU-T G.8273.2 T-BC full on-path without SyncE
- ITU-T G.8273.2 T-BC full on-path with SyncE
- ITU-T G.8273.2 T-TSC full on-path without SyncE
- ITU-T G.8273.2 T-TSC full on-path with SyncE
- ITU-T G.8273.4 T-BC-P (draft)
- ITU-T G.8273.4 T-TSC-A (draft)
- ITU-T G.8273.4 T-TSC-P (draft)

### 3.9.4 Monitoring and Redundancy

The Time Synchronization Algorithm includes monitoring and redundancy for high availability synchronization, including:

- Synchronization to the best available Server
- Client monitoring of secondary Server references
- Monitoring includes full time synchronization reporting of secondary Server
- Supports a programmable number of secondary Server connections
- Hitless reference switching between multiple Servers
- Holdover when Server packet connectivity is lost
- TIE clear option to build out, or clear, phase offsets between Server references

### 3.9.5 General

The Time Synchronization Algorithm includes many advanced features to aid in high-accuracy and high-stability applications, including:

- Full PLL state machine (Freerun, Holdover, Frequency Lock Acquiring, Frequency Lock Acquired, Phase Lock Acquired), with programmable thresholds for state transitions
- Programmable, non-linear packet selection with PDV suppression
- Programmable bandwidth configurability from sub-mHz to hundreds of mHz.
- Programmable packet rates from 1 packet/second to over 128 packets/second
- Programmable phase slope limiting, down to 1 ns/s
- Programmable frequency change limiting, down to 1 ppb/s
- Warm start to initialize or seed the Time Synchronization Algorithm from a stored or last-known-good frequency offset to improve convergence
- Programmable thresholds for management of phase errors - when to adjust with frequency offsets and when to adjust with phase jumps
- User ability to manually add frequency offsets due to temperature or ageing (especially during holdover state)

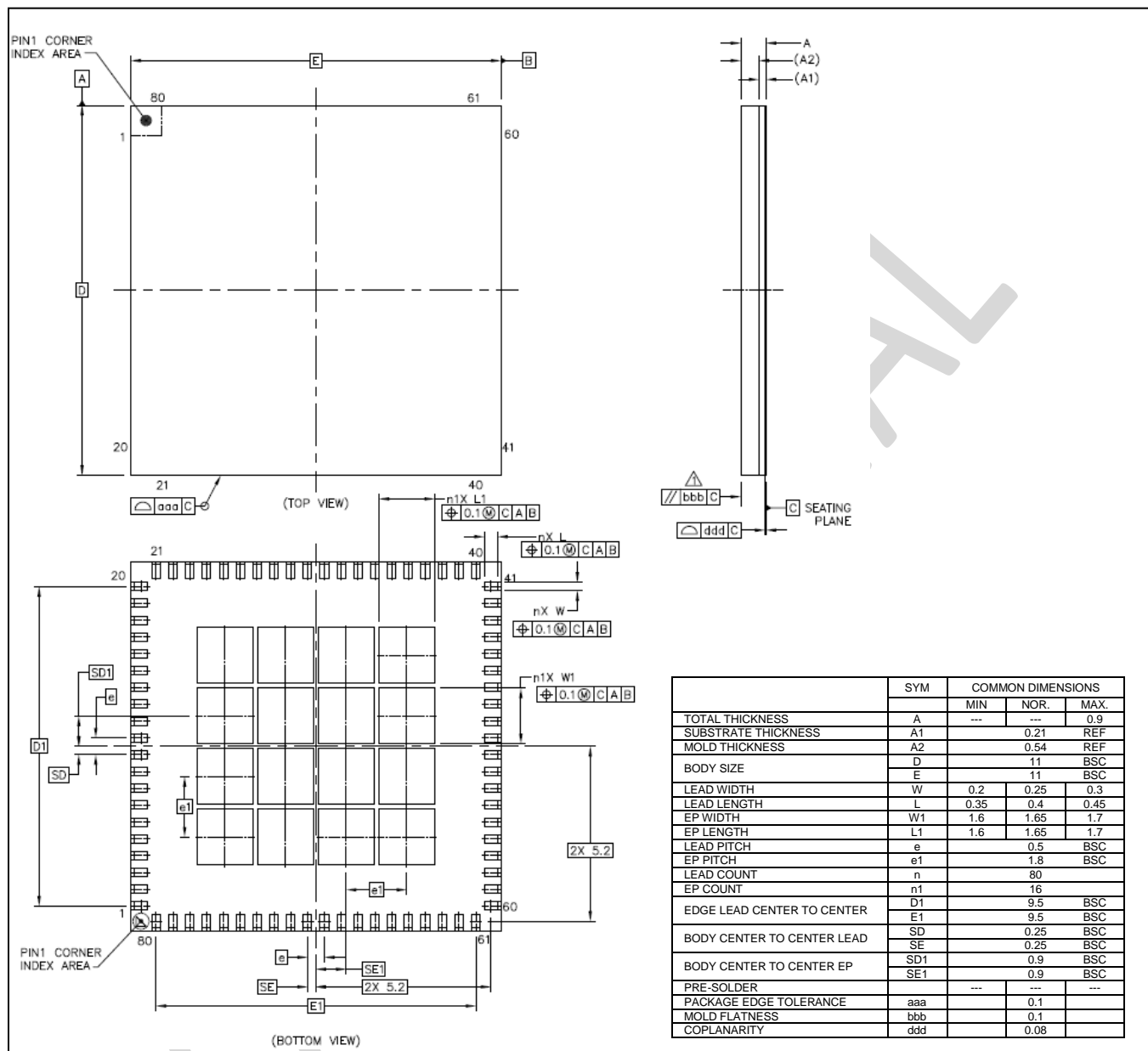
### 3.9.6 Reporting

The Time Synchronization Algorithm includes user reporting to aid in performance debugging, including:

- Set of user notifications about packet network events, such as packet loss, small transient phase jumps, large transient phase jumps, outliers, network path re-routes
- Set of metrics related to the synchronization, such as frequency stability and phase stability
- Independent reporting of the forward path and reverse path lock status
- Oscillator stability analysis for excessive ageing or temperature variation
- Server tracking impairments such as pull-in range exceeded



#### 4. Package Outline Drawing





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