LINEAR TECHNOLOGY

Application Note 30

February 1989

Switching Regulator Circuit Collection

Brian Huffman

Switching regulators are of universal interest. Linear Technology has made a major effort to address this topic. A catalog of circuits has been compiled so that a design engineer can swiftly determine which converter type is best. This catalog serves as a visual index to be browsed through for a specific or general interest.

The catalog is organized so that converter topologies can be easily found. There are 12 basic circuit categories: Battery, Boost, Buck, Buck-Boost, Flyback, Forward, High Voltage, Multi-Output, Off-Line, Pre-Regulator, Switched Capacitor, and Telecom. Additional circuit information can be located in the references listed in the index. The reference works as follows, i.e., AN8, Page 2 = Application Note 8, Page 2; LTC1044 DS = LTC1044 data sheet; DN17 = Design Note 17.

DRAWING INDEX

DRAWING INDEX (Continued)

DRAWING INDEX (Continued)

DRAWING INDEX (Continued)

SUGGESTED READING

Pulse Engineering Catalog — Switching Magnetics
Pulse Engineering, Inc.
P.O. Box 12235
San Diego, CA 92112
Phone: 619-268-2400

Pressman, A.I., "Switching and Linear Power Supplies, Power Converter Design," Hayden Book Co., Hasbrouck Heights, New Jersey, 1977, ISBN 0-8104-5847-0.

Chryssis, G., "High Frequency Switching Power Supplies, Theory and Design," McGraw Hill, New York, 1984, ISBN 0-07-010949-4.

Nelson, C., "LT1070 Design Manual," Linear Technology Corporation, Application Note 19.

Williams, J., "Switching Regulators for Poets," Linear Technology Corporation, Application Note 25.

Williams, J., "Power Conditioning Techniques for Batteries," Linear Technology Corporation, Application Note 8.

Williams, J. and Huffman, B., "Some Thoughts on DC-DC Converters," Linear Technology Corporation, Application Note 29.

Williams, J., "Inductor Selection for LT1070 Switching Regulators," Linear Technology Corporation, Design Note 8.

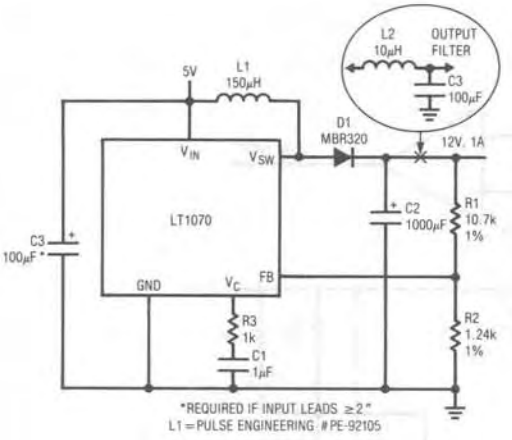


Figure 1. Boost Converter (5V to 12V)

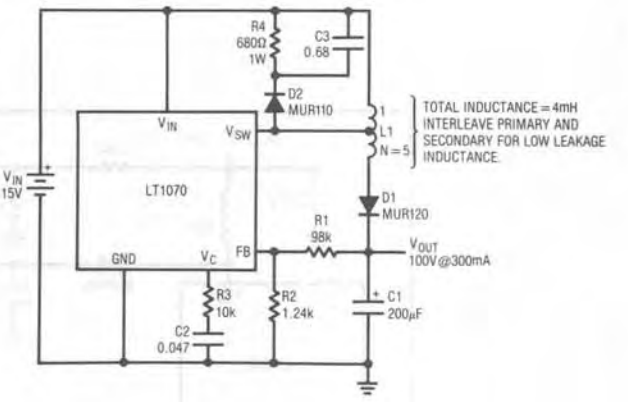


Figure 2. Voltage Boosted Boost Converter (15V to 100V)

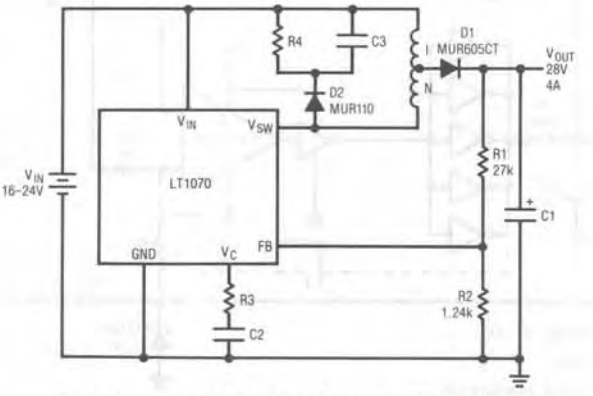


Figure 3. Current Boosted Boost Converter (16V-24V to 28V)

