UNIQUE TRADES FOR A UNIQUE PRODUCT IN DIGITAL POWER

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Abstract

Unique trades for a unique product in digital power have been optimized for a small innovative company with limited resources, resulting in the following choices:

1. Application Volume over Volume Application
2. IC and Board Introductions
3. Origination over Enhancement
4. Simplicity over Maximization
5. Challenge over Acceptance
6. Education over Advertisement

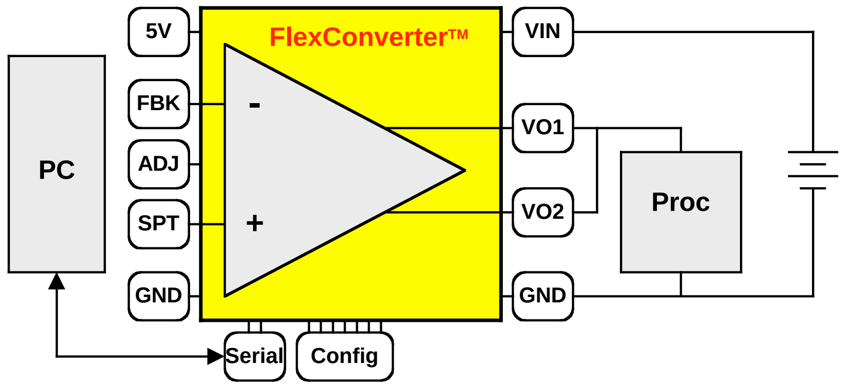
Lessons learned are shared to benefit other developers in digital power.

1. Application Volume over Volume Application

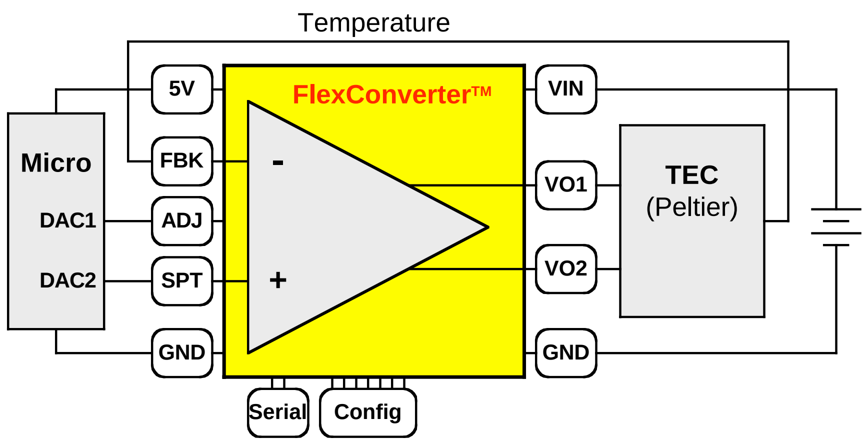
Large companies generally dominate high volume applications such as cell phones and PCs, while multiple related small applications tend to create opportunities for small companies. Many potential customers work outside their primary discipline even if they work in a massive corporation. A mechanical or systems engineer in research and development may require power and control expertise but the bureaucracy of a large company discourages coworker recruitment.

Creating products that are flexible and affordable with simple interfaces is key to attracting these valuable customers that are looking for easier solutions than design-from-scratch. Collectively, sales of products for multiple small applications can exceed that of a single high volume product. Microchip and Digikey are examples of companies that were once considered favorites only among hobbyists and college students, but are now well respected as successful businesses.

