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**SILICON ENGINES** is a full-service electronic design engineering company offering comprehensive electronic engineering, prototyping, testing, manufacturing, and technical marketing services.

Incorporated in 1989, Silicon Engines has been involved in a large number of successful product development projects.

We specialize in **embedded control** applications, products in which a microcontroller and associated digital and analog circuitry yield an automated product solution. We have considerable experience with:

- **Industrial control.**
- **Medical electronics.**
- **Automotive electronics.**
- **Data communications—wired and RF.**
- **Windows CE embedded systems.**

***Silicon Engines is a recognized design consultant in Freescale Semiconductor's Design Alliance program.***

Freescale (formerly Motorola Semiconductor) is a leading manufacturer of embedded microcontrollers, with significant market shares in automotive, industrial, and telecom. Silicon Engines has designed many products using 68HC05, 68HC11, 68HC908, 9S08, and 9S12 microcontrollers, as well as Freescale Zigbee® RF spread spectrum data communications chip sets.

***Silicon Engines is a recognized design consultant for the Atmel AVR RISC processor product family.***

Atmel Corporation manufactures the AVR series of 8-bit RISC microcontrollers. These flash-based processors are increasingly popular for embedded applications of all kinds.

***Silicon Engines is a recognized Microchip design consultant.***

We have worked on both hardware and software for a number of systems that use Microchip's popular PIC microcontrollers. Tens of thousands of units that we designed are in use in the field.

***Silicon Engines is a member of ST's consultant program.***

The largest European semiconductor manufacturer—number five globally—ST Microelectronics has a very diverse line of semiconductors, including its ST7, ST9, STR7 (ARM 7), and STM32 (ARM Cortex) processors. We have worked with all these microcontroller families.

***Silicon Engines is an Altium Designer service bureau.***

Altium is a leading provider of electronic Computer-Aided Design systems. We have four seats of the latest version of this CAD software, formerly known as Protel. Silicon Engines is an Altium-recognized service bureau for PC board designs.

## ENGINEERING SERVICES

### TECHNICAL MARKETING

- Meet with clients to discuss product needs.
- Help develop comprehensive product specifications.
- Produce operating instructions and technical documentation.

### ELECTRICAL ENGINEERING

- Design microprocessor-based digital logic.
- Engineer motor drivers, DC and stepper.
- Design power supplies, linear or switched-mode.
- Interface to displays and keyboards.
- Provide circuitry to interface with industry communications standards.
- Work with RF circuitry and antennas.

### PRINTED CIRCUIT BOARDS

- Schematic capture.
- PCB layout, through-hole, SMD, up to six layers.
- Attention to analog design rules.
- Fabricate prototypes.
- Prototype testing.
- Functional test of final assemblies.
- Ship custom products fully tested and warranted.

### PROJECT MANAGEMENT

- Work with client's internal engineering staff to supplement in-house skills.
- Contract with other consultants where necessary to gain specialized skills.
- Coordinate product introduction into client's manufacturing facilities.
- Locate qualified contract manufacturers and coordinate assembly services.

### SOFTWARE ENGINEERING

- Program in C for projects requiring quick turn-around, applications with large and complex application layers, projects requiring code portability among processors.
- Program in assembly language when necessary for high processing speed, or when cost-effective for high-volume systems to optimize memory utilization.
- Utilize a proven royalty-free multi-tasking operating system to optimize processor power with minimal hardware.
- Take advantage of extensive library of device handlers to match specific hardware requirements.
- Use DSP (digital signal processing) techniques for filtering, equalization, adaptive control.
- Expertise in morphological image processing.

### INTELLECTUAL PROPERTY

- Work with patent attorneys to secure protection for client's product.

### COMPLIANCE ENGINEERING

- Design products to meet agency approvals.
- RFI testing at approved NVLAPS test laboratory.
- Secure approvals from UL, CSA, FCC, TUV.

## DESIGN EXPERIENCE

### DATA COMMUNICATIONS

- Telephone modems, wireless radio modems.
- RF data circuitry, including 2.4 GHz spread spectrum transceivers based on Zigbee®.
- DSP-based data pumps.
- Facsimile transmission.
- Asynchronous, synchronous communications protocols.
- RS-232, RS-485, Modbus, I<sup>2</sup>C, CAN, J1939, USB, J1850, ISO-9141, ISO-14230, LIN.
- 8, 16, 32-bit CRCs.
- Error detection and correction.
- Selective-reject wireless packet protocols.
- Forward error correction, Reed-Solomon, convolutional, Golay, Viterbi.
- Data compression, lossless.
- Low-bit-rate voice compression using CVSD.
- Encryption, hash codes, FIPS 140-2 compliant algorithms.