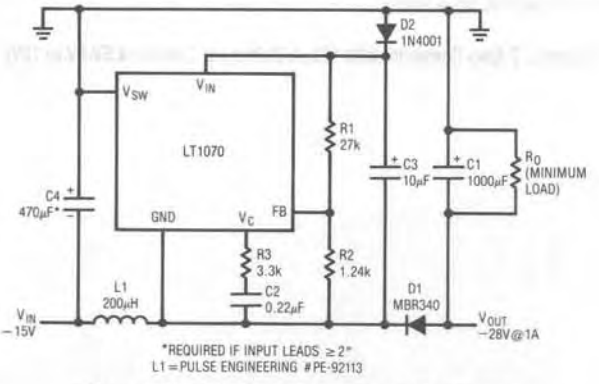


Figure 4. Negative Boost Regulator (– 15V to – 28V)

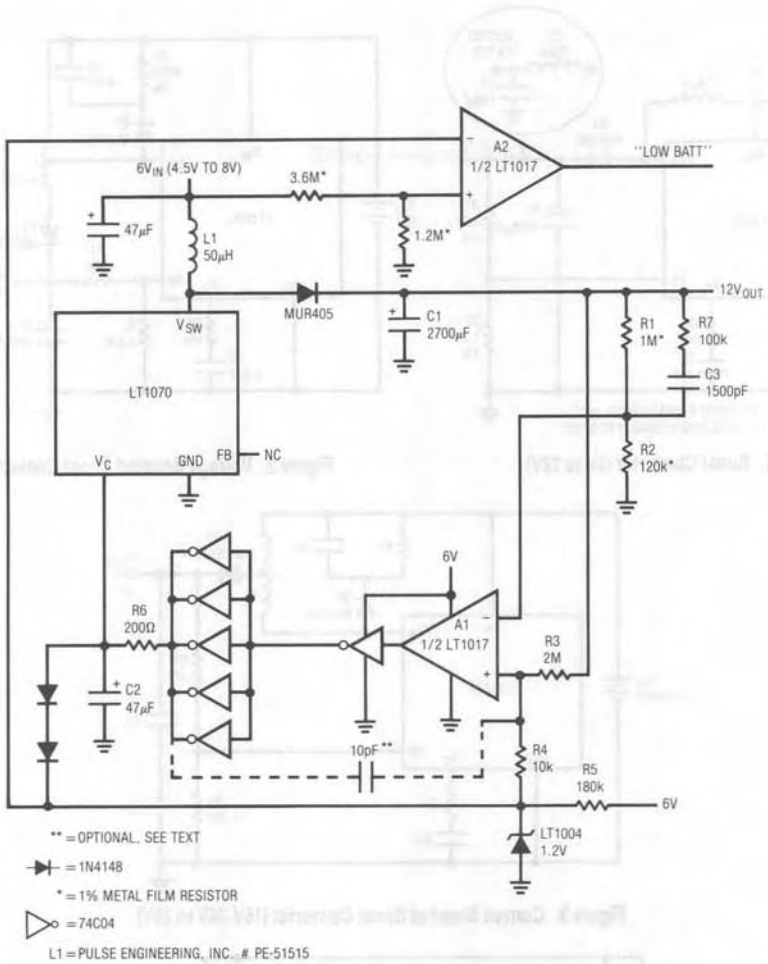


Figure 5. 2 Amp Converter with 150μA Quiescent Current (4.5V-8V to 12V)

