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Geodesic Digital Power: Revolution or Evolution?

Driven by Moore's law, digital-power's move down-market, and the market's advance upward into digital power, are both exponential trends that ensure a revolution.

Power-One is already there to meet it.

"Yeah, **Power-One**'s (PWER) digital power products are pretty good. What's killing them is that they're proprietary," said our sage industry insider, echoing several other well-situated sages giving their mortuary inside dope on our favorite innovator in digital power systems. "The electronics industry hates single-source supply. And digital power is new and unproven. Who wants to box himself in?"

Certainly not us. By all means, shun any bets or boxes based on a proprietary single source supply of a "new and unproven" technology. We prefer new and unproven technologies that have many potential sources—disruptive revolutions that are supported by all the established companies. We like globally standardized inventions that are born already proven, made by everyone and his brother in San Diego, and his cousin in San Jose or China, with software from Redmond and Bangalore, yet unknown to the world and thus vastly undervalued. Anyone know of such breakthroughs? Please don't hesitate to tell us. And yes, Tobin Smith, we already know about WiMax, **Intel**'s (INTC) solution to the next generation of wireless, and about **Alvarion** (ALVA) which makes WiMax systems in Israel.

But why Max? It's a disruptive innovation supported by all the leading players, and it's history, folks. Check into the specs of Flarion, just purchased by **Qualcomm** (QCOM) on August 11 for $600 million (plus $205 million more contingent on further patent approvals). As a mobile broadband wireless system designed to be compatible with 1.2 megahertz CDMA channels, Flarion's Flash orthogonal frequency division multiple access (OFDMA) was regarded to be chiefly a threat to Qualcomm. With lower channel bandwidth and thus smaller evident capacity than the 20 MHz OFDM WiMax, WiBro, **NTT Docomo** (DCM) et. al. Flarion was losing ground with the major carriers. The global drive for WiMax, in particular, had pushed Flarion to the fringes. Few noticed that unlike all the other fourth generation systems, Flarion actually *worked* in the field, rather than merely on PowerPoints, for both fixed and mobile applications.

A big Flarion win with Digita Oy in cell-savvy Finland ignited a flare that could not be ignored, even by Qualcomm. Flash OFDMA test results also intrigued Australians, Croatians, Malaysians, and even Japanese, along with Nextel, now **Sprint** (FON) in the U.S. The performance in Sendai was so good that the Japanese charged Flarion's founder CTO Rajiv Laroia (now Qualcomm OFDM chief) with cheating on the tests. (Flarion CEO Ray Dolan takes over Qualcomm's existing OFDM MediaFLO division.) Now giving the San Diego company offices near Lucent in Bedminster, NJ and 120 more sophisticated engineers, Flarion extends the Qualcomm line through the next decade and pushes WiMax even farther out on the fringes of the next generation 4G wireless choices (see "Kinetic Qualcomm," *GTR* April 2005).

But for all our imaginative powers, we cannot find a Qualcomm everyday. In the absence of bonanzas that combine scores of patents and potential users around the globe with a strategic coup for the big Q, we have been going for the propri-

etary kind of breakthrough: **EZchip**'s (LNOP) unique network processors, **Microvision**'s (MVIS) micro-mirror heads-up displays, **Broadwing**'s (BWNG) all optical network, **Cepheid**'s (CPHD) gene chips, **Essex**'s (KEYW) hyperfine optical devices, and **Altera**'s (ALTR) virtuosity in field programmable firmware. But, by all means, don't forget Power-One. Perhaps our industry insider has *something* encouraging to tell us about our proudly listed vendor of the Z-One digital architecture and our major stake in the coming digital revolution in power control?

Power-One has proved that digital power is feasible. In due course it will be inevitable.

"Well…" grudged our guru, "The Power-One solution does have the flexibility and simplicity designers want—for extremely expensive, super high-end boards." He is right about that. In storage and server systems with thousands of disk drives, digital power management can save between 10,000 and 20,000 components compared to the competitive analog systems. This has led to pioneering design wins at **IBM** (IBM), **Sun** (SUNW) and **EMC** (EMC). Moreover, digitally programmable, the Power-One system does not require you to change or rearrange all those thousands of components every time the semiconductor industry adds new and lower voltages on critical-path microchips. Chip-level voltages are multiplying across the industry, with some mixed signal devices deploying 12 volt, 5 volt, 3.3 volt and one volt and on-down transistors. That's all good for Power-One's digital solution. But what our guru giveth, he also takes away. "Too bad some Z-series features are already offered by suppliers such as **Analog Devices** (ADI) and **Summit Microelectronics** and have been adopted by the likes of **Cisco** (CSCO) and **Hewlett Packard** (HPQ). Too bad **Texas Instruments** (TXN) is aiming much of their company at this market and they are a monster….

"But hey," he japed, "if Power-One is successful, they still might get 15 percent of the $300 million per year market in 2010…."

