



US005568044A

# United States Patent [19]

[11] **Patent Number:** 5,568,044

**Bittner**

[45] **Date of Patent:** Oct. 22, 1996

[54] **VOLTAGE REGULATOR THAT OPERATES IN EITHER PWM OR PFM MODE**

*Primary Examiner*—Peter S. Wong  
*Assistant Examiner*—Shawn Riley  
*Attorney, Agent, or Firm*—Skjerven, Morrill, MacPherson, Franklin & Friel; William L. Paradice, III

[75] **Inventor:** Harry J. Bittner, Santa Clara, Calif.

[73] **Assignee:** Micrel, Inc., San Jose, Calif.

[57] **ABSTRACT**

[21] **Appl. No.:** 313,489

A switching voltage regulator achieves high efficiency by automatically switching between a pulse frequency modulation (PFM) mode and a pulse-width modulation (PWM) mode. Switching between the modes of voltage regulation is accomplished by monitoring the output voltage and the output current, wherein the regulator operates in PFM mode at small output currents and in PWM mode at moderate to large output currents. PFM mode maintains a constant output voltage by forcing the switching device to skip cycles when the output voltage exceeds its nominal value. In PWM mode, a PWM signal having a variable duty cycle controls the switching device. A constant output voltage is maintained by feedback circuitry which alters the duty cycle of the PWM signal according to fluctuations in the output voltage.

[22] **Filed:** Sep. 27, 1994

[51] **Int. Cl.<sup>6</sup>** ..... G05F 1/40

[52] **U.S. Cl.** ..... 323/272; 323/287; 323/224

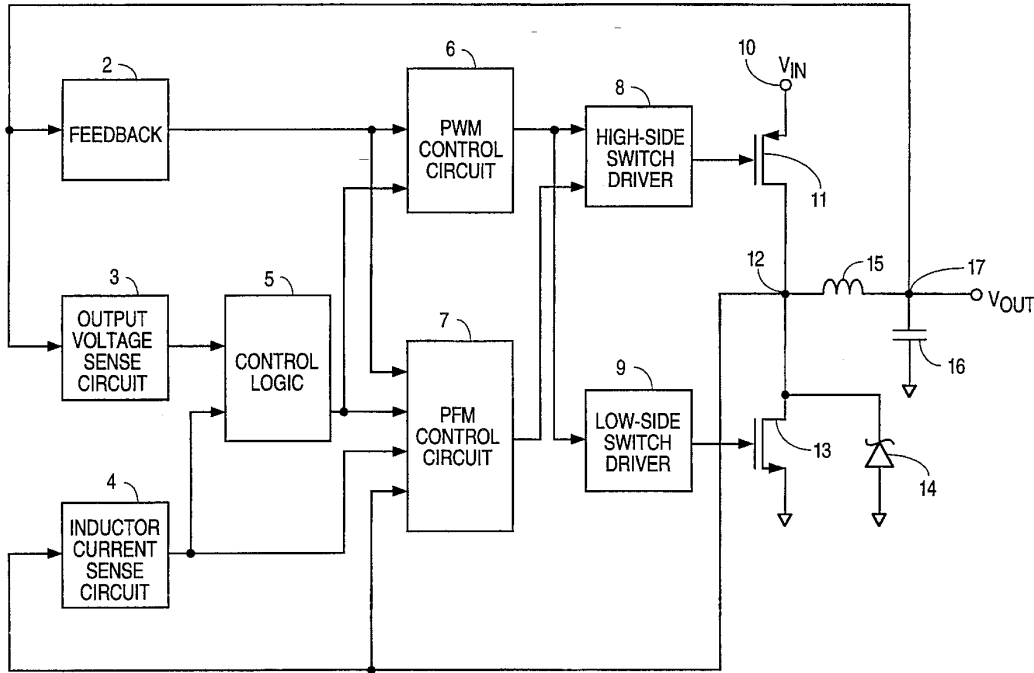
[58] **Field of Search** ..... 363/21, 41, 23; 323/268, 284, 272, 271, 224, 285, 286, 287

[56] **References Cited**

**U.S. PATENT DOCUMENTS**

4,047,083	9/1977	Plunkett	363/41
4,400,767	8/1983	Fenter	363/21
4,456,872	6/1984	Froeschle	323/286
4,626,763	12/1986	Edwards	363/41
5,481,178	1/1996	Wilcox et al.	323/287