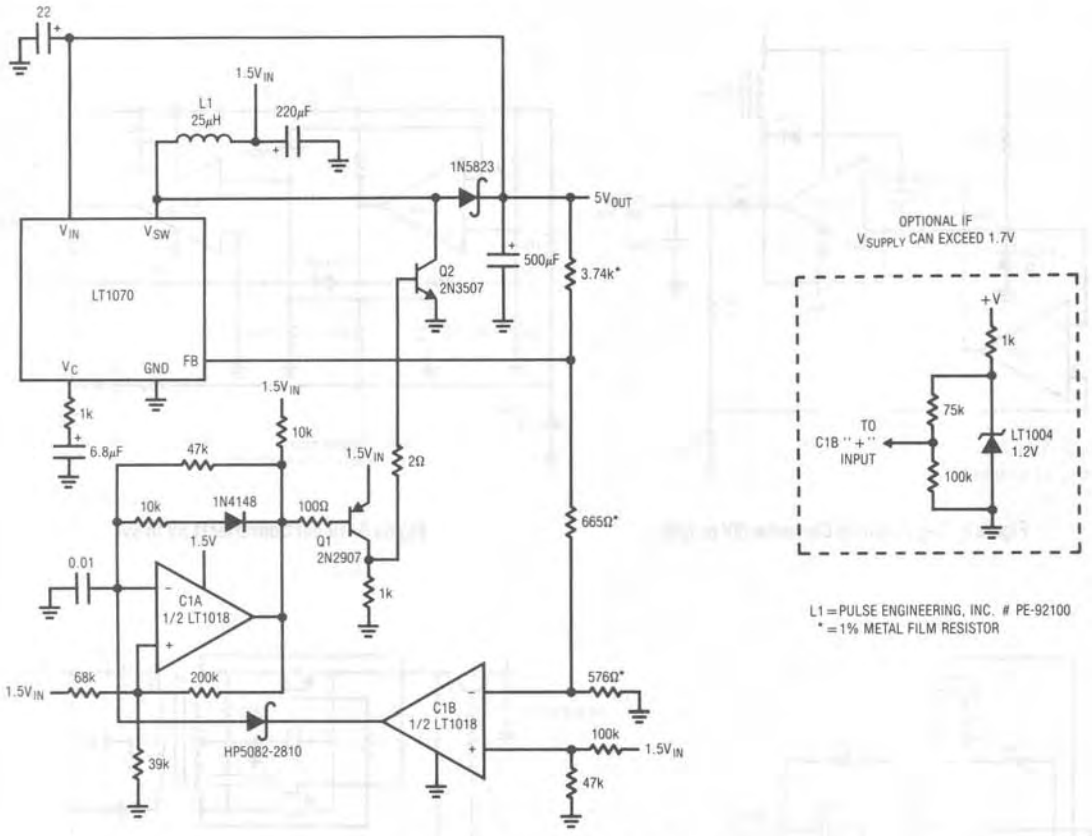


Figure 6. 200mA Output Converter (1.5V to 5V)

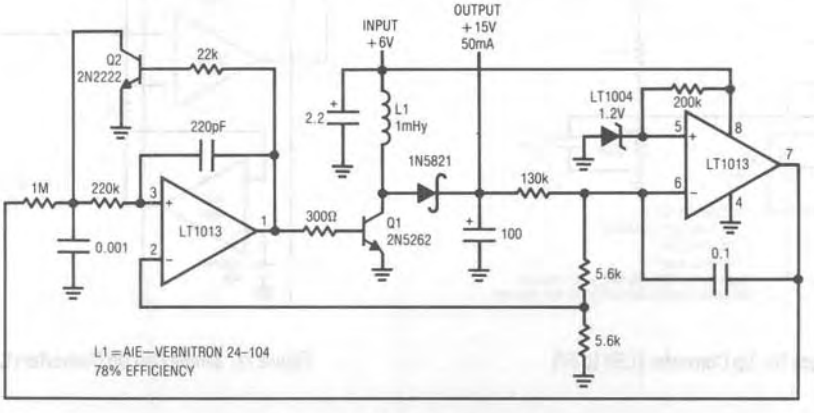


Figure 7. Up Converter (6V to 15V)

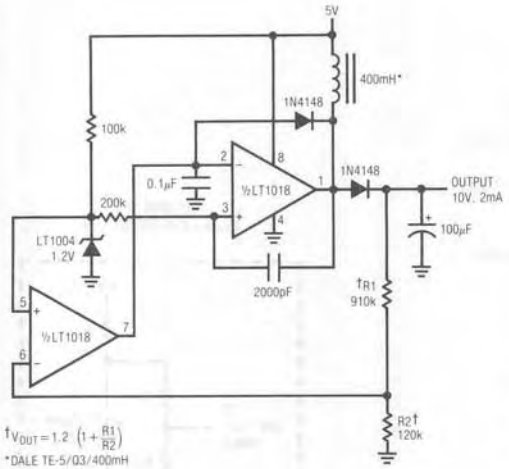


Figure 8. Regulated Up Converter (5V to 10V)

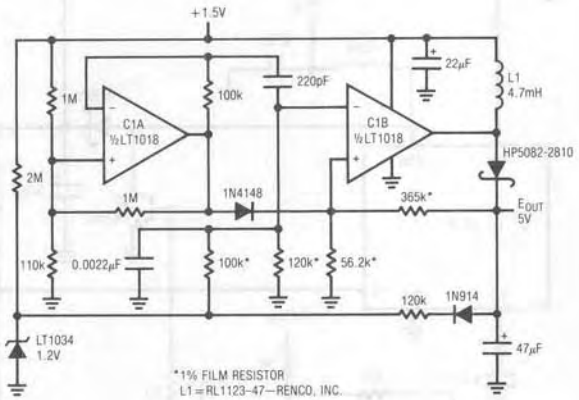


Figure 9. Boost Converter (1.5V to 5V)