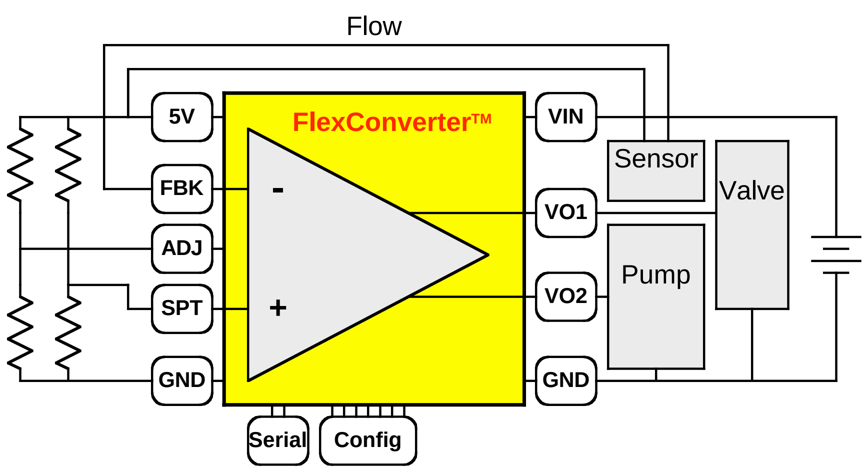
Figure 1 illustrates a few of many FlexConverter^{TM} applications. Circuit A is a PC-based POL converter with parallel phased outputs to increase current and reduce ripple. By grounding the appropriate configuration pins, the outputs are applied full-bridge in circuit B for bi-directional thermal control (cooling or heating). The last example in Circuit C utilizes sequential drive where the valve is first gradually opened then the pump is linearly powered to maintain constant flow. Alternately, the two converter outputs could be set independently as a dual power supply. A single flexible product that satisfies multiple applications greatly reduces manufacturing and operating costs for a company with limited resources, possibly making the difference the between success and failure.



A. PC-Based Point-Of-Load Converter with Paralleled Outputs



B. Bi-directional Thermo-Electric-Cooler with Full-Bridge Power Stage



C. Automatic Flow Controller with Sequential Drives

Figure 1. Examples of the FlexConverter™ Volume of Applications

2. IC and Board Introductions

Introducing both IC and board products has advantages. The IC enables a quick path to market since a chip must be designed or programmed before the board is completed, and magazine IC design briefs provide free international exposure. Following up with a board product that uses an enhanced version of that IC increases profit per unit, which is practical for a small company. CLOZD™ IC and FlexConverter™ board by Flextek Electronics are based on the same flexible control principle with a simple interface.

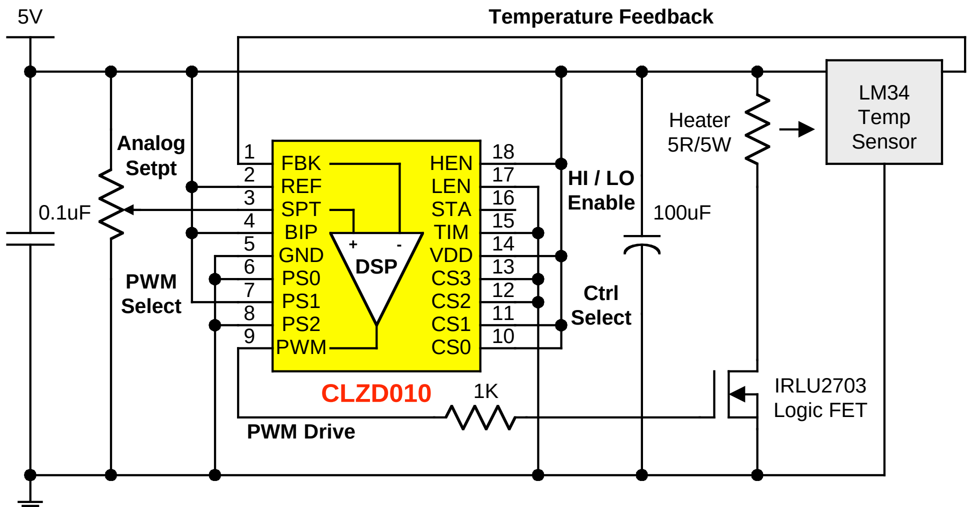
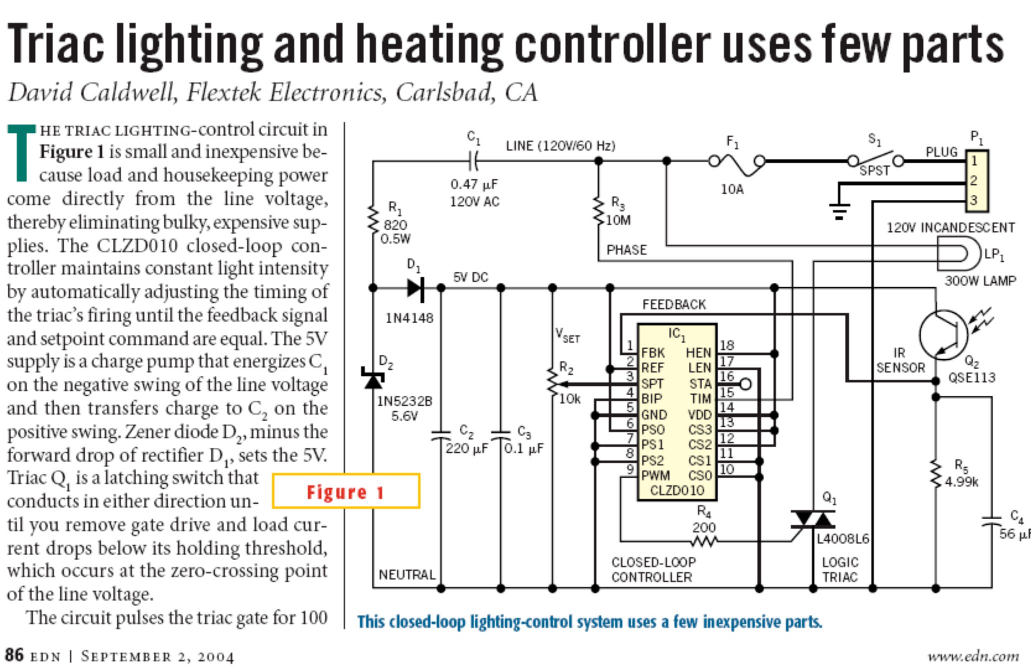