Whoa! By now our file of objections to Power-One, already bulging and tearing on the edges, had begun to slip off the desk and onto the floor of our office, knee deep in random esoterica of power gear. It reminded us our early years pushing Qualcomm's CDMA technology. Of course, as our critics might gently point out, in these days of our dotage almost everything reminds us of our glory years pushing the "Q" uphill—from Corvis all optical networks to **Terayon**'s (TERN) SCDMA cable technology to the information theory behind "intelligent design." But in consulting the earnest advocates of analog power control, we cannot suppress our memory of the Stanford University radio technology titan Bruce Lusignan earnestly explaining to us in 1992 that the cell phone industry was making a fatal mistake in abandoning analog for digital. Now a few billion digital cell phones later, Power-One is making a similar claim for digitization of the power systems in board level electronics. And experts throng to explain the elegance of analog solutions.

Don't get us wrong. We grasp the necessity of analog interfaces for all systems that interact with the real world. Watts after all are analog. *The Silicon Eye* is both about the power of analog and about the inexorable advance of digital solutions in previous bastions of analog. A key lesson of *The Silicon Eye* was that when a digital system becomes feasible, Moore's law will soon make it inevitable.

Thus before developing the capacitive touch pad now on 70 percent of laptop computers and music players, **Synaptics** (SYNA) came a cropper with analog point-of-sale check readers for **Verifone** (PAY), analog memory cells for neural networks, analog optical character recognition imagers for **Caere**, and analog address readers for the U.S. Post Office. All of them worked amazingly well. "But by the time Synaptics would present its amazingly ingenious and low power little analog chip," dourly observed then Synaptics CEO Federico Faggin, "Verifone, the Post Office, Caere—whoever the customer happened to be—would have come up with a high power digital solution that did the job and could be plugged into an IBM PC."

Under the guidance of Faggin and co-founder Carver Mead, Synaptics ended up neatly dividing the digital and analog functions in its touch technologies, now moving onto cell phone teleputers. It then launched **Foveon**, whose unique imagers also combine analog interfaces with digital processing. In June, Synaptics reported seeing progress at Foveon and added $4 million to its existing 17 percent ownership. A key to Synaptics success has been its acute understanding of the ever-changing frontiers between digital and analog functions.

Well, here we go again. Power-One has proved that with the right analog interfaces, digital power is feasible. In due course it will be inevitable. As the vessel of digitization of power control, Power-One is our leading legacy from the "powercosm" launched by Peter Huber and Mark Mills in their *Digital Power Report,* which we published for three years until the crash. Closing it down was the most painful decision of those dismal years.

Throughout my career as an analyst of technology, Peter Huber has rivaled Carver Mead as my most essential guide. Since I met Huber long before I met Mead, it was Huber who prepared the way for me to recognize Mead as the paramount thinker he is. (Lucky Telecosm '05 attendees will be able to sample Mead's genius throughout this year's conference, beginning September 26.) But even before Mead, Huber taught me the optimality of what he called the "geodesic network," with links as short as possible. The geodesic principle explained the exponential impact of Moore's law (make transistors smaller and move them closer together and they run faster, cooler, and cheaper). Huber also grasped the

centrifugal force of the microcosm, pushing capabilities and control to the edges of the network. In *Orwell's Revenge* (Free Press 1994), he explained how the microchip exerts a democratizing imperative. He prompted the theory behind *Microcosm*, *Life After Television*, and *Telecosm*. And then he led me to the powercosm, and to Power-One.

After the demise of the *DPR*, the Huber-Mills vision has since shone forth in *The Bottomless Well,* their shockingly contrarian and iconoclastically optimistic view of the energy crisis. They show that SUVs have a smaller impact on the environment and use less energy than bicycles do. They demonstrate that energy is intrinsically abundant. What is scarce is information and creativity, yielding the "ordered energy" that enables microcosm and telecosm and Power-One's digital system.

Headlined "Cisco of the Powercosm," the monthly Huber-Mills newsletter of May 1999 described Power-One as standing "an excellent chance of emerging as the leading company managing the routing of big electron flows at the building level and on down." Huber and Mills chose Power-One for their comprehensive line of then mostly analog power products—their "bricks" and "power plants" that are already widely used in many systems. In the late 1990s, though, Power-One focused on supplying power systems to the telecosm, which turned out to be a big mistake for a while but gives our readers an inviting opportunity today.

Power-One shares now trade at $4.73, down from $68.25 when listed by the *DPR* in May 2000, *before* its digital power breakthrough. Power-One stands at less than half of its price when we added the company to our Telecosm Technologies list in May 2004, and it is up only slightly from a low of $4.08 this past April. Over the last year and one half, quarterly revenues have declined from $72.5 million to $63.4 million with per share loss sinking from 5 cents to 34 cents before "recovering" to 17 cents in June.

As an assemblage of several power device companies put together by charismatic CEO Steve Goldman over the last six years, Power-One took some time to integrate all the moving parts into the industry's only complete power systems company—from 48 volts AC to less than one volt DC, from analog to digital, from racks to "bricks," from power plant to point-of-load (POL). Almost half of the June loss was caused by inventory write-down and restructuring charges associated with the transition of production from Norway and California to lower-cost Slovakia and the Dominican Republic. The move also took a swipe at sales, which suffered from inventory shortfalls from the disruption.

