Efficiency Challenge 2004 Winner Fact Sheet

Power Integrations, Inc.

Award: Market Ready Category – Best in Class A1 and Grand Champion

Design description:

Product Name	EP-16-2.75 Using LNK501
Internal or External	External
Average Efficiency	69%
Type of Product Powered	Portable Home Phone
Output Power	2.75 W
Output Voltage	5.5 V
Output Current	500 mA
Judges Comment(s)	Remarkable efficiency for a home portable phone – conventional models range from 30% to 55% active mode efficiency – to achieve 69% efficiency is outstanding.

Why this product category is important:
Portable telephones are one of the biggest opportunities for external power supply savings in the U.S. market. Ecos Consulting estimates that there are roughly 220 million of these phones in use in the U.S., and if all U.S. phones had power supplies as efficient as the Power Integrations model, the nation could save 1.5 billion kWh per year. This would prevent the release of one million tons of carbon dioxide into the atmosphere, and save consumers one hundred million dollars on their utility bill – equivalent to powering nearly 150,000 average American homes for one year.

Not only is this power supply more efficient, it also saves the consumer money over the operational life of the cordless phone. Total cost of ownership (TCO) is a technique that has long been used by U.S. federal and state governments when making procurement choices. It determines the total cost of a product over its lifetime and includes the purchase price as well as operational costs of a unit. Because of the outstanding operational and standby efficiency of this product, the TCO of this power supply is at least 70% less than the phone power supplies sold with portable phones today.

The Power Integrations' power supply enabled the cordless phone product that was submitted as part of the competition submission to meet the ENERGY STAR® cordless phone and power supply specification. It also meets the California Energy Commission power supply standard requirement that goes into effect in July 2006.

Design team:
C.W. Park

Spokesperson: Balu Balakrishnan, president and CEO

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About Power Integrations, Inc.:
Power Integrations, Inc. is the leading supplier of high-voltage analog integrated circuits for use in power conversion. The company's breakthrough silicon technology enables compact, energy-efficient power supplies for a vast array of electronic products including consumer electronics, home appliances, computers, and industrial electronics, as well as external adapters for cell phones, cordless phones, and numerous other devices. The company's patented *EcoSmart* technology dramatically improves the energy efficiency of electronic devices during normal operation and standby mode, and gives manufacturers a highly cost-effective alternative to older, less efficient power supply technologies. *EcoSmart* technology has saved consumers and businesses around the world approximately $900 million on their electricity bills since its introduction in 1998, an amount that is now increasing by more than $1 million per day. The Power Integrations Green Room (*www.powerint.com/greenroom)* is a comprehensive resource designed to help power supply designers find, understand, and comply with energy-efficiency standards around the world. Power Integrations is located in San Jose, California and is traded on the NASDAQ National Market under the symbol POWI. The company has sold about 1.5 billion integrated circuits since the introduction of its first commercial product, the revolutionary *TOPSwitch* family of integrated circuits, in 1994.

Quote:
“I am delighted that the U.S. Environmental Protection Agency and the California Energy Commission have selected Power Integrations as the Grand Champion of Efficiency Challenge 2004,” said Balu Balakrishnan, president and CEO of Power Integrations. “It is particularly significant that the winning design is for the cordless phone market, where inefficient linear transformers are still the predominant power supply technology. This award validates the fact that a cost-effective, efficient alternative to these ‘energy vampires’ is now available and ready for market.” *Balu Balakrishnan, president & CEO*

Efficiency Challenge 2004 Winner Fact Sheet

AcBel Polytech, Inc.