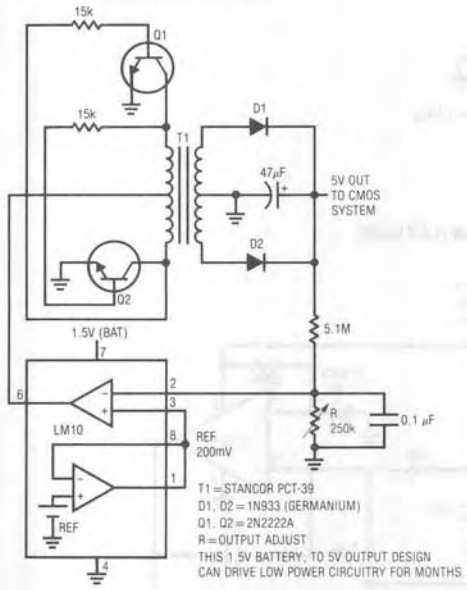


Figure 10. Up Converter (1.5V to 5V)

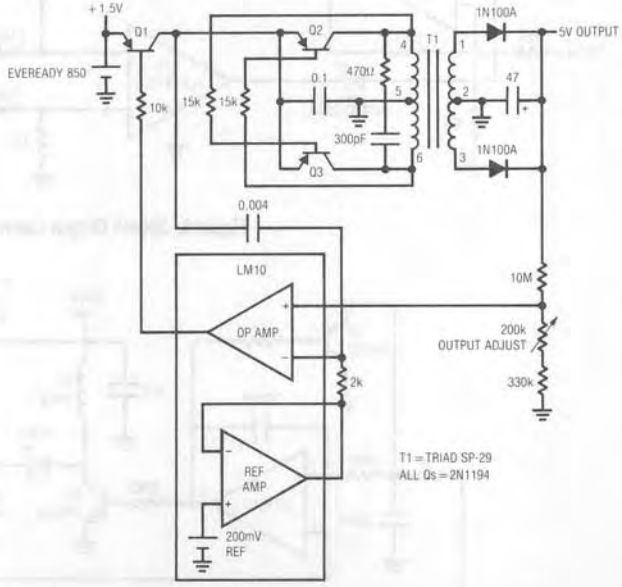


Figure 11. Single Cell Up Converter (1.5V to 5V)

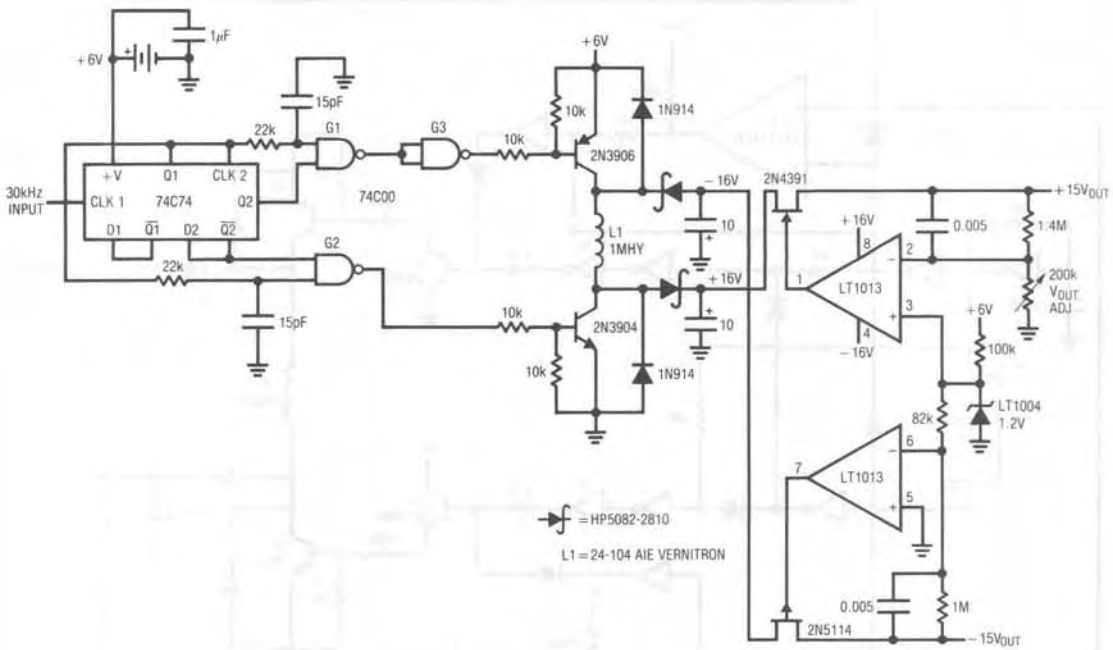


Figure 12. Single Inductor, Dual Polarity Regulator (6V to ± 15V)