Figure 2. CLOZD™ Loop IC Satisfies Multiple Applications and is Configured by a Single Time-Domain Parameter to Eliminate Complex PID and Burdensome PC



Triac lighting and heating controller uses few parts

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THE TRIAC LIGHTING-control circuit in **Figure 1** is small and inexpensive because load and housekeeping power come directly from the line voltage, thereby eliminating bulky, expensive supplies. The CLZD010 closed-loop controller maintains constant light intensity by automatically adjusting the timing of the triac's firing until the feedback signal and setpoint command are equal. The 5V supply is a charge pump that energizes C_1 on the negative swing of the line voltage and then transfers charge to C_2 on the positive swing. Zener diode D_2, minus the forward drop of rectifier D_1, sets the 5V. Triac Q_1 is a latching switch that conducts in either direction until you remove gate drive and load current drops below its holding threshold, which occurs at the zero-crossing point of the line voltage.

The circuit pulses the triac gate for 100

Figure 1

This closed-loop lighting-control system uses a few inexpensive parts.

86 EDN | September 2, 2004 www.edn.com

Figure 3. IC Introduction Enables Speed to Market and Free International Exposure through Magazine Design Briefs

CLOZD™ (Caldwell Loop Optimization in Z-Domain) is a digital closed-loop control chip developed for simplicity, robustness, and flexibility. Select the desired control configuration in Figure 2 through pin settings and quickly close a loop around a power supply, motor drive, lamp, heater, fan, valve, actuator, transmitter, transformer, regulator or virtually anything that needs to be controlled.

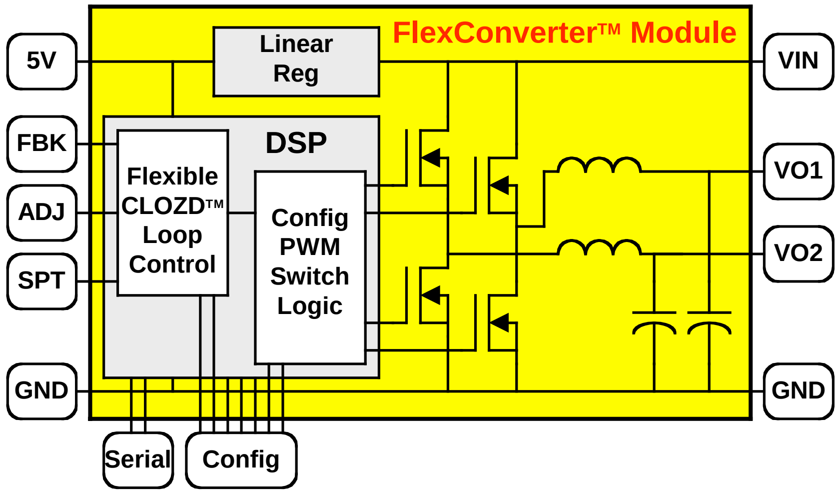

Figure 4. FlexConverter™ Combines Simple CLOZD™ Loop Controller with Flexible Power Converter to Enable Easy Process Control