Awards: Market Ready Category – Best in Class A and Best in Class D2

Design description: Best in Class A

Product Name	API4PC04
Internal or External	Internal
Average Efficiency	74%
Type of Product Powered	Desktop computer
Output Power	450 W
Judges Comment(s)	This power supply had the highest average active mode efficiency of all products submitted for the contest; low idle mode power in the test bed computer; cost competitive

Type of product powered: Desktop computer with ATX 12V form factor power supply

Design team member names:
R&D: Mr. Well ZH, Mr. Dali Yang, Mr. Timi Tang

Design description: Best in Class D2

Product Name	API 3 D25-380
Internal or External	External
Average Efficiency	90%
Type of Product Powered	Laptop computer
Output Power	150 W
Output Voltage	19 V
Output Current	7.9 A
Judges Comment(s)	This product is particularly remarkable because it has an average of 90% efficiency in active mode and still achieves outstanding power factor correction (average of 0.99 across four loading points).

Type of product powered: Desktop replacement laptop computer

Design team member names:
PM: James Lai, Sammi Huang
R&D Electronic: C.P. Lin, Jack Kuo
R&D Mechanical: Tony Yang, Benson Lee, Rayja Chen

Spokesperson: Frank Yu, director

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About AcBel Polytech, Inc.:
In 1996, by joining a strategic alliance, Kinpo Group became the major stockholder of Acbel Polytech Inc., which specializes in manufacturing power supplies.

Relying on sophisticated experiences and technical background, Acbel Polytech has developed a multitude of new generation products in its power management series based on the features of high frequency, high efficiency, high density and miniaturization of the products. At present, a variety of power management product series have been successfully developed, which range from low, medium to high levels of power and are widely utilized in products for the information, communications, network and industry fields. In recent years, the lightweight and compact VRM products have been successfully developed and completely meet the needs for various personal technical appliances. Additionally, DC-DC products have also become one of the key components of the transmitters in wireless communication base and network communication equipment.

Nowadays, Acbel Polytech has its manufacturing factories in Taiwan, China and the Philippines. Their highly efficient process and low manufacturing costs have actually promoted competitiveness, and excellent quality has won positive feedback and secured long-term cooperative relationships with the top ten computer suppliers. Having these advantages, Acbel Polytech has sufficient confidence in reaching the goal of becoming one of the top three power supply manufacturers within three years.

Quote:
“We are honored to be recognized by the U.S. Environmental Protection Agency and the California Energy Commission. Power supply efficiency is a core focus for Acbel Polytech and we congratulate our team for their award-winning designs.” *Daniel Su*

Efficiency Challenge 2004 Winner Fact Sheet

The Hong Kong Polytechnic University

Awards: Open Category – Best in Class A2 and Grand Champion, Best in Class B2

Design description: Best in Class A2 and Grand Champion

Product Name	Not applicable
Internal or External	External
Average Efficiency	74%
Type of Product Powered	Stand alone AA battery charger
Output Power	2.5 W
Output Voltage	6.25 V
Output Current	400 mA
Judges Comment(s)	Low parts count is impressive; extremely good efficiency for such a low output power; no load of 0.16 W is remarkable as well

Important/unique information about the design:

- The high conversion efficiency is obtained through an optimized selection/design of control IC, converter topology, output transformer, operation mode, MOS switch, and output rectifier.
- In the selection of control IC, an NCP1215A is used. This IC uses a variable-off-time technique to reduce the standby-mode power dissipation of the converter.
- In the regulator, a flyback converter is used. A well-designed flyback transformer is used to reduce the loss due to the leakage inductance of the transformer and the resistance of the transformer windings.
- The operation mode is optimally selected to strike a balance between switching loss and conduction loss.
- The MOS switch and output rectifier are also carefully selected to reduce their switching and conduction losses.

ON Semiconductor component used:
NCP1215

Design team member names:
Dr. Martin Hoi Lam Chow
Professor Yim-Shu Lee
Mr. Yiu-Lam Cheng
Mr. Chung-Ping Lee

Design description: Best in Class B2

Product Name	Not applicable
Internal or External	External
Average Efficiency	82%
Type of Product Powered	Cordless phone
Output Power	6
Output Voltage	9
Output Current	0.667
Judges Comment(s)	Average efficiency at this output power for power supplies of this type is around 50% -- to achieve 82% efficiency at this output power is quite an accomplishment. Additionally, this power supply had a no load of 0.2 W – very impressive.

