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# United States Patent [19]

Wilcox et al.

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 [45] Date of Patent: **Mar. 24, 1998**

[54] **HIGH EFFICIENCY SWITCHING  
REGULATOR WITH ADAPTIVE DRIVE  
OUTPUT CIRCUIT**

7-222438 8/1995 Japan

## OTHER PUBLICATIONS

[75] Inventors: **Milton E. Wilcox**, Saratoga; **Robert C. Dobkin**, Monte Sereno; **Carl T. Nelson**, San Jose, all of Calif.

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[73] Assignee: **Linear Technology Corporation**, Milpitas, Calif.

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[21] Appl. No.: **786,500**

[22] Filed: **Jan. 21, 1997**

## Related U.S. Application Data

[63] Continuation of Ser. No. 454,595, May 30, 1995, abandoned.

[51] Int. Cl.<sup>6</sup> ..... **H03K 17/693**

[52] U.S. Cl. .... **327/403; 327/170; 327/389; 327/404; 327/541; 327/543**

[58] Field of Search ..... 327/170, 380, 327/381, 389, 391, 403, 404, 405, 538, 540, 541, 543; 326/87; 323/313, 315, 316

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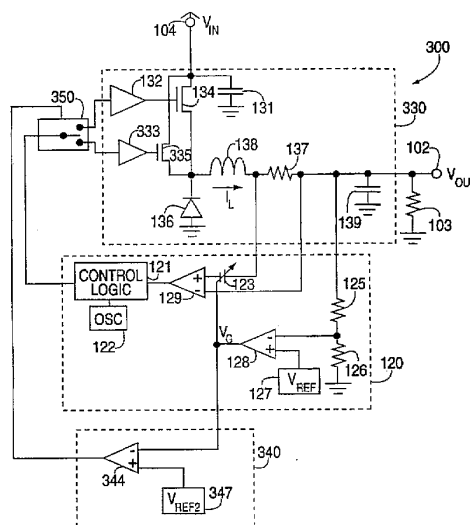
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Primary Examiner—Terry Cunningham  
 Attorney, Agent, or Firm—Fish & Neave; Robert W. Morris; Douglas A. Cardwell

## [57] ABSTRACT

Switching regulator circuits and methods are provided in which the output circuit is adaptable to maintain high efficiency over various load current levels. The regulator circuits generate one or more control signals in response to the load current and selectively route a switch driver control signal to one or more switches in the output circuit. The switches differ in their size, such that the most efficient switch can be used at a particular load current level. At low load current levels, the driver control signal is routed to output circuitry with smaller switch devices, which incur smaller driver current losses for a given frequency of operation, thereby increasing the regulator efficiency. At high load current levels, the driver control signal is routed to large switch devices, which incur greater driver current losses for a given frequency of operation, but which have a lower impedance. The regulator thus maintains high efficiency over a wide range of load currents while operating at a constant frequency.