Now completed, the restructuring has lowered quarterly breakeven revenue to $68 million, a level Power-One hopes to attain this quarter. Many on Wall Street are skeptical. Management had promised a return to profitability last year following a previous restructuring, yet the company continues to lose money as it has each year since 2000 in the continuing telecosm slump. And now the latest rumor has Power-One losing "significant" business for its conventional power systems at Cisco, its largest customer.

The skeptics are handing us a great long-term investment opportunity. Design wins in the Power-One's *traditional* business were strong this spring, including significant AC-to-DC "power plant" front-ends with large server and storage companies promising millions of dollars in new business in 2006. These new analog customers open up additional digital Z-One opportunities, just as the new customers on the Z-One side are buying some of the traditional product lines as well.

Financially sound, Power-One has no long-term debt and net cash of $72 million, down only $24 million during the restructuring. By contrast, power-systems competitor **Artesyn** (ATSN) is burdened with a net debt of $24 million, though the company anticipates earning some $10 million this year, or $0.26 per share. Both companies are on sale at reduced enterprise values about equal to yearly revenues. Meanwhile, systems competitor **Vicor** (VICR), which like Power-One boasts a strong balance sheet, has managed to earn a more typical enterprise value of 2.6 times sales by flirting with breakeven revenues. If Power-One makes good its promise to approach profitability this year, a similar revaluation by Wall Street would double its stock price.

When Alex Lidow of the industry consultancy **iSuppli**, former CEO of powerchip titan **International Rectifier** (IRF), first alerted us to the company's invention on a bus last year in Seoul, Korea (*GTR* May 2004), he told us that the digital transformation could take five years or more. Nothing significant has changed during the past year. iSuppli remains positive about Power-One and the digital-power paradigm. Confirming its analysis is the competition, which amid brash dismissals of the technology, is engaged in a panicky drive to duplicate it.

Crucial to the company's success will be how swiftly its digital-power solutions move down market and how fast the market moves up to meet them. Since power is proportional to clock frequency, peak power requirements on chips and motherboards rise as gates multiply and clock speeds rise. Even as power requirements rise, however, voltages are falling. More gates on a chip mean thinner silicon walls between them. If voltages don't fall, the walls won't hold. As a measure of electrical pressure or potential, voltage can be likened to the slope of a pipe carrying water. As the slope decreases, water runs more slowly downhill and the pipe must widen to maintain a constant flow. Similarly, at a given level of electrical power (measured in watts [W]), lower voltages imply larger currents (flows of electrons) across the ever-expanding millions of microchip gates. Power requirements rising while voltages fall means that currents are surging.

Rising currents require ever larger "pipes" or copper wires to carry the electricity. As the cable thickness increases to an unacceptable size, the final layer of power-condition-

TELECOSM TECHNOLOGIES

Advanced Micro Devices	(AMD)
Agilent	(A)
Altera	(ALTR)
Analog Devices	(ADI)
Broadcom	(BRCM)
Broadwing	(BWNG)
Cepheid	(CPHD)
Corning	(GLW)
Equinix	(EQIX)
Essex	(KEYW)
EZchip	(LNOP)
Flextronics	(FLEX)
Intel	(INTC)
JDS Uniphase	(JDSU)
Microvision	(MVIS)
National Semiconductor	(NSM)
NetLogic	(NETL)
Power-One	(PWER)
Qualcomm	(QCOM)
Semiconductor Manufacturing International	(SMI)
SK Telecom	(SKM)
Sprint	(FON)
Synaptics	(SYNA)
Taiwan Semiconductor	(TSM)
Texas Instruments	(TXN)
Wind River Systems	(WIND)
Xilinx	(XLNX)
Zoran	(ZRAN)

Note: The Telecosm Technologies list featured in the Gilder Technology Report is not a model portfolio. It is a list of technologies that lead in their respective application. Companies appear on this list based on technical leadership, without consideration of current share price or investment timing. The presence of a company on the list is not a recommendation to buy shares at the current price. George Gilder and Gilder Technology Report staff may hold positions in some or all of the stocks listed.

Agilent (A)

PARADIGM PLAY: NANO TEST AND MEASUREMENT

AUGUST 29: 31.26; 52-WEEK RANGE: 20.02 – 31.22; MARKET CAP: 15.36B

Is A looking more like A+ or F? In mid-August, Agilent announced the sale of its unprofitable chip business to two private equity firms, the sale of its stake in an LED business called Lumileds, and a planned IPO spin-out of its system-on-a-chip and flash memory test units. "Capital 'A'" will now become "small 'a' with a lot of capital" as it loses a third of its revenue stream while caching enough cash to buy back $4b in shares over the next two years and to call over $1b in convertible debt due December 2006. Financial analysts grade this an A+. At the current price, shares outstanding would be reduced by almost a third while the downsizing generates $450m in cost savings. Agilent's remaining businesses—electronic measurement and bio-analytical measurement—currently contribute nearly 90% to operating earnings on 63% of revenues, encouraging Agilent to project a 14% operating margin after divestiture and to hint at an EPS of $1.80 to $2.00 next year. The company believes sales can grow 10% annually.