Important/unique information about the design:

- The high conversion efficiency is obtained through an optimized selection/design of control IC, converter topology, output transformer, operation mode, MOS switch, and output rectifier.
- In the selection of control IC, an NCP1215A is used. This IC uses a variable-off-time technique to reduce the standby-mode power dissipation of the converter.
- In the regulator, a flyback converter is used. A well-designed flyback transformer is used to reduce the loss due to the leakage inductance of the transformer and the resistance of the transformer windings.
- The operation mode is optimally selected to strike a balance between switching loss and conduction loss.
- The MOS switch and output rectifier are also carefully selected to reduce their switching and conduction losses.

ON Semiconductor component used:
NCP1215

Design team member names:
Dr. Martin Hoi Lam Chow
Professor Yim-Shu Lee
Mr. Yiu-Lam Cheng
Mr. Chung-Ping Lee

Spokesperson: Andy Williams, Vice President of Power Conversion Division, ON Semiconductor

Media contact name, phone, e-mail:
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About The Hong Kong Polytechnic University:
The Power Electronics Research Center is one of the prominent research centers of The Hong Kong Polytechnic University. It is jointly owned by the Department of Electronic and Information Engineering and the Department of Electrical Engineering. The Center has an impressive research track record in areas of computer-aided design of environmentally friendly switch-mode power supplies, power factor correction, motor drives, integrated magnetic components, electromagnetic compatibility, and application of power electronics in power system engineering. The Center has a wealth of experience in research, testing, product evaluation, and new technology development. In addition to conducting research and development work, the Center provides various services to industry, such as design of new products, consultancy, testing of utility system components, quality assurance evaluations, and professional training.

Quote:
“We are honored to receive the award from the U.S. Environmental Protection Agency and the California Energy Commission. The protection of environment has always been the top-priority consideration in our research and development activities in the Power Electronics Research Center of The Hong Kong Polytechnic University. In the design of new products, high conversion efficiency, low Interference, and minimum material wastage are our major features. We are working closely together with industrial partners to contribute towards building a greener world. We would also like to thank ON Semiconductor for providing key components in this project.” *Dr. Martin Chow*

Efficiency Challenge 2004 Winner Fact Sheet

University of Illinois at Urbana-Champaign

Award: Open Category – Best in Class A1

Design description:

Product Name	PB00351
Internal or External	External
Average Efficiency	68%
Type of Product Powered	Cordless vacuum or stand alone AA battery charger
Output Power	2.5 W
Output Voltage	6 V
Output Current	417 mA
Judges Comment(s)	Average efficiencies of these types of power supplies are around 50% in active mode. Achieving 68% efficiency represents a great leap in what is possible with power supply efficiency in this product type.

Important/unique information about the design:
The high efficiency of this converter design system comes from two features: (1) the converter uses micropower logic to achieve very low overhead energy consumption; and (2) burst-mode control is used to halt switching entirely for light loads. Power factor correction for the system is automatic through the use of an off-line flyback converter in discontinuous current mode for all load levels.

ON Semiconductor components used:
1N4004 diodes
BF422 bipolar transistors
BZX84B18LT1 zener diode
BZX84B8V2LT1 zener diode
BZX84B5V1LT1 zener diode
MUR115 diode

Design team member names:
Student team members: Joseph Mossoba, Nicholas Benavides, Grant Pitel, Timothy O'Connell, Xin Geng, Surya Musunuri, Alexis Kwasinski. *Faculty advisors:* Jonathan Kimball, Philip Krein, Patrick Chapman.