### INDUSTRIAL CONTROL

- Industrial lighting controllers.
- Motor drivers.
- Flow sensors.
- Analog monitoring.
- Closed-loop control.

### AUTOMOTIVE ELECTRONICS

- Body control modules, specifications through production.
- DC motor control.
- J1850 (GM Class 2), CAN, J1939, ISO-9141, ISO-14230, Keyword Protocol 2000, LIN communications protocols.
- DC motor actuation using programmable state tables.
- Sensorless DC motor control using commutation pulse detection.
- Simulators for engine control and transmission control ECUs.

### MEDICAL ELECTRONICS

- Motor controls.
- Keyboards, displays.
- Data communications interfaces to host systems.
- Provide circuitry to interface with industry communications standards.

### RETAIL AUTOMATION

- Credit card acceptors.
- Magnetic card readers.
- Custom keyboards.
- Receipt, ticket, and card printers.
- Dial-up transaction modems.
- On-line transaction protocols.
- DES encryption.
- Fluorescent, LED, LCD displays.



***Silicon Engines played a key role in the design of the AutoMARK election machine—with lead responsibility for electronic hardware design and embedded software. This product includes a single board computer running Windows® CE® 5.0 on a 533 MHz XScale processor, with an 80 MIPS TI DSP for interface to three image scanners. Three microcontroller-based peripheral boards handle the printer mechanism, keyboard, and ultrasonic sheet detector.***

# INTRODUCTION TO SILICON ENGINES

## DESIGN PHILOSOPHY

### CUSTOMIZATION

- Self-contained products.
- Hardware specially designed for application.
- Software assembled to task from library of device handlers.

### ECONOMICAL HARDWARE

- Attention to manufacturing cost.
- Skill in using minimal hardware.

### HARDWARE DESIGN DEPTH

- Microprocessors, microcontrollers, DSPs.
- Solid-state memory, flash, serial EEPROM, SPI or I<sup>2</sup>C.
- Analog to digital converters, DACs.
- Input sensors, output drivers.
- Motor control, DC, stepper.
- Communications interfaces.
- RF circuitry, antennas.
- Power supplies, linear, switched.
- Displays, LED, LCD, fluorescent.

### REAL-TIME SOFTWARE

- Multi-tasking software executive.
- Maximizes processing capability of low-cost processors.

### BROAD SOFTWARE RANGE

- Character-oriented messages.
- Display drivers.
- Keyboard handlers.
- Print mechanism drivers.
- Communications handlers.
- Math routines.
- Morphological image processing, for machine vision and similar applications.
- Motor handlers.
- Diagnostics, including ISO-9141, 14230, CAN, LIN.
- Modular architecture.
- Custom compilers, assemblers.



*Test bench for custom industrial controllers designed and manufactured for a Silicon Engines customer. Each unit is given complete continuous functional test under load before being shipped under warranty.*

## PROCESSORS

### FREESCALE 68HC908, 9S08

- 68HC908QT1, 68HC908QY4, 68HC908QB8, 68HC908KX8, 68HC908GP32, 68HC908JB16, 68HC908AS60, 68HC908AZ60, 9S08QE8, 9S0QT60.
- Mid-range 8-bit microcontroller family, upgraded from the 68HC05.
- Flash-based microcontrollers.
- USB, CAN, J1850, I<sup>2</sup>C, RS-232.

### FREESCALE MC9S12

- MC9S12NE64.
- Versatile 16-bit microcontroller family, upgraded from the 68HC11.
- '9S12 parts are flash-based.
- Ethernet, CAN, I<sup>2</sup>C, RS-232

### ST MICROELECTRONICS ST7

- ST72254, 264, ST7FLite05
- ST enhanced version of legacy 68HC05 family.
- Targeted at high-volume automotive, industrial control.

### ST MICROELECTRONICS ST9

- ST92F120, ST92F150.
- Flash-based 16-bit MCUs.
- CAN, J1850 bus support.
- Popular for automotive apps.