Well, excuse us, but we don't rate that an A+. Shares will be reduced by a third, but so will revenues. And consider that Agilent reaps but 2.5% of its $40b test and measurement market. If that market grows more than a *quarter of a percent* a year, the emergent pure-play would *lose* share if it grows at a rate of 10%. But then, no one has suggested that A stands for aggressive or ambitious. Today, investors are buying in at a forward PE of 16.5 based on an EPS next year of $1.90, a bland valuation to match a bland outlook. It seems Wall Street agrees with us.

Gone with the amputations will be some promising technologies. The old Agilent was the leading supplier both of CDMA duplexers and amplifiers and of fiber-optic transceivers, which convert electronic signals to photonic inputs and outputs. Based on integrated arrays of vertical cavity surface emitting lasers (VCSELs), Agilent's transceivers and connectors bring hundreds of gigabytes per second of optical communications power into the back planes and motherboards of computers. Last year, Agilent was awarded a DARPA contract with IBM to extend this technology to terabit speeds. More important, the company had apparently aligned itself with fused-chip technology, which promises to eliminate the crucial I/O bottleneck—the gap between the external bandwidth of chips and on-chip bandwidth.

Crucial now is whether the new Agilent will excel as a test and measurement specialist. On the electronics side, Agilent has long been a leader in fiber-optic and wireless test and measurement, including enterprise networks. Still showing signs of life here, over the past few months the company has made advances in test and optimization for wireless video streaming, announced the world's fastest jitter and bit-error-ratio tester for high-speed communications ports, and claimed the first spectrum analyzer with resolution bandwidths up to 8 MHz for analysis of microwave and millimeter applications such as satellite and digital communications, pulsed signals, and 3G wireless systems.

On the bio-analytical side, products identify, measure, and analyze thousands of substances in the environmental, petrochemical, energy, food, safety, agriculture, security, forensic, and drug industries. Agilent purchased Computational Biology in January with an eye toward expanding its genetic research, and followed in May with the acquisition of Scientific Software, which sells chromatography data systems and content and process management software to the chemical, food, health care, and pharmaceutical industries. Chromatography is a process used to separate a mixture for analysis, and the purchase gives Agilent one of the largest chromatographic data systems and one of the broadest portfolios of laboratory-data software in the life science and chemical industries. Recent cutting-edge achievements include a fully automated, high-throughput lab-on-a-chip that can analyze thousands of DNA or protein samples per day for basic life science research and drug discovery, and enhancements in Agilent's genomic hybridization techniques that improve researchers' ability to pinpoint genetic aberrations thought to be responsible for cancer. Working in collaboration with Japanese bioventure firm Human Metabolome Technologies, Agilent is expected to offer before the end of the year a unique mass-spectrometry-based analysis tool designed to speed the identification of the thousands of metabolites in human cells and thereby help researchers to develop drugs for stress and disease.

Based on the near-term financial outlook, Agilent does not appear to be a bargain for investors, and until the dust settles next year, we won't know how well the company managed its makeover. But regardless, to earn its keep on our list, Agilent will need to demonstrate ascendancy in the indispensable and increasingly intricate science of testing, measuring, and analyzing ever smaller scale particles, molecules, and biological structures. *– CB*

Cepheid (CPHD)

PARADIGM PLAY: MICROELECTRONIC MACHINES FOR DNA IDENTITY

AUGUST 29: 7.38; 52-WEEK RANGE: 6.93 – 11.45; MARKET CAP: 314.23M

Cepheid can't seem to make any mistakes. A leader in lab-on-a-chip technology, the company has installed over 800 GeneXpert systems in U.S. Postal Service processing centers, where over a million anthrax tests have now been run *with no false positives*. With GeneXpert—possibly the world's only fully-integrated and automated genetic analysis system—postal employees find out if it's anthrax in half an

MEAD'S ANALOG REVOLUTION

NATIONAL SEMICONDUCTOR (NSM)
SYNAPTICS (SYNA)
SONIC INNOVATIONS (SNCI)
FOVEON
IMPINJ
AUDIENCE INC.
DIGITALPERSONA

COMPANIES TO WATCH

ADAPTIX
AMEDIA (AANI.OB)
ATHEROS
ATI TECHNOLGOIES (ATYT)
BLUEARC
COX (COX)
ENDWAVE (ENWV)
FIBERXON
LINEAR (LLTC)
LUMERA (LMRA)
ISILON
LENOVO
MEMORYLOGIX
NOVELLUS (NVLS)
POWERWAVE (PWAV)
SAMSUNG
SEMITOOL (SMTL)
SIRF
SOMA NETWORKS
STRETCH INC.
SYNOPSYS (SNPS)
TEKNOVUS
TENSILICA
VIA TECHNOLOGIES
XAN3D

hour rather than waiting until the next day. Cepheid will deploy GeneXpert in all 282 postal processing centers by the end of the year and thereafter continue to sell replacement test cartridges for the units.

