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EnLight256®

8000 Giga MAC / sec fixed point DSP

Overview

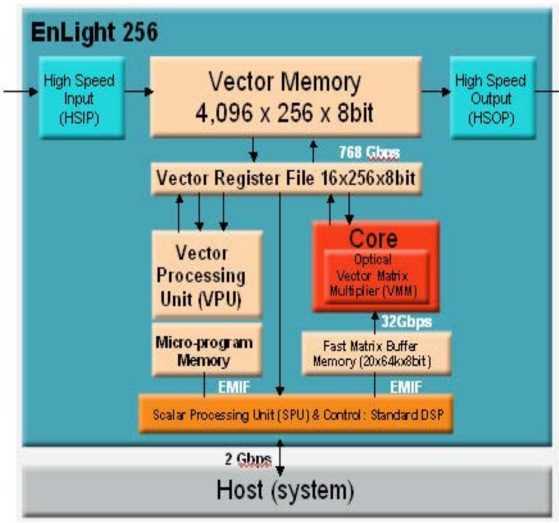
Lenslet Ltd. delivers the first ever Optical DSP (ODSP). The Enlight256® is the first product in a line of ultra-fast Digital Signal Processors, specified to 8-Tera (10^{12}) Multiply Accumulate operations per second. This performance mark is about 3 orders of magnitude better than current state of the art DSP's. The device is based on a 3-core engine: An optical Vector-Matrix Multiplier (VMM), a Vector Digital Processing Unit (VPU), and an off-the-shelf scalar DSP. The Optical core is the prime contributor to the outstanding processing power. All EnLight's interfaces are electronic and standards based.

The EnLight256® is primarily designed for standalone operation, however, it is equally suited to function as a system-embedded accelerator for heavy-duty computational tasks, where fixed-point processor capable of performing vector-vector and vector-matrix operations is most beneficial.

Architecture

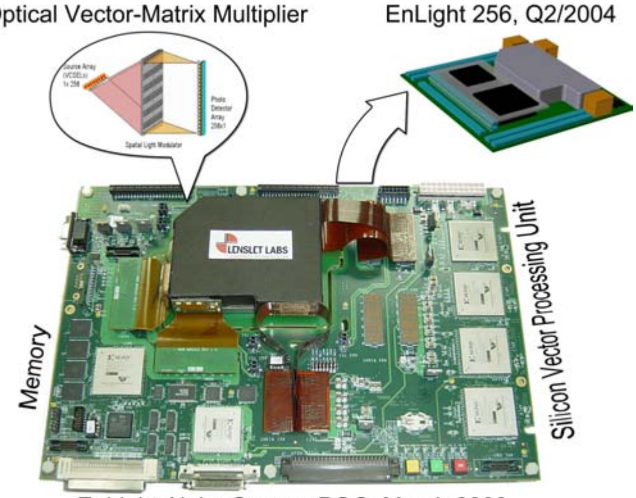
The EnLight256® embodies powerful processing power in a vector-matrix DSP by providing 125 Mega vector-matrix multiplications and 500 Mega vector-vector operations per second. Matrix size is 256x256 and vector size is 256 elements.

For optimal utilization of the processing potential of the optical core, the EnLight256 architecture is comprised of several processing layers. The optical core performs a 256 8-bit element vector by a 256x256 8-bit element matrix multiplication in a single clock cycle. In order to implement a complete algorithm, vector-vector and scalar processing are also required.



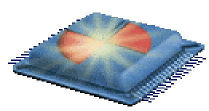
The EnLight256 is in particular beneficial to computation intensive tasks, and since it is fully software programmable it poses a worthy alternative for replacing several DSP boards and ASIC (or FPGA's) boards alike. The flexibility of a fully (on-the-fly) programmable device and the associated scalability in harnessing the power of more than a single such device make the EnLight256® a premium processing solution that can cope with tasks beyond the capabilities of other competing technologies while providing a "Future Proof" platform.