### ST ARM PROCESSORS

- STR710FZ2, ARM 7 processor with large arrays of internal flash and RAM, rich peripheral set.
- STM32F103, latest 32-bit ARM core, up to 72 MHz, price points competitive with 8- and 16-bit processors.

### MICROCHIP PIC

- 16Cx, 18Fx, PIC24F families.
- Popular series of RISC microcontrollers, 8 and 16-bit.
- Low-cost development tools readily available.

### ATMEL AVR

- ATMEGA8, 16.
- Low-cost high-speed RISC microcontrollers.

### TI TMS320 DSP SERIES

- TMS320203, 241, 2406, 2407, 548, 5409, 5503, DM642.
- Digital signal processors for modems, error coding, filtering, signal conditioning, image processing applications.
- Texas Instruments has leading market share in DSP.
- 2400 series provides full set of on-board peripherals, including ADC and PWM, priced to compete with microcontrollers.
- 5400 and 5500 series provide host port interface, serve as data and image processing accelerators for attached host processor. Processing power of 120 MIPS and above at competitive prices.
- DM642 and 6000 series utilize VLIW (very long instruction word) technology to provide peak speeds of over 5 billion operations per second.

### INTEL XSCALE ARM

- Third-party off the shelf and custom single board computers based on Intel IXP420, IXP425
- Windows CE® experience.
- Application code, customized drivers, image processing.
- LCDs, touch screens, communications interfaces.
- Integration with coprocessors to handle real-time peripherals.
- Product system integration.

### INDUSTRY-STANDARD 8051

- 8031, 8051.
- Industry-standard microcontroller family.
- Widely sourced, many variants from Intel, Philips, Dallas, Atmel, Infineon (Siemens), TI.

## TECHNICAL STAFF

### **KERRY BERLAND, PRESIDENT**

As Vice President of Martin Research, edited and published in 1973 the first full-length design book on 8-bit microcontrollers, *MICROCOMPUTER DESIGN*, with Donald P. Martin, the firm's President. The firm developed a line of microcomputer circuit boards and software, using them to launch a design consulting and manufacturing business. Kerry was in charge of marketing the firm's consulting services and custom products. Customers included Abbott Diagnostics Division (semi-automated spectrophotometer for diagnostic testing), Atlantic Richfield (the first integrated POS terminal for the oil industry).

Vice President Marketing of Qwint Systems, which introduced, in 1980, the world's most compact keyboard impact printer. Over 30,000 teleprinters were delivered to customers worldwide. Customers included RCA Service Company (nation-wide distributor for telex machines), ADP (portable terminals for insurance estimators). Set up the firm's advertising and documentation groups; negotiated OEM contracts with major customers; and was legal liaison with the firm's corporate law firm.

Headed up manufacturing for Qwint Systems for two years, producing teleprinters and custom point-of-sale products. Gained experience in manufacturing management, purchasing, subcontracting, computerized inventory control systems (MRP).

Upon purchase of the teleprinter product line by Zebra Technologies Corporation, assisted in transferring the manufacturing process, then took on the role of supporting Qwint customers as VP Marketing. Managed the development of a 2400 bps modem with MNP-5 communications.

Established Silicon Engines in December 1989. Developed product documentation for a medical diagnostic instrument for Baxter. Generated a series of marketing specifications for Cherry Electrical Products, Automotive Group, covering microprocessor-based control modules. Served as engineering project manager for modules that control sunroofs, convertible tops, and motorized seats. Experience with J1850 and related serial data communications protocols. Supervised hardware, software, and customer support functions.

Co-inventor on three patents on automotive control systems, and sole inventor on two patents on radio communications products. Has served as a consultant to a patent law firm on several patent cases.

Hardware engineer, project manager on numerous development projects at Silicon Engines.

U.S. patents: 5,282,238; 5,451,849; 5,497,326; 5,509,050; 5,825,147; 6,114,819; 6,246,199; 6,288,511; 7,109,853; others pending.