Jumping off from its successful postal deployment, Cepheid is bounding into the clinical, biothreat, industrial, life sciences, food, agricultural, and environmental markets. The company has doubled to 10 the number of ASRs (analyte specific reagents) available for gene expression and bacterial targets. A new general use PCR (polymerase chain reaction) mastermix product has been released for use in both the ASR and industrial markets. Collaborations have begun with the FDA, the University of North Carolina, and the Public Health Research Institute for testing of Salmonella, E. coli, a resistant strain of Staph, and other public health threats. For the FDA, products for the detection of Group B Strep should be available by early next year. Also to be released in 2006 are new tests for MRSA (Staph bacteria resistant to certain antibiotics). And soon customers will be able to choose from an expanded line of biothreat cartridges for the testing of from 3 to as many as 10 agents.

For investors, profits will not come as quickly as products. Near-term gross margin is being pressured by increased license and royalty costs and by the transition to automated manufacturing. Thus, management has increased its expected net loss for 2005 to about $13m or $0.31 per share from a loss of $10m or $0.24 per share, while reaffirming sales of $82m. Cepheid will continue to invest heavily in research and in manufacturing to accelerate delivery of clinical products, sacrificing near-term profitability for long-term growth. Trading at an enterprise value of 3.6x estimated 2005 sales, the stock likely has baked in management's expectation of a 55% sales surge this year. For far-sighted investors, that should not be a problem. With concerns about terrorism and globalization of highly-infectious diseases growing apace, the coming decade looks bright for Cepheid. *– CB*

Essex (KEYW)

PARADIGM PLAY:"TURPIN'S LAW"—ANALOG OPTICS GALORE

AUGUST 29: 20.70; 52-WEEK RANGE: 8.85 – 24.21; MARKET CAP: 440.54

Investors are expecting big things from the biggest name in analog optics, Terry Turpin. A genius in the field, Terry is driving Essex Corporation ever deeper into the furtive military world with stunning advances in synthetic aperture radar, 3-D imaging, antimissile defense, and real-time analysis of satellite images without using racks of digital computer boards. During the second quarter, Essex successfully demonstrated its all-optical encryptor, optical spectrum analyzer, and advanced optical signal processor, and announced that the long-awaited testing of its advanced optical processor for missile defense applications would begin this quarter at MIT. The company continues to promise sales of $160m for the year, and based on current margins the stock trades at a porky PE of 65 for 2005, even after pulling back from its peak of $24.21 on July 11. If organic growth continues through next year at its present rate of 30–35%, today's price yields a still lofty PE of 52 for 2006.

Clearly, stockholders are expecting yet more from Terry and have already priced some of their hopes into the market cap. Additional breakthroughs in military applications are a good bet as a hungry defense community, beset by terrorists and rising powers in Asia, stands ready to devour Terry's unique treats. Though it doesn't work widely, optical processing is virtually magical in its niches, and Essex claims the field to itself. Several weeks ago, the company formed a team experienced in commercializing technology. Success outside defense would improve margins as well as solidify sales. One possibility has Terry calling on air and seaports offering products that find explosives without sending in the dogs. Interestingly, a recent rumor had Cisco partnering with Essex to distribute its all-optical encryptor. Based on Terry's Hyperfine WDM multiplexer, the encryptor works an order of magnitude faster than its closest competitors. In June, Essex filed a shelf registration for an additional 5m shares ($100m at the current price). Though the company doesn't need the cash for continuing operations, it is eyeing further acquisitions, a prospect that pleased Wall Street, which sent the stock up $1.50 on the news. *– CB*

Qualcomm (QCOM)

PARADIGM PLAY: AIR KING: WORLD'S BEST TECHNOLOGY COMPANY

AUGUST 29: 39.37; 52-WEEK RANGE: 32.08 – 44.99; MARKET CAP: 65.17B

The acquisition of Flarion catapults Qualcomm from a position of 3G dominance toward an era of 4G leadership as well. For $600 million, Qualcomm obtains 120 wireless engineers, probably the world's largest portfolio of OFDM (orthogonal frequency division multiplexing) patents, and thus further protection from any WiMAX threat and would-be rival Intel. Flarion CTO Rajiv Laroia will lead QCOM's OFDM technology efforts, and CEO Ray Dolan will take on QCOM's OFDM-based MediaFLO network. Qualcomm expects 3 cents of dilution, but the deal is strategically accretive. QCOM says its existing OFDM patents and now Flarion's additional portfolio apply to WiMAX. With the broadest and deepest intellectual property portfolio, Qualcomm boosts its strategy of integrating the various wireless modes (CDMA2000, WCDMA, GSM, Wi-Fi, WiMAX) on single chip-sets. QCOM will be able to deliver powerful new multi-mode, multi-band teleputers — all with its own technology — even as competitors necessarily use more and more QCOM IP.

Lower profile was Qualcomm's $57-million purchase of Elata, a European wireless software company. Elata facilitates the delivery of content and applications to mobile phones and has signed up several of Europe's large mobile carriers such as Hutchison-Whompoa's "3" network in the UK and Orange in France. Qualcomm believes Elata complements its own BREW mobile software platform and that Elata's customer base could eventually adopt the full BREW GSM suite.