Spokesperson: Professor Philip Krein

Media contact name, phone, e-mail:
Joyce Mast, (217) 265-5128, machines@ece.uiuc.edu

About the University of Illinois at Urbana-Champaign:
The University of Illinois at Urbana-Champaign is home to the Grainger Center for Electric Machinery and Electromechanics (CEME), a research and education program in the Department of Electrical and Computer Engineering. The Grainger CEME comprises three faculty, two staff members and about thirty graduate and undergraduate students. Research activities include advanced power electronics applications from less than 1 V to more than 1000 V, control of electric machines, and innovations in machine design. The application areas range from power conditioning of individual fuel cells to efficient electronic drives for automobiles. Major themes include research intended to make the best possible use of electrical energy and to enhance electric energy conversion processes.

The CEME supports student projects such as the International Future Energy Challenge and the Efficiency Challenge. More information can be found at http://machines.ece.uiuc.edu. The Efficiency Challenge project was a student-led team effort. Team members took full responsibility for the design, construction, and testing of a complete high-efficiency power supply. The students also carried out all aspects of project management. The University of Illinois at Urbana-Champaign has one of the strongest U.S. programs in electrical energy. The ECE Department enrolls more than 1600 undergraduate students and over 500 graduate students.

Quote:
"We are honored to be recognized by the U.S. Environmental Protection Agency and the California Energy Commission. Electrical energy efficiency is a central theme in the Grainger Center for Electric Machinery and Electromechanics at the University of Illinois. We are excited that our students have worked together as an outstanding power supply design team to demonstrate a highly efficient solution. We are grateful for the support of ON Semiconductor during the Efficiency Challenge Competition." *Professor Philip Krein*

Efficiency Challenge 2004 Winner Fact Sheet

Thayer School of Engineering, Dartmouth College

Award: Open Category – Best in Class C2

Design description:

Product Name	Big Green
Internal or External	External
Average Efficiency	88%
Type of Product Powered	Office phone, computer peripheral
Output Power	11.2 W
Output Voltage	7.59 V
Output Current	1.48 A
Judges Comment(s)	This entry demonstrated outstanding active mode efficiencies; typical output power is at 60% in active mode.

Important/unique information about the design:
In most power supplies, the magnetic components—transformers and inductors—are responsible for the largest fraction of the loss. Our approach was to accurately model all the losses in the main high-frequency transformer, and to optimize the design to minimize losses. The transformer uses litz wire to achieve very low winding losses. Litz wire requires careful design—we used the LitzOpt program, available for free download or use online at http://power.thayer.dartmouth.edu. The circuit is a flyback converter—a standard circuit, but with careful attention to details in order to minimize loss throughout. For example, we used a synchronous rectifier on the input with an innovative low-power control circuit.

ON Semiconductor components used:
For the bridge rectifier we used the following diodes from ON Semiconductor:
Zener Diode - 1N5343B
Schottky - 1N5818RL

Design team member names:
Jennifer D. Pollock - Project Leader, Ph.D. Candidate
Professor Charles R. Sullivan
Xi Nan – Ph.D. Candidate
Magdalena Dale - MS Student
Satish Prabhakaran – Ph.D. Candidate

Spokesperson: Jennifer D. Pollock

Media contact name, phone, e-mail:
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About the Thayer School of Engineering, Dartmouth College:
Power electronics circuits, unlike most other modern electronics, require magnetic components—inductors and transformers. These components are often responsible for the most loss in a power supply or other power circuit, and are also often the components that are the largest, most expensive, and most difficult to design. The Dartmouth Magnetics and Power Electronics Research Group is focused on improving efficiency and reducing size and cost of power electronics by improving magnetics design and technology. The seven-person group, led by Associate Professor Charles Sullivan, includes experts on magnetic materials, electromagnetics, and electronics.