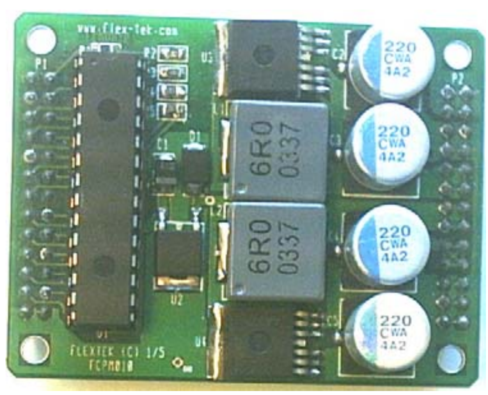

Figure 5. Board Introduction is Profitable for Small Business

Figure 4 contains a block diagram of the FlexConverter™ module. The power stage has dual filtered half-bridges that can be run independently or paralleled for higher current and lower ripple, as well as full-bridge or sequentially switched. The power module in Figure 5 is 2.5in X 1.9in with 0.1in spaced pins to fit standard prototype boards or solder to PCB for production. Input voltage range is 10–14V and output is 0–12V. Total output current is 10A through the two phase shifted outputs. Full load efficiency is 92% and recovery time to stepped loads is less than 100uS.

3. Origination over Enhancement

Most new products are enhancements of existing products, resulting in inefficient layered technology suitable only in resource rich environments like industrial automation and PC visual programming. An emerging technology with challenges in cost, processing speed and power consumption requires an original streamlined approach.

Figure 6 illustrates the flexible control technology patented by Flextek Electronics that enables a single product to satisfy multiple applications quickly and easily. Figure 7 extends flexible control to a digital power converter that doubles as a process controller.