Further good news came on August 29, when Verizon Wireless announced it was cutting the price of its BroadbandAccess wireless service (based on QCOM's EV-DO high speed data technology) from $80 to $60 per month. QCOM has been agitating for mobile carriers to slash data prices, and now that Sprint's EV-DO network is about to come online, with Cingular soon to follow, QCOM is getting its wish.

QCOM shares have risen 20% in the last two months but remain $5 short of their 52-week high. The company's current $65-billion market cap is no chump change, but hardware and software dominance of the era's key device, the teleputer, is increasingly probable and means further gains are likely. It remains a core holding. *– BTS*

Wind River (WIND)

PARADIGM PLAY: WINDOWLESS REAL TIME OPERATING SYSTEMS

AUGUST 29: 13.00; 52-WEEK RANGE: 10.50 – 17.68; MARKET CAP: 1.09B

The breeze is still at Wind River's back as it continues to sail upstream at the pace at which it has promised investors. A leading vendor of real-time operating systems for embedded software, Wind last year made its first profit in half a decade and still expects to triple earnings to $0.27 per share this year. CEO Ken Klein's revival strategy of offering royalty free licenses and moving down market with Linux-based products is paying off. Particularly on the balance sheet, where long-term net cash has surged 77% to $169m over the past year and where the quick ratio of cash and short-term investments to current liabilities stands at a healthy 2. Since the quarterly call of August 23, Wind's stock has lost about a fifth of its value, dropping from a forward PE of over 60 for the current year to a still high 48. Apparently, investors suffered a blow to their great expectations when they found that management's forecast was right. Today's PE implies future earnings of $0.40 per share next year and $0.59 the year after. Since Wind expects to earn $0.19 during the remaining half of this year, these expectations could well prove conservative. The wind has not changed. The paradigm continues to predict a proliferation of real-time operating systems for embedded applications such as net processors and cellphones that must perform complex operations without discernable delays. By continuing the proper focus, Wind River should prosper along with this trend. *– CB*

ing has to be located very close to the final load. Just as Moore's law improves chip performance by moving transistors ever closer together, Huber's "geodesic imperative" enhances the performance of both power and information systems. As Huber puts it, "Short wires are as important for the electrons that carry power as they are for electrons that carry information."

Also impelling the geodesic digital power revolution in the latest high performance chips are rapid current swings, from milliamps to tens of amps and back. Each of these large, fast devices often needs its own highly reliable power source, a so-called brick, usually supplying one or more voltages different from the rest of the circuit board and other chips. And the more densely chips are packed on a board, the more exacting the controls must become to handle the cacophony of harmonics and noise and competing demands for power. Responding to the geodesic imperative, most high-end equipment today uses a form of distributed power called intermediate bus architecture (IBA).

In this system, down the line from the cabinet-level *power plants* that convert 480 V-AC from the public grid to a more manageable 48 V-DC, are arrays of *power bricks*. Mounted on each circuit board and line card, the brick converts the 48 V to voltages useful in microelectronic applications—12 V or 5 V and increasingly down below a volt. Using a transformer to isolate the board, the brick protects it from other nearby boards, boxes, and the network, assuring that a single brick's failure shuts down (or fries) only a single board, not a roomful of electronics. Branching out from the brick are *point-of-load converters* (POLs)—essentially non-isolated bricks which dot the board next to the processors they serve, fueling them with a reliable supply of precision electrons at a desired voltage.

An advanced telecosmic circuit board now requires many hundreds of components just to ensure that key chips get fed the right number of electrons in the right sequence. All around the POLs sprout analog devices—resistors and capacitors in clusters and patches, temperature sensors, voltage references and current protectors, switches and timing circuits, proliferating "set points" in mazes across the board. These analog circuits are linked together and back to a central analog system manager, keeping watch over the performance of the POLs.

For producers of bricks and POLs, such as Power-One, the challenges are to shrink size, boost power, and cut heat.

Advancing since 1984 when Vicor introduced the first commercial high-power brick—a 4.6 x 2.4 inch monster that defines the footprint of the "full-size" brick—brick size has continued to drop from one-eighth bricks today toward one-sixteenth of the Vicor standard while increasing efficiency and power. A breakthrough in conversion technology came in 1995 with the emergence of low-cost, high-performance MOSFETs—metal oxide semiconductor field effect transistors—which can be instructed by logic circuits to turn current on and off to step down the voltage.

Think of a dam on a river. To regulate the dam, you could open it a little to get just the right current. That's the linear way of controlling the power. It's very inefficient because you lose a lot of the power at opening due to resistance, generating heat and waste. The solution is pulse width modulation (PWM). Instead of opening the dam a little, you let down the floodgates for a very short period. That's the pulse.

Letting the current flow freely is very efficient. If you want one-third the power that comes at full-open, you leave the dam open one-third of the time. In electronics, the current flows through capacitors, which store voltage, and inductors, which maintain inertia. Thus, instead of an enormous flow for a split-second and then no flow at all, you get a steady output. The faster you can open and close the dam, the steadier the flow seems. Similarly, the faster MOSFETs are switched, generally the smaller the capacitors and inductors needed to deliver the same amount of nicely regulated power, decreasing the size of the POL modules and increasing their efficiency and accuracy.