**6 Claims, 9 Drawing Sheets**



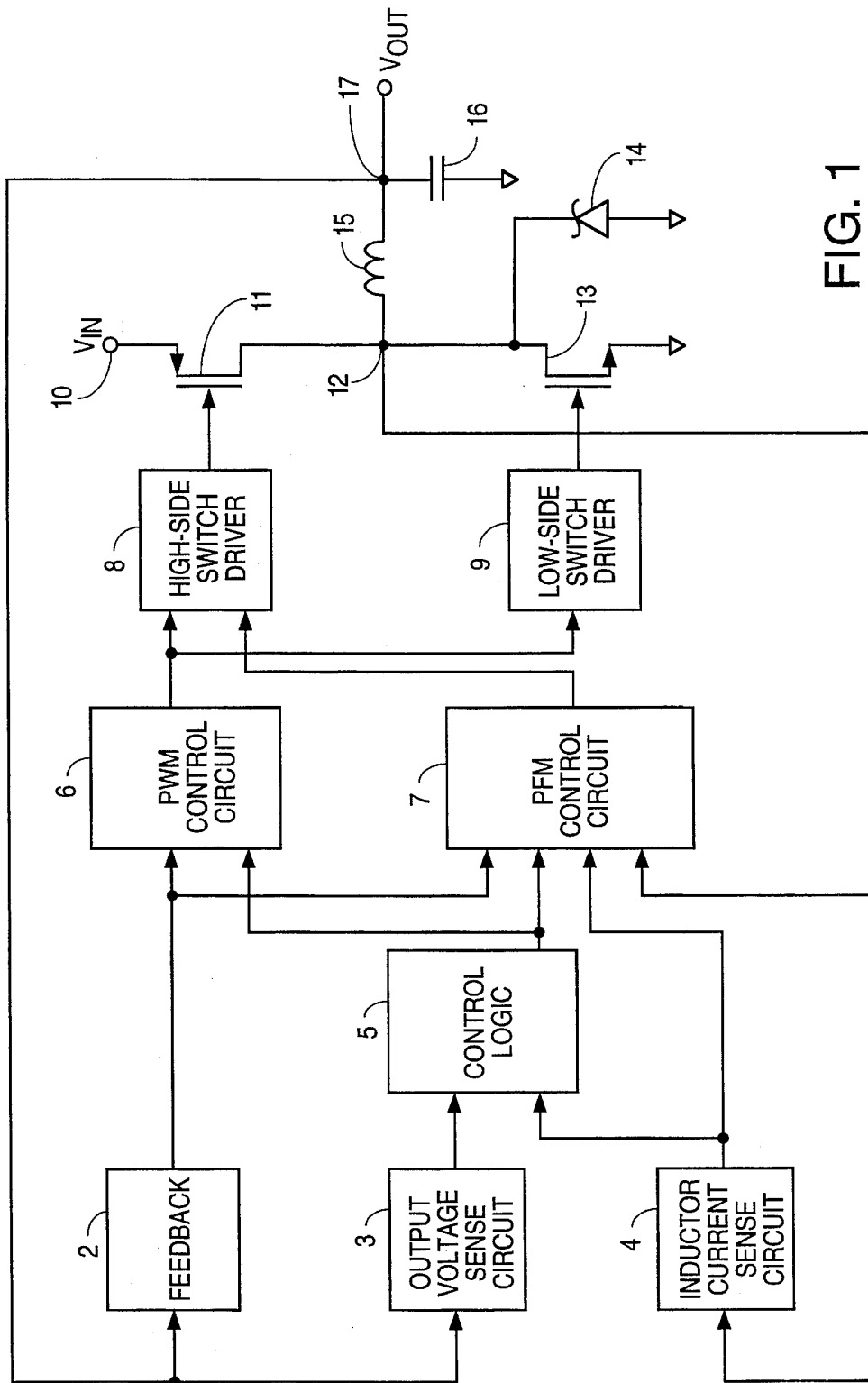


FIG. 1

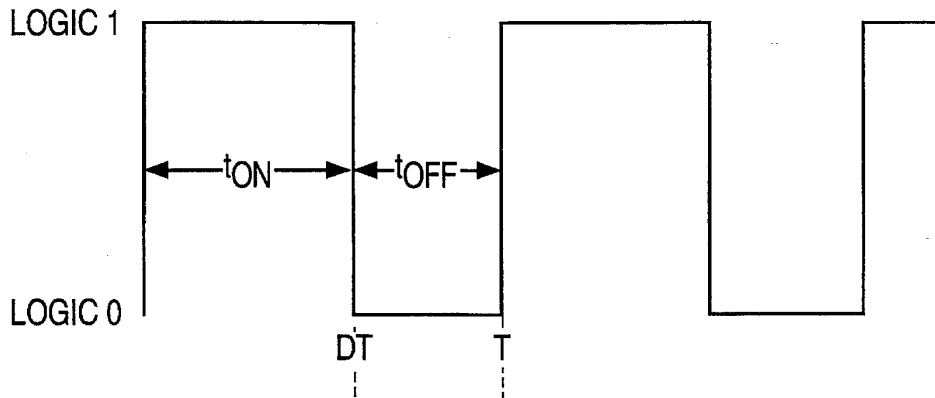


FIG. 2A

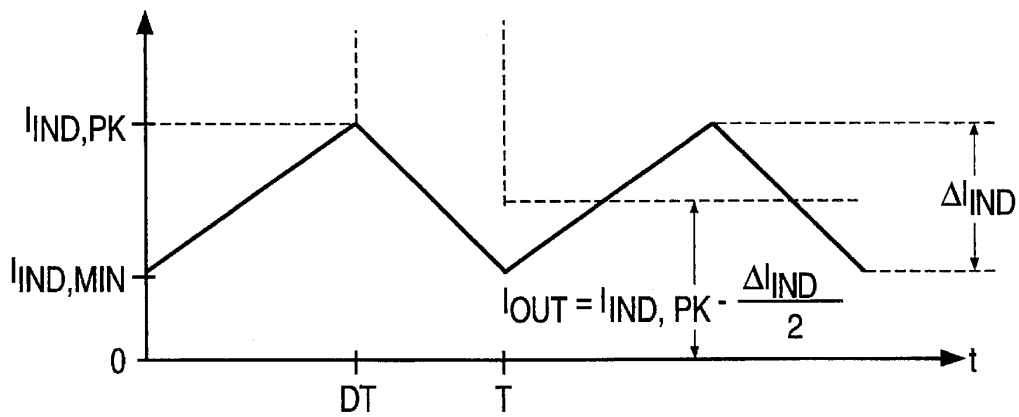