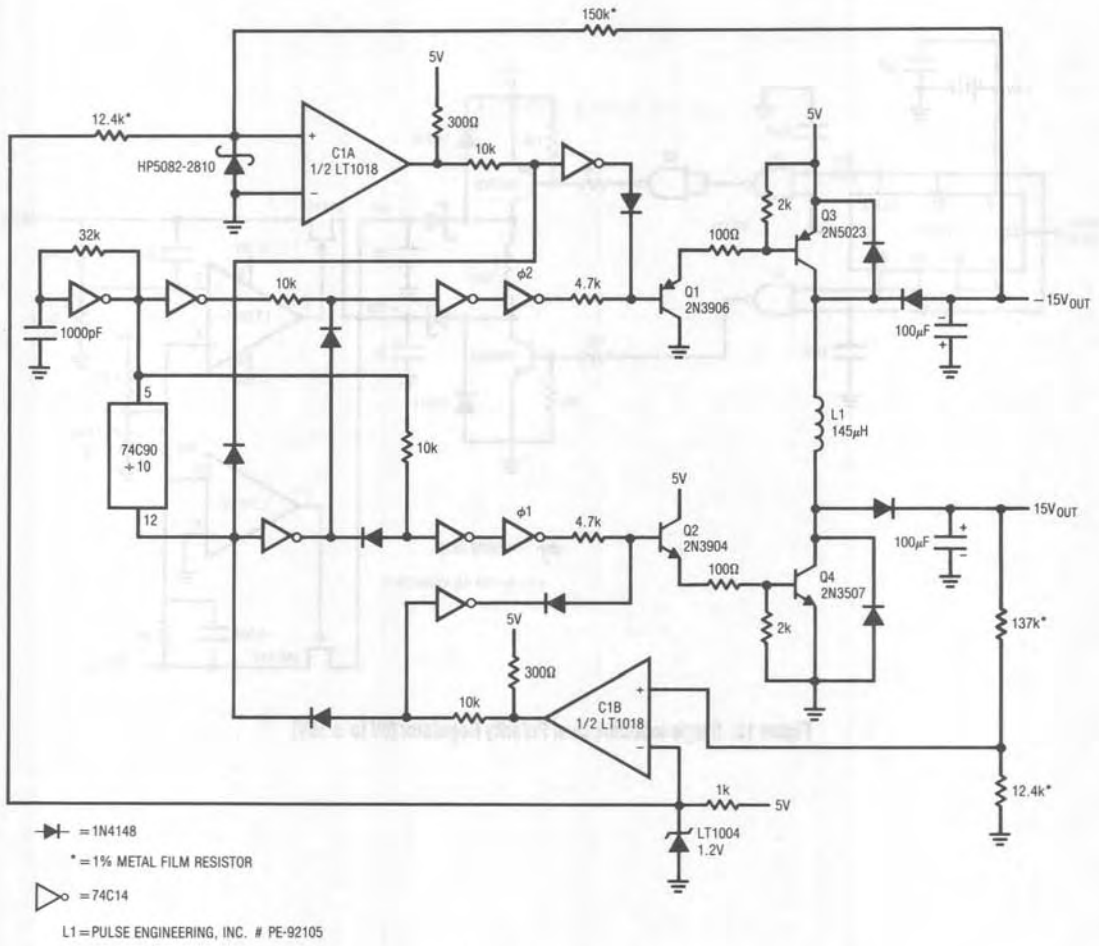


Figure 13. Single Inductor Regulated Converter (5V to ±15V)