Board-level power architecture can be divided into management and control functions. *Management* conducts the orchestra of power from the top, setting the levels and voltages, while the *control loop* actually drives each switch to achieve the correct POL output.

Using field programmable gate arrays (FPGAs) from Altera and Xilinx (XLNX) to orchestrate complex power systems, digital power *management* has already established a foothold displacing analog power *management* components. With digital's performance and flexibility advantages over analog, digital will take over power *management* as soon as Moore's law makes digital also cheaper.

Much more difficult to convert to digital is regulating the control loop to each device. Pulse width modulation (PWM) remains mostly an analog process with functions hardwired to the chip design using almost two dozen low-cost components. For smooth output and fast response, the adjustment must be made each cycle, comparing the output voltage against some known reference. But voltage spikes and dips are nonlinear problems, making the analog comparator difficult to design. A typical POL module includes a PWM controller, at least two discrete power MOSFETs, a large power inductor, large input and output capacitors, and a number of feedback and compensation components. Total parts count is typically between 15 and 20 components, requiring 4 to 6 square inches of board area.

To close the loop digitally, you convert your analog voltage measurement into bits. For instance, if you use an 8-bit analog-to-digital (A-to-D) converter, voltage will be measured in 8 bits. A microprocessor uses that information to adjust the pulse width. Now, say, your voltage spikes three times higher than what you want. The digital PWM circuitry can turn the clock off for three or four cycles. Or, suppose your voltage is dropping way down. The digital circuitry can keep the switches on the whole time. With non-

linear control, bid good-bye to the external resistors, the feedback loop, and the compensation network required in hardwired analog. Now you can do it all internally, with the added flexibility to change the desired voltage with the click of a mouse. This is the Power-One revolution.

A slam-dunk for digital, right?

Not necessarily. A-to-D converters are complex and costly. Add to that all the intricate control algorithms. And, of course, the accuracy of your control loop depends on how many bits you have to work with. Today, if you digitize everything, you not only add cost, but the A-to-D process may limit what you can do, such as how much current you can drive into the switches.

But the slam-dunk is coming, as Moore's law lowers the basket and makes the game easier, and the players grow taller and more power hungry. On the supply side, it is becoming possible to integrate more complex digital-power circuitry onto smaller chips at increasingly lower costs. On the demand side, high-end LAN Ethernet switches will soon burn 800 W, compared to 100 W to 200 W five years ago. (That's why the industry needs low powered EZchips.) Along with power comes complexity that will require power specialists to remedy.

With analog power components, every experiment or change of plans requires a hardware change, creating a nightmare for the line-card designer who needs to stitch together hundreds of customer devices from dozens of vendors. Increasingly, today's power supply vendors must provide the support or they must offer flexible, easy to use power products.

Okay, you know where we're headed: Power-One understood the trend early on and has become the first power-supply company to take full advantage of the Moore's law advances to develop what today remains the only complete digital power system, including both the control and management functions. Operating in stealth for more than two years during the telecosm depression, Power-One introduced the fruits of its $50 million program last year. Integrating all the analog sensing, monitoring, and adjusting functionality into its own digital POLs called Z-POLs, Power-One creates a general-purpose, integrated, software programmable power environment. Instead of many tens or hundreds of parts, Power-One condenses all board-level power into two: the Z-POL and the digital power manager (DPM). Key to the system's simplicity and programmability is digital PWM within the Z-POL and a proprietary high-speed bus and communications protocol.

Through software and a graphical user interface, engineers can program and reprogram each Z-POL for any output voltage. They can tell the digital power manager chip to turn the POLs on and off in proper order. Real-time telemetry continually monitors temperature, current, and voltage for precise and optimized control. The digital power manager and POLs are connected via a high-speed bus that supports up to 32 Z-POLs. Most other nonprogrammable custom-built systems can support a maximum of 4 or 8 POLs. With a digital system, software allows trial and error and no-fault do-overs. Power-One estimates its system could reduce design time for an advanced board from 8 weeks to 3 days. In a typical board design with 8 voltage outputs, the company claims reductions from some 200 components to just 9; from 600 traces or printed wires on the board to just 76; from 10 square inches of board space to just 4.4—all at a 20 percent cost reduction.

Moving down-market, Power-One introduced its Z-1000 line of no-bus POLs this spring. In power components such as MOSFET switches, most stand-alone analog POLs require yet more costly circuitry to detect and protect against excessive temperature and voltage spikes. One solution would be to design an intermediate bus architecture system into every board, complete with management capabilities. Alternatively, Power-One stand-alone programmable POLs not only eliminate the need for a bus, a system microcontroller (such as Power-One's DPM) and nonvolatile memory, they also banish copious hardwired analog parts while shortening the design cycle by 30 to 50 percent over the Z-7000 product. And as system complexity inevitably increases, customers can easily upgrade to the Z-7000 series since the products are compatible.

Using FPGAs from Altera and Xilinx to orchestrate complex power systems, digital power management has already established a foothold.