**22 Claims, 5 Drawing Sheets**



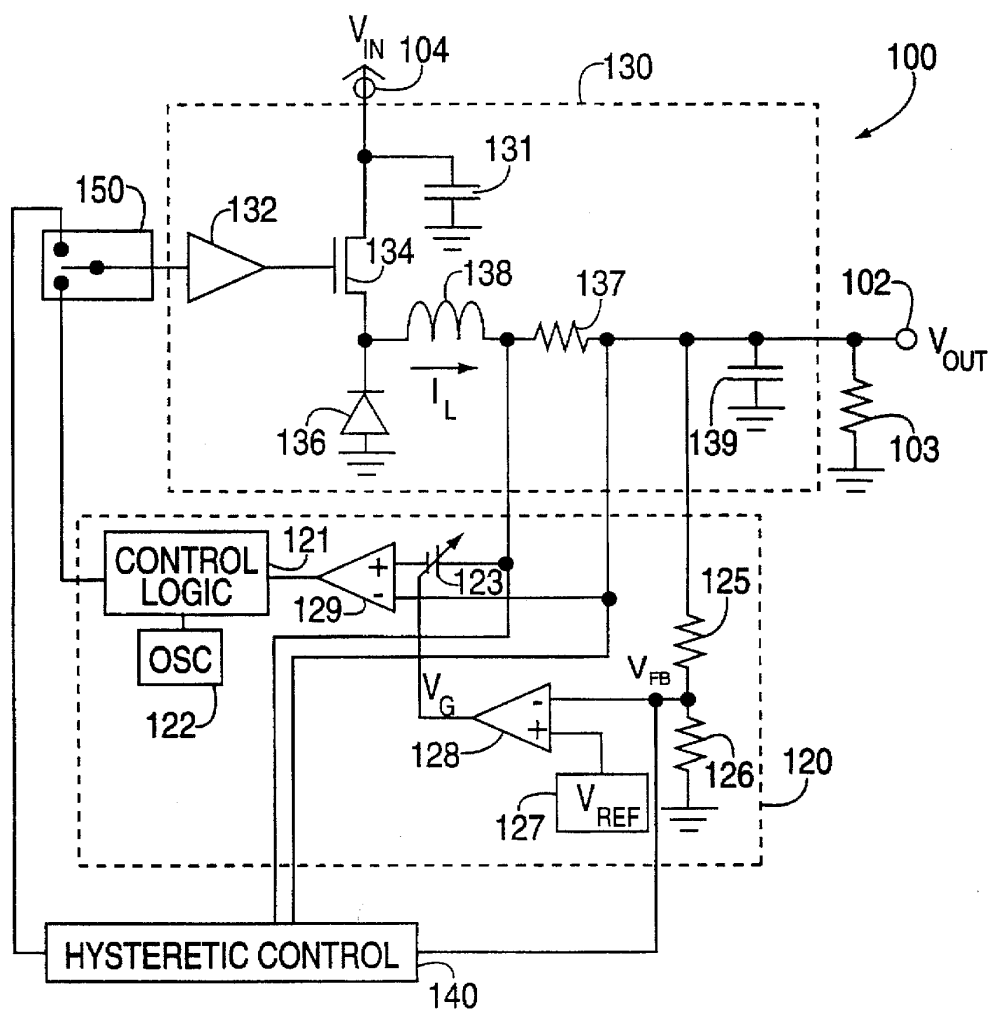


FIG. 1  
PRIOR ART