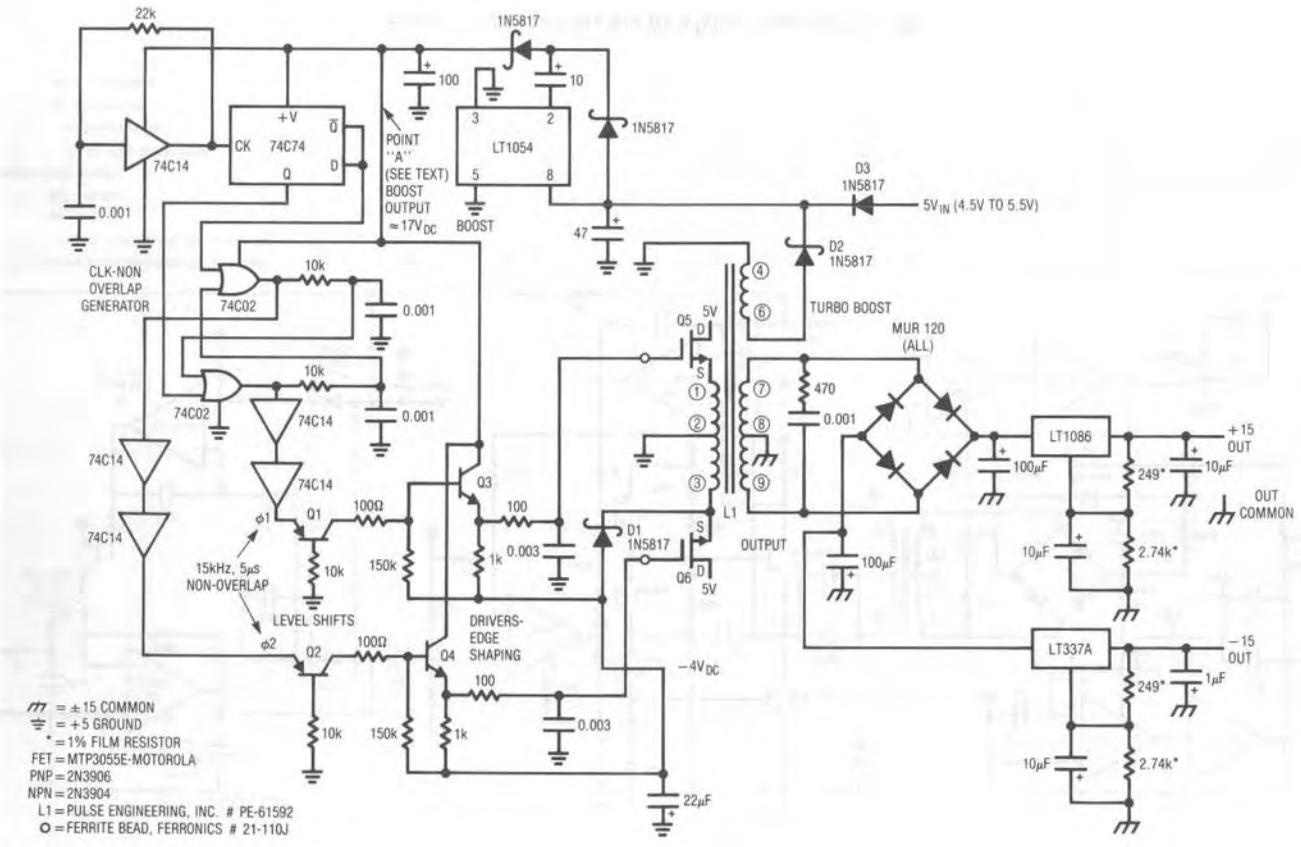
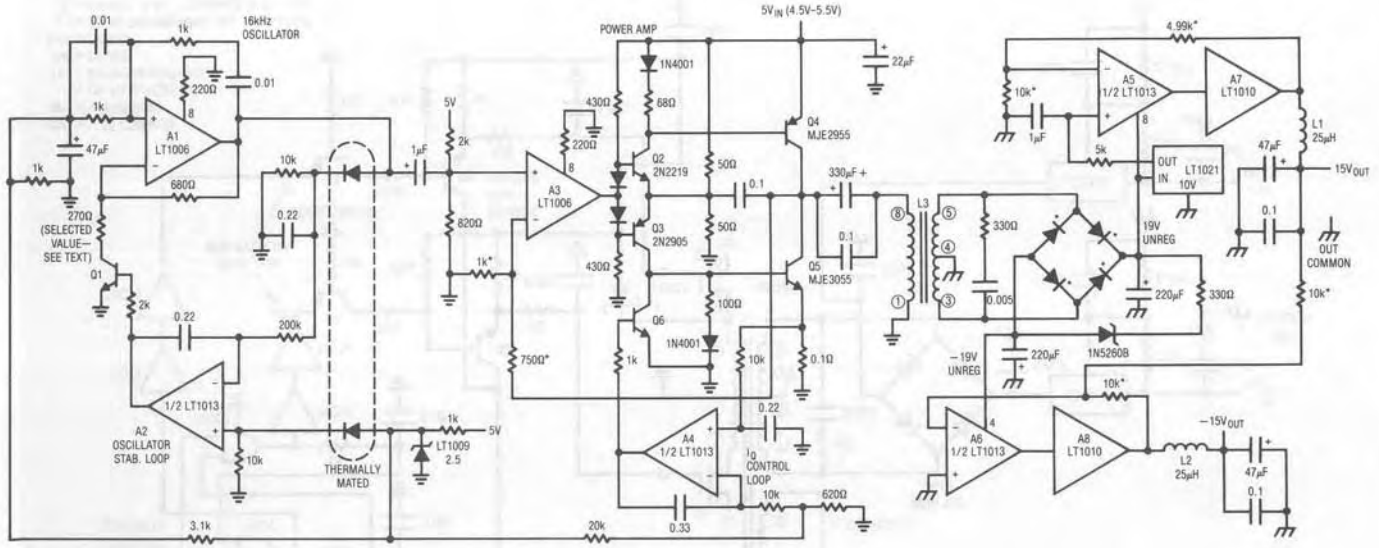