Optical Vector-Matrix Multiplier EnLight 256, Q2/2004



EnLight Alpha System POC, March 2003

EnLight Future
Single chip solution



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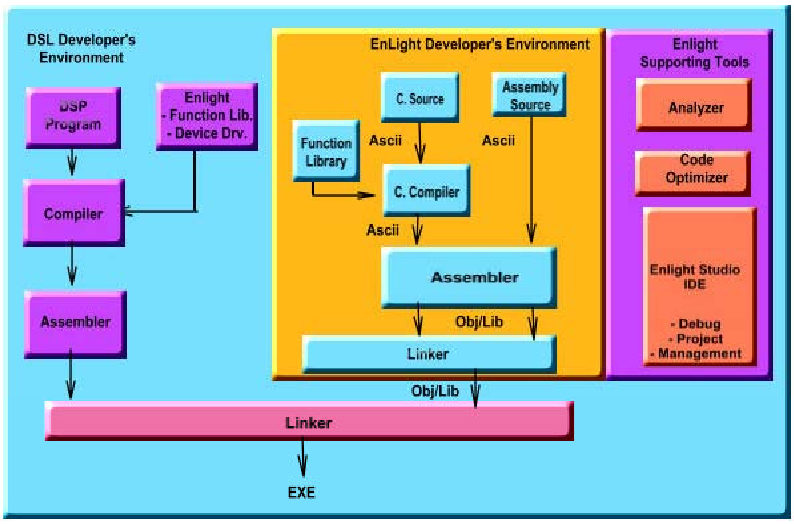
Software Development:

Special care has been taken to make the software development on the EnLight256® platform as similar as possible to the de-facto industrial standards. The EnLight256® utilizes a standard DSP as the interface to the system host and eventually to the programmer. This means, that in most cases, software can be developed on the standard DSP software tools while using the EnLight's function library.

The unique capabilities of the EnLight256® call for specifically designed micro-programmed Instruction Set. EnLight256® instruction set directly supports vector-vector manipulation and computation, as well as vector matrix multiplication. Arithmetic and logical operations between 8-bit and 16-bit vectors are included for real and complex vectors alike. Vector comparisons, shifts and manipulations are included in the instruction set for optimal execution of basic functions as well as application-specific macro-functions.

Ultimately, system developers would like to benefit from the full power of the EnLight256® vector & matrix DSP might. For these, Lenslet has developed a wide range of software tools for the advanced developer. Software can be written on a standard text editor, in the EnLight256® assembly language or in C code, and then assembled and compiled. The result Object code can be then linked to the main program written over the standard off the shelf DSP. This whole process is made possible through the EnLight Studio IDE, which is a fully integrated programming environment.

Software debugging can be done using the EnLight Studio Simulator, over a standard PC. Hardware debugging is possible through the standard JTAG. The EnLight256 Analyzer provides further detailed debugging capability.



Applications

The EnLight256® will serve best any application that can utilize Tera operations per second. For example, in one second the EnLight256® can perform:

- 125,000,000 correlations (each 128 complex 8-bit, 128 length),
- 125,000 parallel FIR filters (1000 samples, 256 filters each of length 256);
- 125,000,000 complex DFT of 128 points;
- 500,000 complex DFT's of 16K points each, etc.

Following is a partial list of applications that are considered natural beneficiaries of said capabilities. Lenslet is leading a constant evaluation of additional applications for the EnLight platform.

Wireless Communications: robust communications, e.g. multi-Spread Spectrum techniques, also including spatial processing through array antennas.

Cellular: Interference cancellation between users (MUD – Multi User Detection) and Smart Antenna algorithms may under certain conditions more than triple system capacity without adding RF hardware. This, of course, is directly translated into lower running costs. In addition, such a system can support of multiple standards and modulation techniques simultaneously. A Lenslet homegrown SA/MUD algorithm is predicted to support more than 200 simultaneous UMTS users. While running conventional demodulating techniques (e.g. Rake receiving) a single EnLight256® is capable to support about 2000 simultaneous non-interfering users.

Software definable radio: A single radio will be able to simultaneously transmit and receive several communication channels of a variety of communication modes. For example this may solve communication problems between different security forces that may be involved in same events.

Real time video compression: H.264 video compression for full quality standard and HDTV transmissions – single and multi channel.

Homeland Security: Improve detection and extraction of image and audio features as well as and other parameters like behavioral analysis, for reliable automated screening of massive amount of data and for identifying potential threats no matter how rare may they be. The EnLight256 architecture is particularly a powerful correlation engine and therefore can significantly improve performance of such systems at an affordable cost (both for the system, and for the staff that needs to screen the suspected threats afterwards). The EnLight256 can be used for *voice analysis, face recognition, image processing*, and other applications.