In the Advanced Magnetics for Power Electronics program sponsored by the Department of Energy, the Dartmouth Magnetics and Power Electronics Research Group is developing analysis and optimization methods and software. Much of the software is available for free download or use through a web interface at http://power.thayer.dartmouth.edu. Other government research sponsors include the National Institute of Standards and Technology (NIST) and the National Science Foundation. Corporate sponsors and partners include Intel, Volterra, West Coast Magnetics and New England Wire Technologies.

Dartmouth College, located in Hanover, New Hampshire, is a member of the Ivy League and has been in the forefront of American higher education since 1769. Founded in 1867, Dartmouth's Thayer School of Engineering is one of the nation's oldest professional schools of engineering. The School comprises both the Undergraduate Department of Engineering Sciences at Dartmouth and a graduate professional school in engineering.

Quote:
"Incredibly high efficiency—even much higher than our entry—is technically feasible. Manufacturers and consumers should accept nothing less." *Professor Charles Sullivan*

Efficiency Challenge 2004 Winner Fact Sheet

National Taiwan University of Science and Technology

Award: Open Category – Best in Class D1

Company name: National Taiwan University of Science and Technology

Spokesperson: Yu-Kang Lo

Design description:

Product Name	Not applicable
Internal or External	External
Average Efficiency	89%
Type of Product Powered	LCD Monitor
Output Power	80 W
Output Voltage	12 V
Output Current	6.7 A
Judges Comment(s)	This design approaches the 90% active mode efficiency level, which is remarkable.

Important/unique information about the design:
DCM PFC + SRC

ON Semiconductor components used:
NCP 1601 (control IC for DCM PFC)

About the National Taiwan University of Science and Technology:
For years, Power Electronics Application Lab of NTUST has been devoted to developing new topologies and novel control schemes for AC-DC and DC-DC switch-mode converters. Also, we are very encouraged and honored that with the support of ON Semiconductor, the required performance for Class D1 can be achieved.

Design team member names:
Sheng-Chin Yen, Yu-Chiao Lee and Yu-Kang Lo

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Efficiency Challenge 2004 Winner Fact Sheet

Texas A&M University, Department of Electrical Engineering
Lite-On Technology Corporation

Award: Open Category – Best in Class D2

Design description:

Product Name	Not applicable
Internal or External	External
Average Efficiency	89%
Type of Product Powered	Laptop computer, all-in-one small form factor desktop
Output Power	90 W
Output Voltage	19.5 V
Output Current	1.5 A
Judges Comment(s)	Active mode efficiency for this type of power supply typically ranges between 75% and 80%, so near 90% efficiency with such great power factor correction (average of 0.99) is an outstanding accomplishment.

Important/unique information about the design:
Use of Silicon Carbide diodes in the PFC stage and better design of the DC-DC converter input/output stages improved the overall efficiency. There is still room for improvements; the design team hopes to introduce a better product in the next competition.

Design team member names:
Mr. Leonardo Palma, Ms. Maja Harfman Todorovic, Dr. Prasad Enjeti (team leader), Mr. Howard Ho & Dr. Sangsun Kim (Liteon Corp – team mentors)

Spokesperson: Dr. Prasad Enjeti

Media contact name, phone, e-mail:
Staff Writers, Texas A&M Aggie Engineering Weekly, Lesley Kriewald: lesleyk@tamu.edu & Bonnie Shortner, Tel: 979-458-2277

About Texas A&M University, Department of Electrical Engineering:
Texas A&M University is a land-grant, sea-grant and space-grant institution located in College Station, Texas. The university is centrally located, approximately equidistant from three of the 10 largest cities in the United States (Houston, Dallas and San Antonio) and the state capitol (Austin). The university's enrollment includes approximately 44,000 students studying for degrees in 10 academic colleges. The university is dedicated to the discovery, development, communication, and application of knowledge in a wide range of academic and professional fields. Its mission of

providing the highest quality undergraduate and graduate programs is inseparable from its mission of developing new understandings through research and creativity.