### **DOUG REINKING, VP ENGINEERING**

Experienced engineering project team leader, with a background in software engineering and in field application engineering. Has worked as a software engineer, as a Field Sales Engineer for software development equipment and RTOS software tools, and as an engineering project team leader. C and assembler in embedded environment. Experience with embedded RTOS (real-time operating systems), formal automotive software development process under ISO-9001 Employed by Silicon Engines, Motorola Automotive, QNX Software Systems. Extensive experience with 68HC05, 68HC908, 68HC11, Atmel AVR processors. Project manager for a major networked industrial lighting system project, and for a major food service product. Responsible for software for a number of automotive electronic control modules—seat modules, door modules, body control modules. Detailed knowledge of ISO-9141 and 14230 diagnostic protocols, certified for GM Class 2 (SAE J1850). Designed software for position control and obstruction sensing seat system using DC motor commutation pulse detection, put into production at Honda. Wrote software, did technology transfer for Rover seat module in UK and Germany. Experience with J1939 CAN protocol for truck and heavy-duty transportation. Motorola 68HC11 international design competition winner while still in college. BS, Computer & EE, Purdue University.

### **JEFF HUNSINGER, SENIOR PROJECT ENGINEER**

18 years of experience in hardware design, software development, and field support. At Motorola Semiconductor (now Freescale), Austin, TX, modeled microcontroller cores and peripherals using Verilog, generated pre-silicon models with FPGAs. Worked at Silicon Engines for two years in the late 1990s on automotive applications, including J1850 and CAN; did hardware development, PCB layout, C and assembly language firmware. Worked as firmware engineer for Detroit-based automotive diagnostic tool vendor, including CAN and USB protocols. Over six years of experience as a Field Applications Engineer for Atmel Corporation in Michigan—assisting customers with designs; prototyping sample applications; developing hardware and software using AVR, ARM and 8051 processors; diagnosing customer problems at the board, source code, and tool levels; and providing on-site technical support.

BSEE, University of Michigan-Dearborn.

# INTRODUCTION TO SILICON ENGINES

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## **PAUL BERLAND, SENIOR SOFTWARE ENGINEER**

C programming in PC environment; C and assembler in embedded environment. Visual Basic for PC, generating user console software for embedded systems. Extensive experience with Windows® CE®. Intern at MIT Media Lab, generated C code for networked video applications. Wrote microcontroller-based code implementing the CCITT Group 3 fax protocol. Wrote PC-based code for the SAE J1850 multiplex protocol, for the ISO-14230 Keyword 2000 automotive diagnostics protocol, and for the LIN protocol. 68HC908—C and assembly language—SAE J1850, keyboard handler, carbon dioxide sensor, carbon monoxide sensor, humidity sensor, temperature sensor, engine simulator modules, variable-baud-rate controllers for ISO-14230 and LIN. 68HC11 C and assembler—GM Class 2 handler, cellular telephone interface device, programmable convertible top controller, CAN-based industrial laundry controller system. Microchip PIC—handheld electrical tester, audio controller, two LCD panel projects implementing I<sup>2</sup>C, studio sound equipment devices. ST7—paint gun, automotive sensors, electrical tester. Hitachi H8/3644 C and assembler—flash programming handler, memory seat module, SAE J1850. Z80/Z180 C and assembler—thermal printer firmware; multi-tasking monitor; flash and EEPROM device handlers; Reed-Solomon, Golay, and convolutional forward error correction; CRC-8, CRC-16, CRC-32 algorithms. TMS320 assembler—12-channel Viterbi encoder and decoder, high-speed I<sup>2</sup>C handler for interface to video camera chip, FFT algorithms for networked sound level measurement system. ARM 7: sensor data logger for secure container system. Three years toward BSEE, MIT.

## **DAVID REID, SENIOR SOFTWARE ENGINEER**

Over 15 years experience programming in C. Ten years as an R&D engineer developing new products for a wide variety of industries including automotive, mining, food inspection, voting machines, and pressure sensors. Ability to formulate and implement high-level strategies to solve real-world problems. Prior to joining Silicon Engines, responsible for refining the Kinotex® sensor system, and assisting customers to develop products utilizing that technology. Developed and wrote the image processing and ballot recognition software used by the AutoMARK voting machines, utilizing morphological image processing techniques. Using expertise in image processing and advanced classifiers, developed other image-based systems, including automatic food inspection, automated mining operations, and an advanced occupant detection system for airbag deployment. Expertise with C, C++, for Windows,

embedded microcontrollers, and DSP. Completed the TI TMS320C6000 code optimization course. Applying that knowledge, David was able to optimize image processing using a DM642 DSP for a speed-up of over 75 to 1 over the initial implementation. Experience with MatLab; Matrox image processing libraries; libraries implementing FIPS 140-2 based encryption and hash codes. Has worked with GPS and cellular systems, and has designed special-purpose communications protocols for a variety of systems. BSEE, Memorial University of Newfoundland, Canada.