Figure 14. Low Noise Converter (5V to ± 15V)



L1, L2 = PULSE ENGINEERING, INC. # PE-92100
L3 = PULSE ENGINEERING, INC. # PE-65064
= 1N4148
= 1N4934
UNMARKED NPN = 2N3904
* = 1% METAL FILM RESISTOR
+ = THF337K006P1G
= +5 GROUND
= ±15 COMMON

Figure 15. Ultra Low Noise Sine Wave Drive Converter (5V to ± 15V)

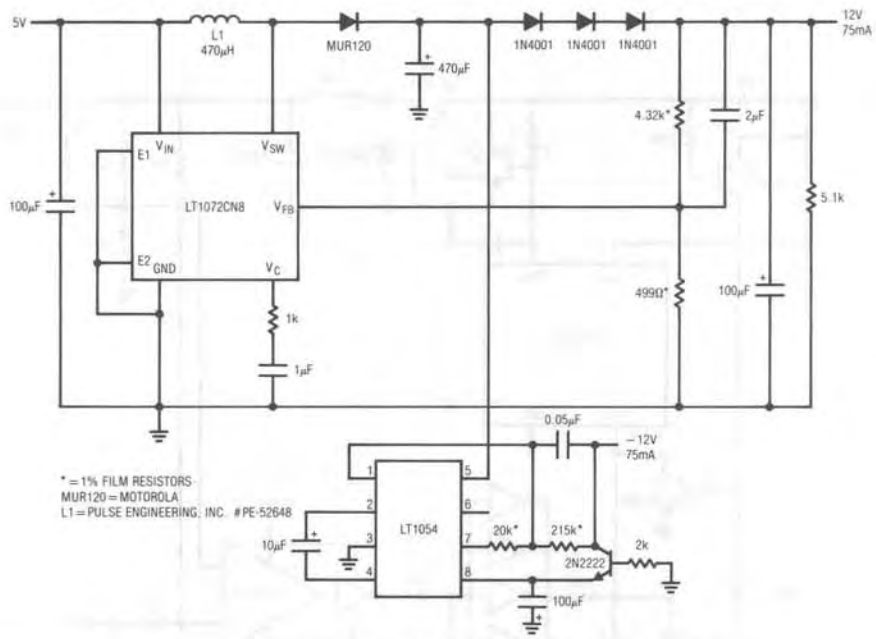


Figure 16. Single Inductor, Dual Output Converter (5V to ±15V)

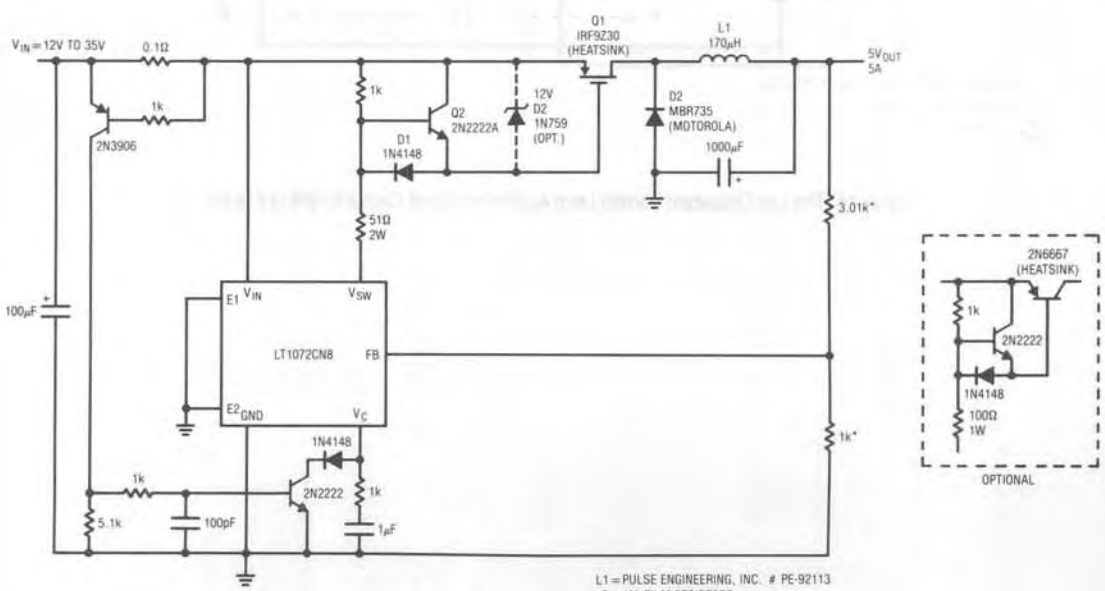


Figure 17. Positive Buck Converter (15V-35V to 5V)