Dr. Enjeti's laboratory's main focus is power electronics and clean power research, since its inception in 1988. His research team is currently active in advancing switching power supply designs and solutions to complex power management issues in the context of analog mixed-signal applications; exploring alternative designs to meet the demands of high slew rate load currents at low output voltages; power conditioning systems for fuel cells in stationary and portable applications, wind and solar energy systems; and design of high temperature power conversion systems with wide band-gap semiconductor devices. The laboratory is actively involved in many research projects (both near term and forward looking) with industries. Dr. Enjeti also provides consulting and design review assistance in the area of power electronics to select industries and expert advice to Venture Capital and Law firms.

Quote:
"We are honored to be recognized by the U.S. Environmental Protection Agency and the California Energy Commission. Power supply efficiency is a core focus of our power electronics and clean power research lab at Texas A&M University and we congratulate our team for its exemplary design." *Dr. Prasad Enjeti*

Efficiency Challenge 2004 Winner Fact Sheet

BIAS Power, LLC

Award: Open Category – Honorable Mention

Design description:

Product Name	BPA 1.5-US-15 Series
Internal or External	External
Average Efficiency	65%
Type of Product Powered	AC adapter for charging mobile phones
Output Power	1.5 W
Output Voltage	14.8 V
Output Current	100 mA
Judges Comment(s)	Efficiency and no load of the power supply are remarkable for its low output power. The small size of the power supply could be particularly attractive for consumers, especially if this form factor is paired with a cell phone.

Type of product powered:

This switching power adapter is a direct replacement for inefficient linear power adapters for charging cellular phones such as Nokia, Motorola, Samsung, Sony/Ericsson, LG or Siemens. Additionally, other small personal devices including PDAs, games, MP3 players, etc. can be supported.

Important/unique information about the design:
This product offers power conversion from AC to DC without generating EMI and with less than 30 mw of standby power.

While manufacturers are competing to create the lightest and most sophisticated portable product design, often the power supply shipping with the innovative product is clunky and as big as the product itself! Not only does the BIAS product have a remarkable efficiency for its rated output power, it offers key advantages to consumers beyond energy savings. It is only slightly larger than a standard sized AC plug, increases portability and convenience for consumers, and reduces packaging and shipping costs for manufacturers.

Design team:
BIAS internal design and product development team

Spokesperson: John Muntean, president

Media contact name, phone, e-mail:
John Muntean at (847) 358-1259 or cell phone (847) 867-7752

About BIAS Power, LLC:
BIAS Power, LLC is a design, product development and sales company focused on low-wattage (0.5 to 2 watts) AC-DC power supplies.

The company owns several patents in the area of noiseless power conversion. This technology has been implemented in a custom integrated circuit, which forms the basis of the company's products. BIAS is currently working to extend the operating range of its technology above 5 watts.

Applications are in electronic consumer products where standby power consumption is significantly lower than operating power or total power requirements are 2 watts or less. Typical applications include TVs, monitors, VCRs, audio receivers and amplifiers and DVD players. Other applications are found in consumer appliances, including microwave ovens, rice cookers, dish- and clothes-washers, as well as security systems, process control equipment, automatic meter reading equipment, and home networking apparatus.
The technology is also well suited for and provides significant reductions in quiescent current compared with other designs. Mobile phone users often leave their AC adapters plugged in constantly. Although convenient, this approach using previous technology consumed nearly as much power when the phone was disconnected or fully charged as during charging. By comparison, BIAS technology uses only 20 mW. This is a 10-fold improvement over other switching designs and a 100-fold improvement over linear designs!

The company has a network of distributors and sales representatives around the world as well as design and applications engineering support in its Chicago area headquarters.

For more information about the products, refer to their website at www.biaspower.com.

Quote:
"We are honored to be recognized by the U.S. Environmental Protection Agency and the California Energy Commission. Power supply efficiency is a core focus for BIAS Power along with lowest standby power consumption and ease of use. We congratulate our team for its exemplary design." *John Munteen*