Radars & Electronic Warfare:
Being able to run long Fourier Transform tasks at a tremendously high pace makes it a natural candidate for advanced **RADAR** applications, e.g. **SAR**. This and the **SDR** capabilities mentioned above may be utilized for **COMINT**, **ELINT** and other **SIGINT** applications. Size and cost of the EnLight256® may allow for implementations in smaller platforms than possible today. Consequently, better performing facilities may be achieved for large installations (including ground installations, airborne, etc.) and adequate performance of this domain may be installed in smaller platforms like guided and autonomous self-propelled weaponry.

Biotechnology: The requirement to correlate gene data and multiply matrices allow biotech calculations to be greatly accelerated by the EnLight platform. Sample applications: Linkage analysis, Hidden Markov Models.

Data Mining: Analysis of large networks requires matrix multiplication and manipulation. Other data mining applications require pattern searches. All these can be accelerated by 3-4 orders of magnitude using the EnLight256® platform as compared to standard processors.

Performance Benchmarks

Function		Lenslet EnLight256 (8,000GMAC)	State of the art DSP (8 GMAC)	Ratio
FIR (1000 samples 128 complex filters 128 taps)	# of Cycles	1,000	8,200,000	X 8200
	Time	8 µSec	8.2 mSec	X1000
Correlator (128 complex of length 128)	# of Cycles	1	1,050,000	x1M
	Time	8 nSec	1.05 mSec	x100K
FFT/DFT (128 complex)	# of Cycles	1	400	X400
	Time	8 nSec	400 nSec	X50
FFT/DFT (16 K samples complex)	# of Cycles	256	100,000	x400
	Time	2 µSec	100 µSec	x50
FFT 32 K samples	# of Cycles	512	200,000	x400
	Time	4.1 µSec	200 µSec	x50
FFT 64 K samples	# of Cycles	1024	450,000	x440
	Time	8.2 µSec	450 µSec	x54

Note (*): This benchmark was calculated based on an extrapolation of published performance data on the competing DSP components as expected to be by the end of 2003.

Technology Highlights

The optical core of the EnLight256 is comprised of lasers, detectors, optical modulators and lenses. In a single clock period (8nsec) it can multiply a 256-byte vector by a 256 x 256 byte matrix. This sums-up to $256 \times 256 \times 125 \times 10^6 = 8 \times 10^{12}$ MAC operations per second.

The figure below depicts the principal design of the optical core. 256 non-coherent lasers that represent a vector of 256 elements, each one 8 bits represent the input vector **X**. A Minimum Quantum Well Spatial Light Modulator of 256 x 256 pixel-modulators on a single miniature chip realizes a 64K simultaneous multipliers (matrix **A**). A column of 256 light-detectors integrated with Analog to Digital Converters, is positioned to receive the beams from the modulator matrix. The output of the detector column is the result vector **Y**.
Each element from vector X is projected on a column in the matrix A. Each row from the matrix A is projected on a single detector in vector Y. The result energy in a detector can be represented in mathematical terms as follows: $Y_i = \sum_{j=0}^{255} X_j \cdot a_{ij}$

The result is a full vector-matrix multiplication in a single clock cycle.

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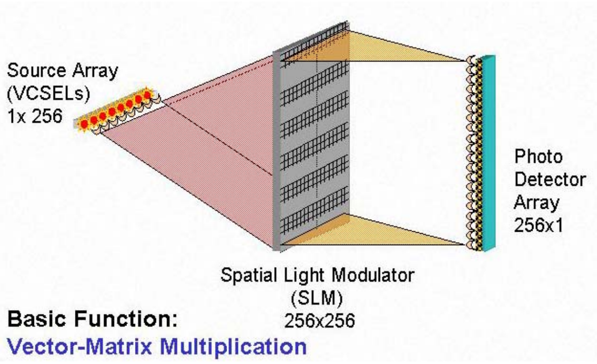

An Optical Vector Matrix Multiplication (VMM) Core

Company Overview:

Lenslet Ltd. is a source for innovative Optical Digital Signal Processors. Lenslet was founded in mid-1999, located in Israel, and has over 30 employees composed of highly experienced physicists, electro-optics specialists, system engineers, and a variety of development & design engineers. Lenslet is privately held and is backed by venture capital firms and financial institutions: Goldman Sachs & Co., Walden, Star Ventures, JK&B Capital, and eXseed Technology Investments.

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