FIG. 2B

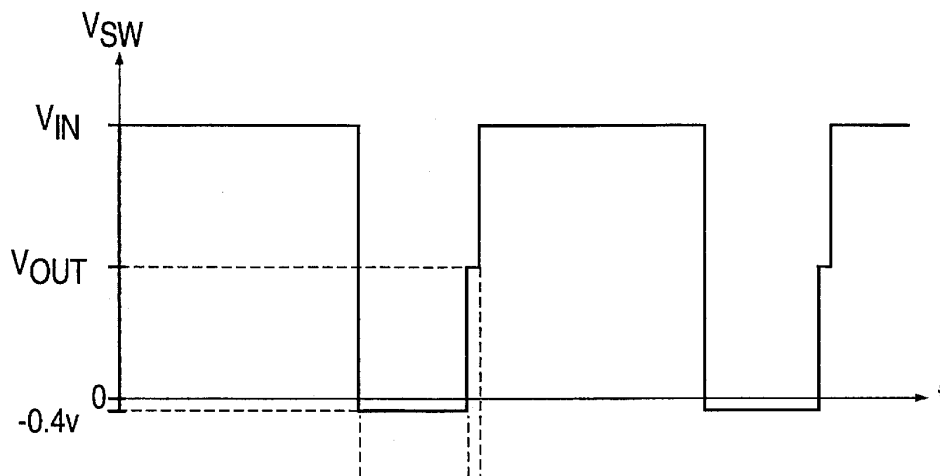


FIG. 3A

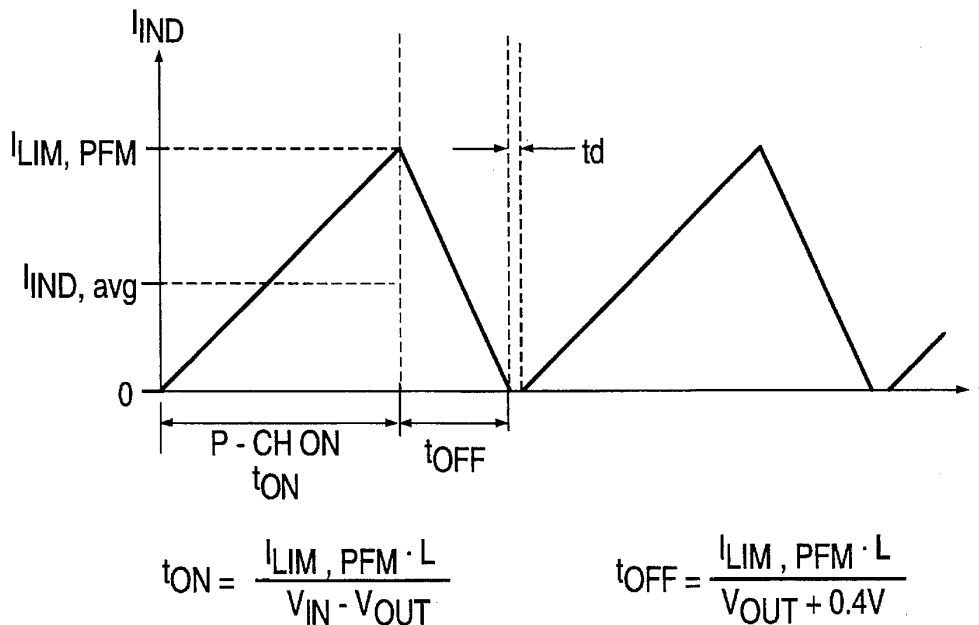


FIG. 3B

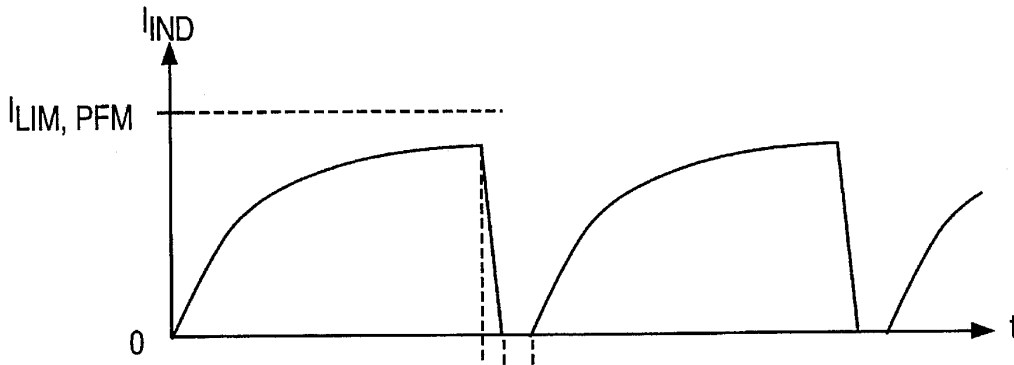