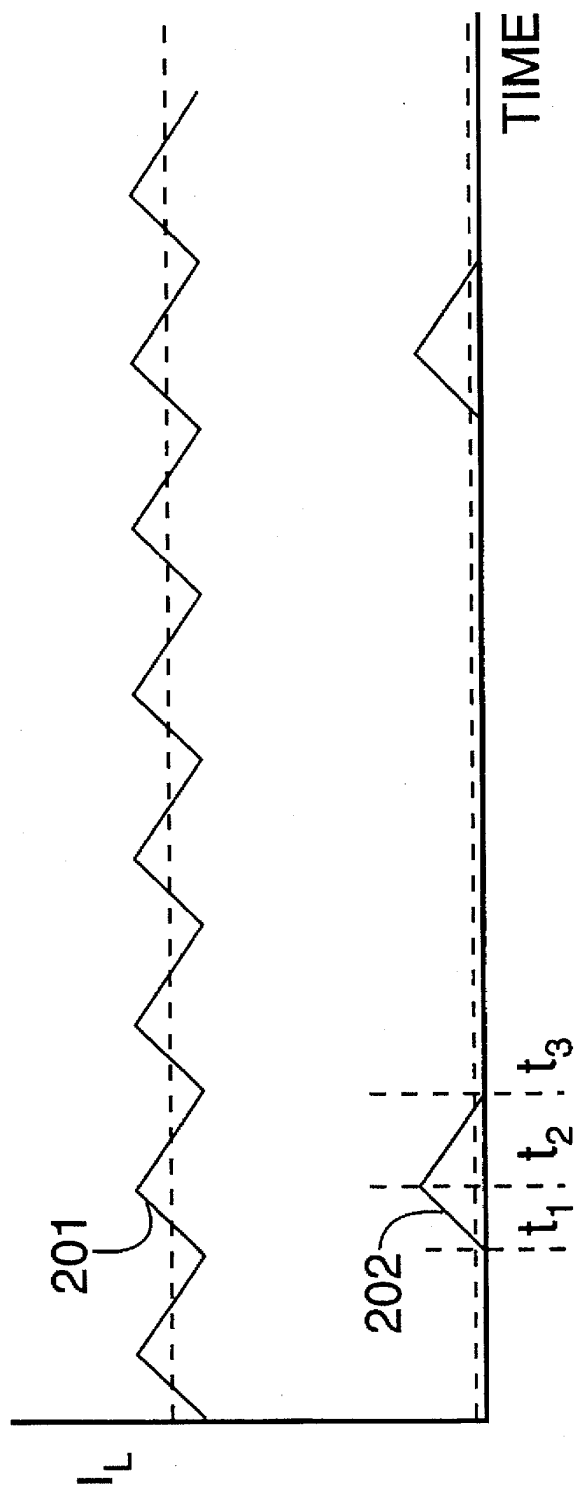


FIG. 2

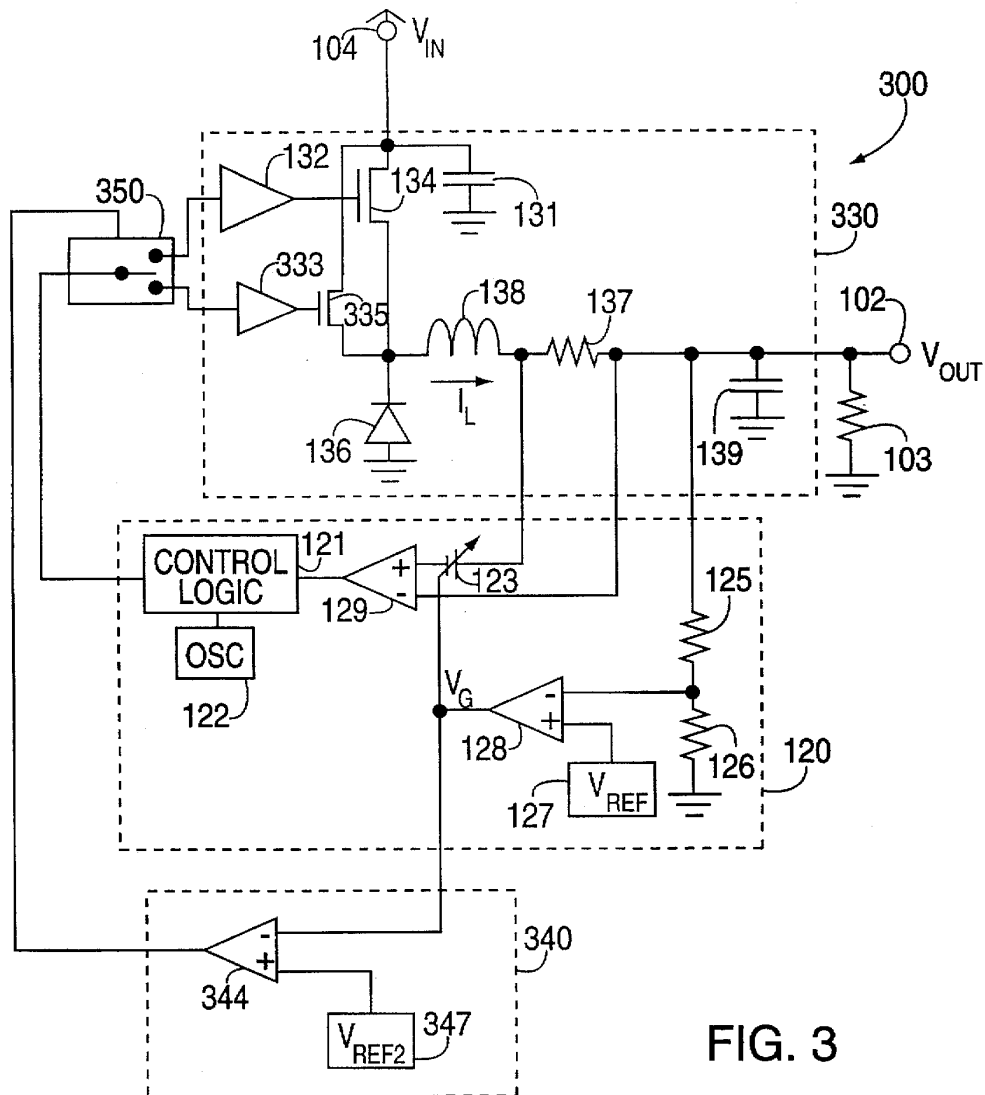


FIG. 3