## **MARK KMIECIK, SOFTWARE ENGINEER**

C, C++, assembler for Microchip PIC, Freescale, and Atmel processors. 50 MHz 8-bit processor design using Verilog, implemented in FPGA. 100 kHz IR communications system for remote. Design project team leader for interface device developed for major consumer electronics manufacturer. Software, test equipment for industrial lighting control system. Assisted in defining communications protocol enhancements to improve flexibility and security for a major industrial control system. Software for a family of food service products; defined the communications protocol and implemented it on several of the modules in the system. BS Computer Engineering, Cum Laude, Rose-Hulman Institute of Technology.

## **TRY TY, HARDWARE ENGINEER**

Design, troubleshooting, and testing of PC boards, interconnect systems. Electronic design, schematic capture, printed circuit board layout. Trained and certified for PCB layout by IPC. Dozens of PCB designs for industrial controls, RF antennas, RF boards. Multiple power supply designs using Power Integrations off-line switchers. Responsible for developing and maintaining engineering change order system for major customer projects. BSEET, Magna Cum Laude, DeVry University.

# INTRODUCTION TO SILICON ENGINES

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## MITCH BUDNIAK, SENIOR ANALOG ENGINEER

Over 30 years of experience in analog hardware design. Specializes in switch-mode power supply design, motor control, A/D conversion, and closed-loop systems. Projects have included medical instrumentation (PMT and photodiode amplifiers, power supplies), automotive controllers (engine control, motor drivers, motor feedback), printer design (print head drivers, auto-ranging power supply, stepping motor feedback system), telephony (modems, telephone line interfaces, PA systems), industrial control (building automation, factory data collection network), audio systems (low-noise audio circuits, Class D amplifiers), and test equipment (handheld electrical testers, analog circuits for automotive engine simulator equipment). Awarded 11 U.S. patents including bedside medication dispensing and alert system, medical A/D conversion design, step motor feedback system, DC motor positioning system, electrical tester systems. BSEE, University of Illinois.

US patents: 3,507,460; 3,547,374; 3,584,291; 4,282,471; 4,711,987; 4,740,080; 5,102,008; 5,230,441; 5,497,326; 6,362,714; 6,844,712; others pending.

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## PROJECT TEAM

For a typical project, Silicon Engines forms a project team to deliver the design. The team includes members of our technical staff, along with the customer's in-house engineers—when available—to leverage industry-specific experience.

We also use outside independent consultants with specific expertise in microcomputer hardware and software, mechanical engineering, and industrial design—when necessary to round out the project team. Specific skills provided by our associates include:

- **ELECTRONIC HARDWARE.** Engineers with specific expertise with RF design, emissions testing, FPGA designs, power supplies, to supplement in-house staff.
- **SOFTWARE ENGINEERING.** Programmers with specific expertise on various microprocessors and programming languages, to supplement in-house staff.

- **INDUSTRIAL DESIGN:** Human factors analysis to make sure that a product is easy to use. Design of packaging, enclosures.
- **MECHANICAL ENGINEERING:** Detailed design of enclosures for mass production tooling. Design of mechanisms, including paper handling, printing.

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## AUTOMOTIVE DATA CONVERTERS



*The Model 9004 LIN/USB Converter is a tool used by automotive engineers developing in-vehicle automotive data networks. This product, developed and marketed by Silicon Engines, provides an interface between the Local Interconnect Network bus and the USB port on a laptop PC. The device comes with PC software developed in Visual Basic.*

*Thousands of units of the Model 9004 and related products have been sold to automotive development and test engineers world-wide. The product line includes the following models:*

- *Model 9001, 9141/RS-232 Converter.*
- *Model 9002, 14230/RS-232 Converter.*
- *Model 9003, LIN/RS-232 Converter.*
- *Model 9009, 14230/USB Converter.*

**Contact Silicon Engines for more information.**

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