Power-One thinks that its Z-1000 no-bus POLs, which began sampling last month, will quadruple the size of its addressable market. Today, the entire market for POL modules built by systems vendors such as PWER totals $500 million. But only a small percentage comes from high-end POLs that Z-7000 will serve. The remainder of the $3 billion market is fueled by systems designers purchasing parts to build their own POL converters directly onto their boards. As power demands and complexity increase, however, modules designed by experts at systems companies such as Power-One should gain share. POL sales overall, self-built and modules, are expected to grow to $3.5 billion in three years, which at today's ratio would boost the module market to $583 million. If modules double their share of POL sales to a third, they could quickly grow into a billion dollar bonanza.

As we know from EZchip, design wins are not sales, just a necessary step to that end. Power-One itself cautions us not to expect significant sales from its design successes until 2006 and beyond. To incorporate Z-One designs, Power-

One has to convince customers to redesign their boards completely, using unproven products that lack standards and interoperability. Notoriously conservative power supply designers, who have invested years of hard won experience in analog, will have to learn a whole new vocabulary and toolset. With advances in traditional analog components and MOSFET switches continuing apace—from **Bel Fuse** (BELFB), Artesyn, **Infineon** (IFX), **Enpirion**, **Volterra** (VLTR) and **Potentia Semiconductor**—the transition to digital may seem like more trouble than it's worth.

The integrated POL converters from Enpirion, for example, reduce module size and part count by more than half by integrating not only the PWM, switches, and gate drives but also the magnetic components onto a single CMOS (complementary metal oxide semiconductor) chip, leaving only four external parts. Moreover, long recognized as the leader in power switches, International Rectifier recently unveiled a unique MOSFET chipset with a drastically lower on-resistance, enabling systems vendors to build brick modules with 40 percent fewer switches. All of these analog advances come with the promise of interoperability, which enables customers to fall-back on second and third sources, crucial in an industry that relies on multiple vendors per board to supply hundreds of components.

In response to Z-One's proprietary bus and communications protocol, Artesyn has taken the initiative in setting up the PMBus special interest group, aligning itself with some of its power-system competitors, **Emerson** (EMR) and **Astec Power**, as well as leading silicon suppliers, **Intersil** (ISIL), **Microchip Technology** (MCHP), Texas Instruments, Volterra, Summit, and Zilker Labs.

Forming its own group, dubbed "Z-One Digital Power Alliance" or Z-Alliance for short, Power-One is hoping to allay some of the standards angst. With only two takers so far—semiconductor manufacturer **Atmel Corporation** (ATML) and systems vendor **C&D Technologies** (CHP)—the group looks more like a Z-One promotion than an industry open-standards committee. The third largest manufacturer of DC-DC converters in the world, C&D has been licensed as a second-source supplier of Z-One intermediate bus architecture (IBA) systems to the industry.

Meanwhile, digital competitors are gathering. With its purchase of Power Trends and alliance with **Arasan**, Astec, and Emerson, TI now has a team working on digitizing the control loop, with the first products to be shipped later this year for use in battery-powered products such as cell phones and notebook computers. A high volume supplier with experience in both analog and digital design, test, and manufacture, TI already has a strong presence in telecom with its POLA (point of load alliance) products and digital power management solutions.

Moving up from below is Potentia with a comprehensive family of digital power devices that are fully configurable using Potentia's graphic user interface. Potentia will offer different mixes of analog and digital for different applications, performance, and cost targets, giving the company, initially, a wider audience than that commanded by Z-One. That's the official line, but the truth may be that the company hasn't yet figured out how to do it all digitally.

These are all cut-and-paste, partial solutions far behind Power-One on the digital learning curve. By developing a complete digital power architecture, only Power-One has mastered the entire set of skills needed to clear the brambles off the board and launch digital power management down a new learning curve, benefiting from Moore's law. As an early leader, Power-One will relentlessly push performance and volumes up and costs down, forming circles of collaborative design and development with customers, smartchip manufacturers, and board-level designers.

With such a head start, could Power-One possibly be losing business at high-end Cisco? We don't know if the rumor's true, but the answer to the question is, certainly. Cisco designs many of its own converter modules and will likely be enticed by many of the rival cutting-edge analog technologies, giving it a large pool of vendors from which to choose and with which to collaborate. Count on a turbulent market. With Power-One, the big gamble for investors is time. The question is not *whether* Moore's law advances will accelerate digital power into a revolution, but *when*—crucial in light of the headwinds now resisting Z-One. Driven by Moore's law, digital-power's move down market, and the market's advance upward into digital power, are both exponential trends that ensure a revolution. Power-One is already there to meet it. You should be there with them.

— George Gilder and Charlie Burger
August 30, 2005

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291A MAIN STREET, GREAT BARRINGTON, MA 01230, TEL: (413) 644-2100, FAX: (413) 644-2123 • EMAIL: INFO@GILDERTECH.COM

EDITOR	EDITORS	EXECUTIVE EDITOR	TECHNOLOGY ANALYST	MANAGING EDITOR	ART DIRECTION	SUBSCRIPTION DIRECTOR	CUSTOMER SERVICE
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