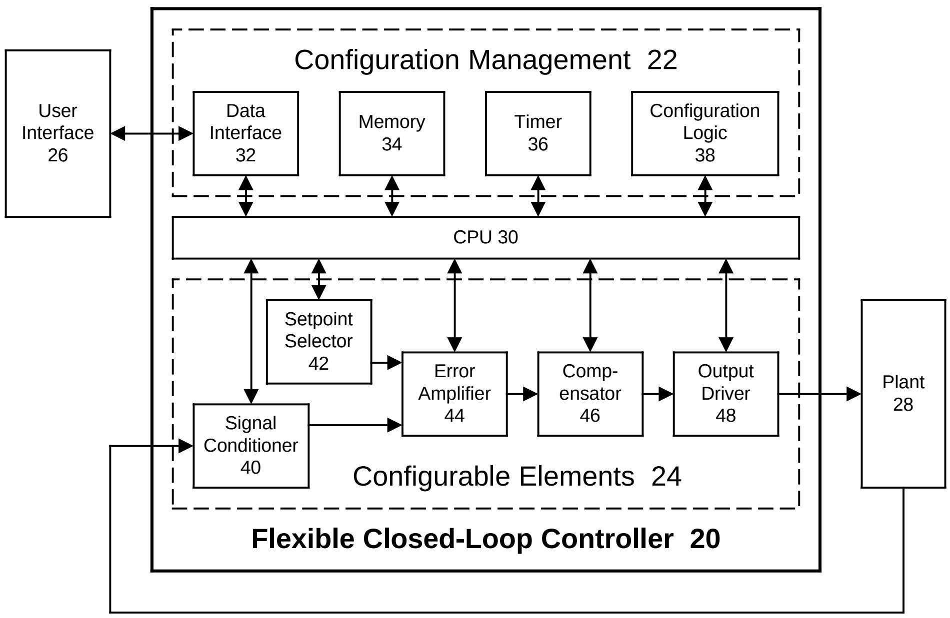

Figure 6. Patent 6697685: Flexible Closed-Loop Controller

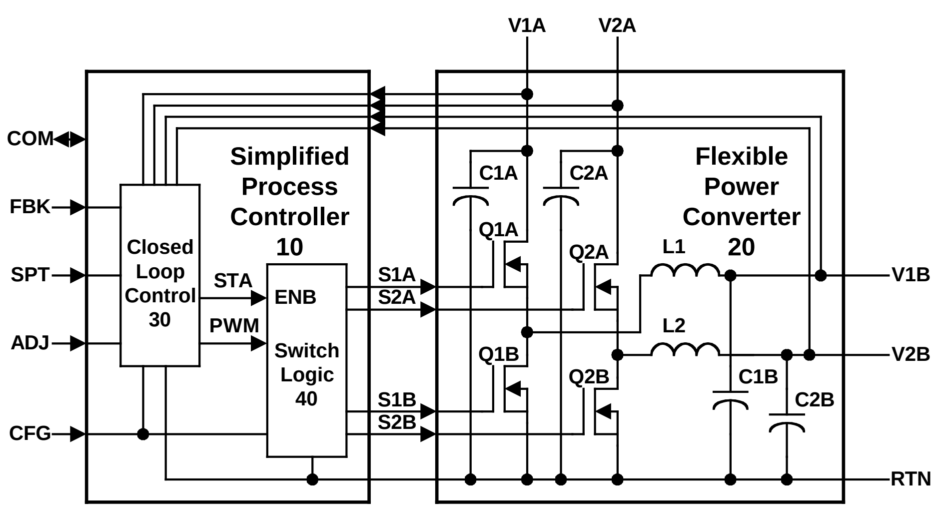

Figure 7. Patent Application 20070120543: Flexible Power Converter and Simplified Process Controller

4. Simplicity over Maximization

The future can often be predicted by reviewing the recent past. Peak current mode is more popular than average current mode. Converter ICs with built-in compensation are incredibly successful but resonant converters only hold a niche market. Customers like simple products that are easy to use. Most manufacturers opt to maximize a single product parameter for easy marketing, rather than innovate easy-to-use products. That approach is easier for the manufacturer than the customer.

The CLOZD™ algorithm compares the sensor feedback to the analog setpoint and calculates the appropriate PWM drive to equalize the two. Figure 8 shows the heater voltage and temperature response for a thermal system, both open and closed loop. Simply inspect the open loop time constant of the system (approximately 180 seconds to reach 63% of final value) and look up pin setting from the data sheet. Timing is adjusted for a specific application through a single parameter, in comparison to the three parameters of the analog-based PID technique. Another simplification is that the control adjustment is an intuitive time-domain setting rather than the complex PID frequency-domain settings.

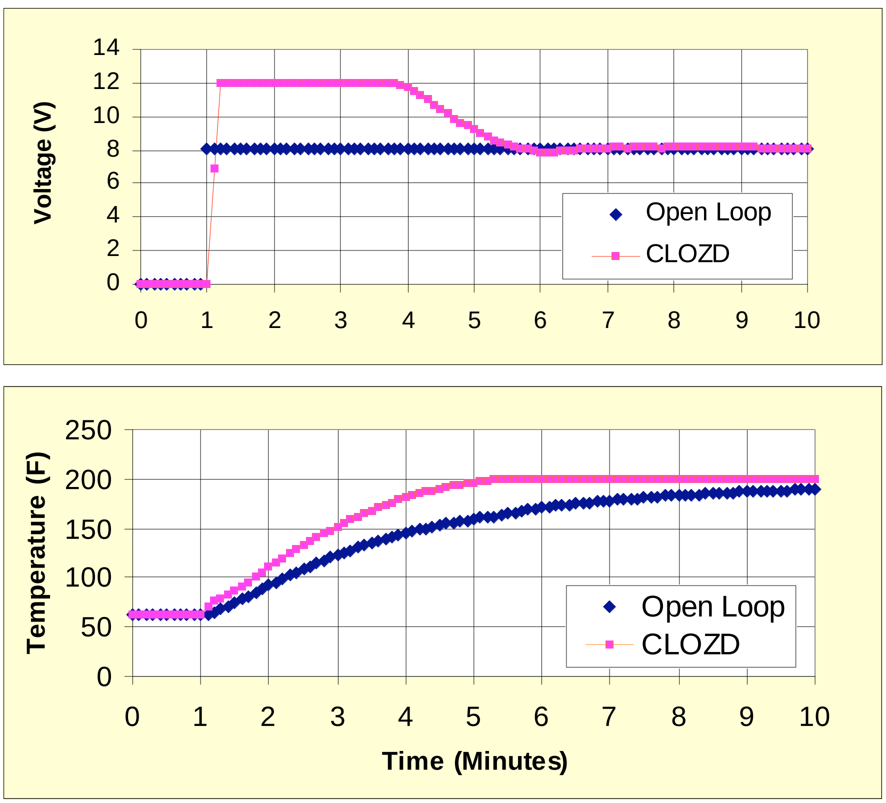

Figure 8. CLOZD™ Configuration by Intuitive Time-Domain Setting through Inspection of Open Loop Response in Thermal Example

5. Challenge over Acceptance

Accepting expert advice without question is risky. For example, it is widely published that PWM resolution should meet or exceed ADC resolution in a digital power converter. This requirement pushes processor clock speed, which pushes power consumption and cost, needlessly.

