

## Description

Equities, futures, and options exchanges; market makers; hedge funds; and traders require real-time knowledge of the best bid and ask prices for the instruments that they trade. Algo-Logic Systems' Full Order Book is an FPGA hardware accelerator with the entire feed processing module and Order Book implemented in logic. Algo-Logic Systems' single-FPGA platform architecture achieves deterministic, ultra low latency without jitter regardless of the number of tracked symbols at data rates of up to 10 Gbps.

The L-3 Order Book provides traders the best opportunity to receive real-time information about the trading activity on their exchange by taking advantage of the exchange's market data feeds that offer the highest level of transparency. The Order Book works on incremental L-3 update messages that come in as part of the market data feed over UDP/IP Multicast.

The Full Order Book performs all book building processing and reporting as logic inside a single FPGA. The low latency order book is designed using the on-chip memory for customer book sizes with many thousands of open orders, a dozen symbols, and reporting of ten L-2 levels. For use cases where millions of open orders and full market depth need to be tracked, the scalable order book is still implemented with a single FPGA but stores data in off-chip DDR3 memory.

Moreover, the Full Order Book can be seamlessly integrated with all existing components of Algo-Logic Systems' low latency application library, including pre-built protocol parsing libraries, market data filtering, and TCP/IP endpoints to deploy complete tick-to-trade applications within a single FPGA platform.

## Applications

- High frequency market makers
- Algorithmic trading systems requiring both complexity and speed
- Exchanges needing jitter-free matching engines
- Highest performance tick-to-trade systems
- Low latency feed distributions needing to minimize bandwidth utilization
- Arbitrage opportunity discovery in the nanosecond timescale

## Key Features and Use Cases

- Full Order Book with a L-2 default size of 10 price-levels per symbol, fully scalable to larger sizes
- Depth of L-2 price-level snapshots runtime configurable between 1 (BBO) and 30 deep, by the user via the application programming interface
- By default L-2 snapshots are generated for each symbol. The number of symbols in use and their respective snapshots are user configurable. L-2 snapshot generation frequency is also user configurable
- Full Order Book output logic seamlessly connects to customer's proprietary algorithmic trading strategies
- Full Order Book building process includes
  - I. Receiving parsed market data feed messages
  - II. Building and maintaining L-3 order level replica of the exchange's displayable book
  - III. Building L-2 books for each symbol with the market depth and weight summary of all open orders
  - IV. Reporting locally generated copy of the top-of-book with configurable amount of market depth (L-2 snapshots) as well as the last trade information when orders execute

## Full Order Book Metrics

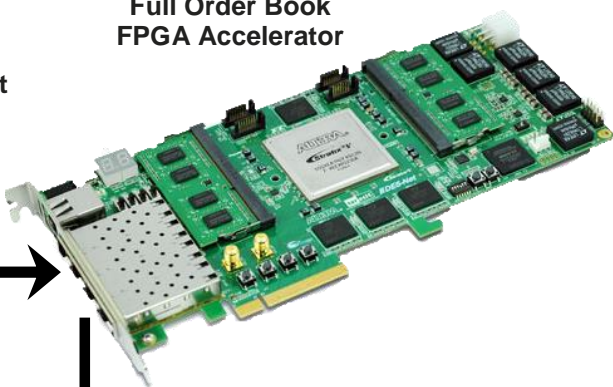
L-2 Snapshot Generation	On change of top levels of book, peak rate user configurable
L-2 Price Levels	Provided in snapshot from 1 to 30 levels, user configurable
Maximum L-3 Table Depth	3k (default) and up to 96k on-chip; 100k+ off-chip DDR3/QDR11 memory
Order Book Update Message Rate	4 million add/delete incremental order book update messages per second
Number of symbols	12 (default) and up to 80 on-chip
Platforms supported	Terasic DE5-Net, SolarFlare AOE, Nallatech P385, Bittware S5PH-Q, PLDA
Market Data Filtering Latency	180 nanoseconds
L-2 Book Processing Time	Under 120 nanoseconds
L-3 Book Processing Time	Under 230 nanoseconds
Complete Tick-to-Trade Latency	Under NDA

## Full Order Book application with Level-II sample screenshot

The Algo-Logic Systems' Order Book application Level-II sample screenshot is illustrated below. Symbols filtered by the Market Data Filter application are used as input to generate the L-3 and L-2 Order Book.

Market data via 10Gbps Ethernet

Full Order Book FPGA Accelerator



Order Book L-2 snapshots

Order Book: GE

Last Trade Block					
Cur: +23.18		Vol: 3273			
Top of The Order-Book Block					
9	722	23.17	23.18	2261	2
Level-II Price-level Book					
Name	Bid	Size	Name	Ask	Size
Tier 1	23.17	722	Tier 1	23.18	2261
Tier 2	23.16	2325	Tier 2	23.19	861
Tier 3	23.15	1077	Tier 3	23.20	2483
Tier 4	23.14	2202	Tier 4	23.21	1581
Tier 5	23.13	1773	Tier 5	23.22	569
Tier 6	23.12	1771	Tier 6	23.23	1388
Tier 7	23.11	1716	Tier 7	23.24	1558
Tier 8	23.10	2260	Tier 8	23.25	1919
Tier 9	23.09	1193	Tier 9	23.26	2442
Tier 10	23.08	1625	Tier 10	23.27	2460

## Ordering Codes

AL-OB – (Market) (# Symbols) (L3 depth) (Platform) → Example:

- Market (e.g.: NASDAQ ITCH 5.0)
- Number of symbols to monitor = 12, 24, 48, 80+
- Level 3 depth (# of Open Orders) = 3k or 48k on-chip; 100k+ off-chip
- Platform: Terasic DE5Net, SolarFlare AOE, Nallatech P385, Bittware S5PH-Q, PLDA