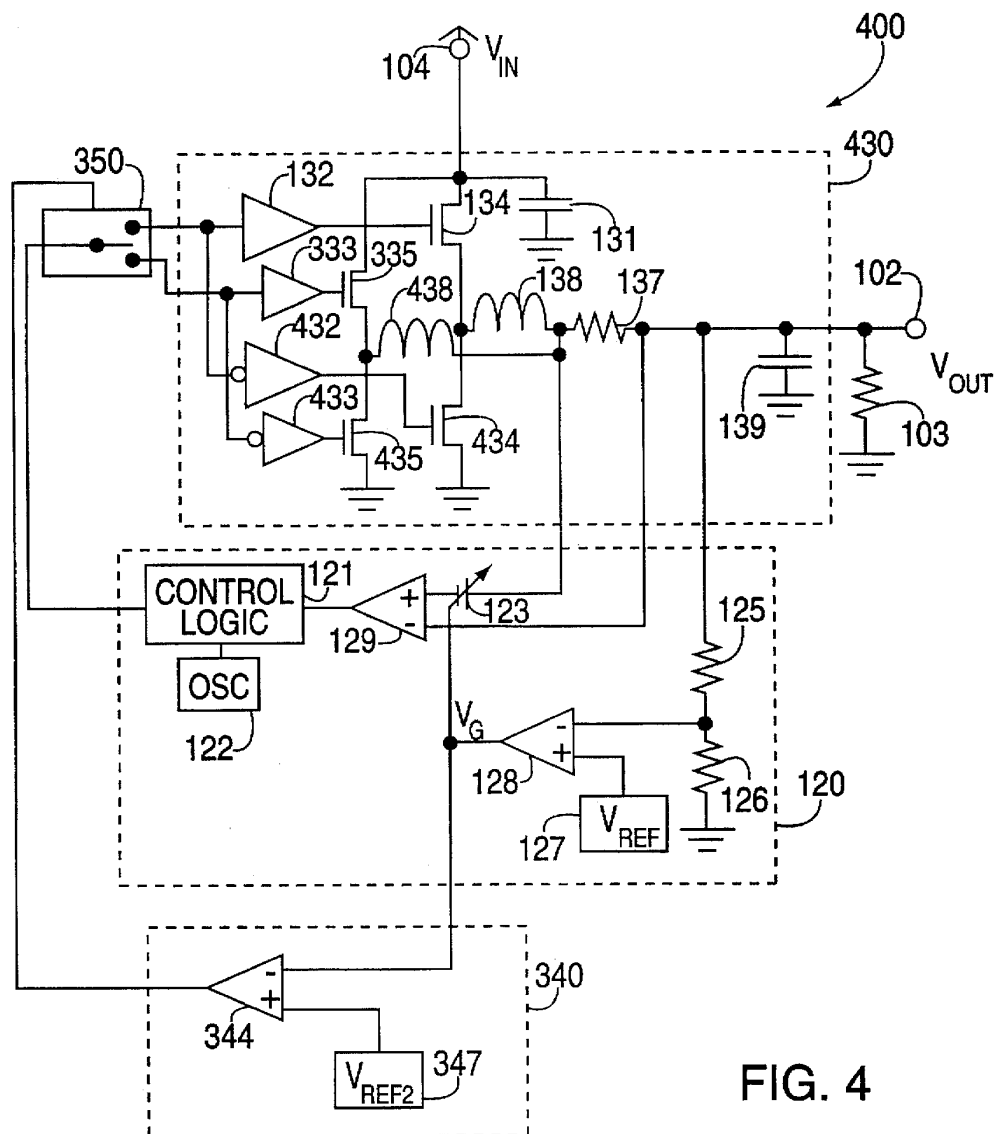


FIG. 4

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