Figure 9 illustrates ten-bit output voltage regulation with seven-bit digital PWM resolution. High frequency ripple in the output voltage of the upper trace is from FET switching and only slight variations in the average are due to PWM resolution limits. The PWM voltage in the lower trace is the analog equivalent of the PWM register value.

Real knowledge enables use of a lower cost microcontroller with lower power consumption. For example the general purpose PIC24FJ16GA002 from Microchip for $1.66 drawing 15mA can be substituted the dsPIC30F1010 for $2.99 drawing over 100mA that was developed specifically for digital power control.

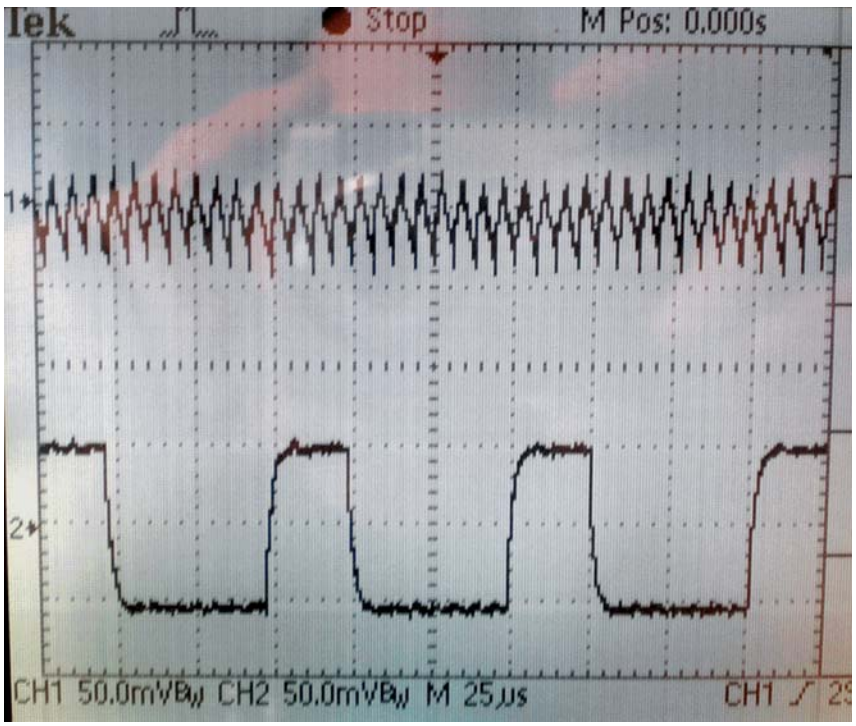

Figure 9. Ten-Bit Output Voltage Regulation (Upper Trace) Accomplished with Seven-Bit PWM (Lower Trace) Contradicting Expert Guidelines and Enabling Control by Low Cost Microcontroller with Low Current Draw

The closed loop control algorithm in a digital power converter will automatically adjust the PWM value at a rate faster than the time constant of the converter LC filter. Averaging of multiple varying PWM cycles will then maintain a relatively constant output voltage despite lower PWM resolution than ADC. Complete design guidelines for digital power control are given in Reference 3.

6. Education over Advertisement

Engineers intentionally overlook ads because they do not trust marketing, but they are constantly searching for opportunities to extend their knowledge to satisfy challenging tasks. Professional advancement courses, magazine articles and design briefs, and application notes with extensive practical examples are extremely effective in reaching engineers, as demonstrated by Unitrode. A small company with limited resources cannot afford an extensive advertising campaign so education is an effective means of product exposure.

Trade Results

CLOZD™ IC and FlexConverter™ effectively utilize digital power control to fill the gap between power converters and real-time controllers. Using the same product in a variety of applications reduces component cost through volume purchase, reduces development time by re-applying familiar technology, and increases reliability by utilizing proven components. Flexibility and simplicity are key to success in digital power control.

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