FIG. 4A

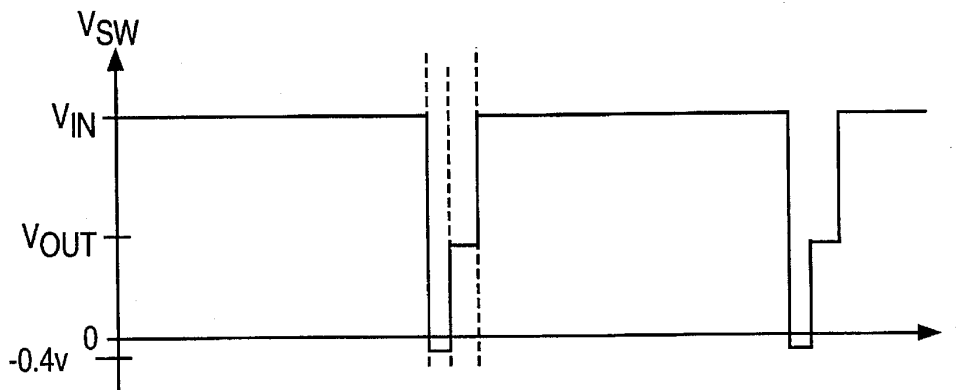


FIG. 4B

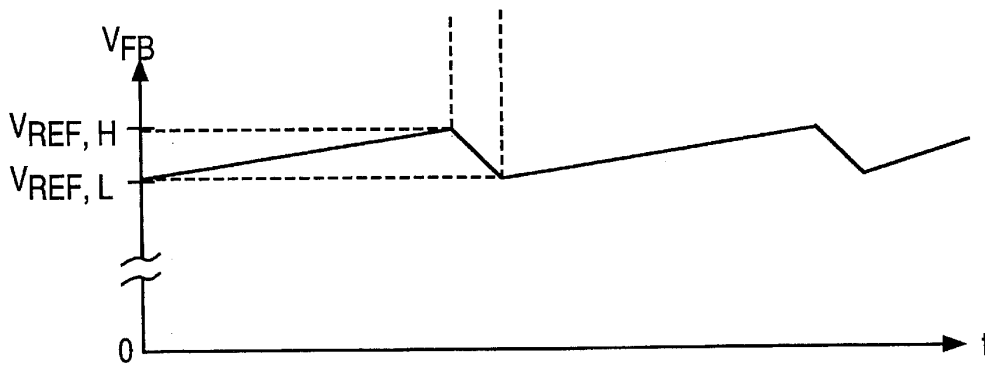


FIG. 4C

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.