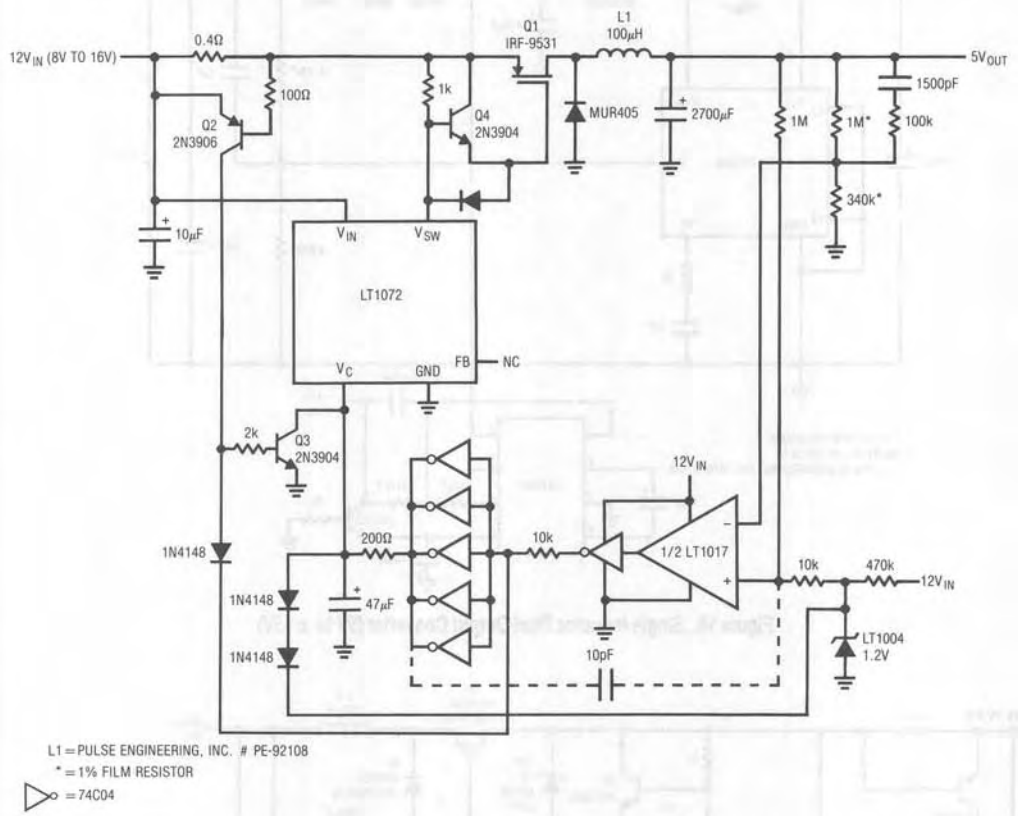


Figure 18. The Low Quiescent Current Loop Applied to a Buck Converter (8V-16V to 5V)

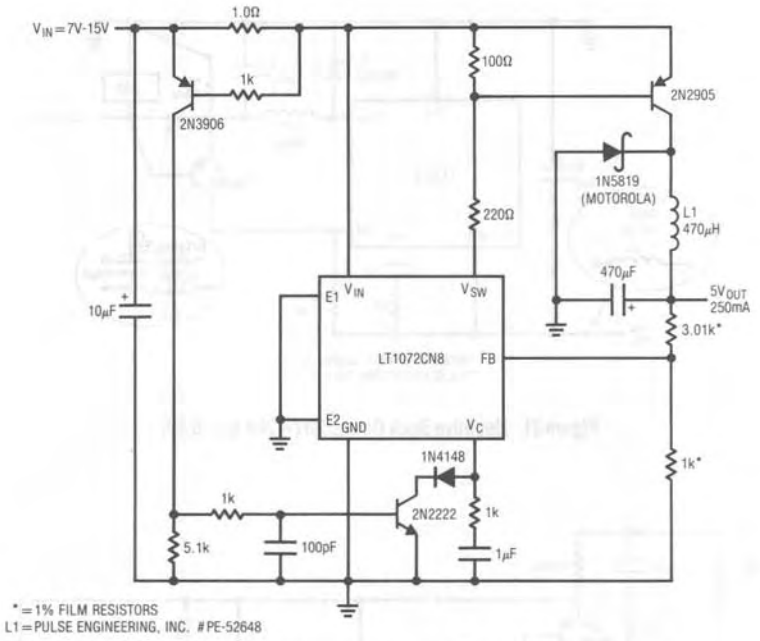


Figure 19. Positive Buck Converter (7V-15V to 5V)

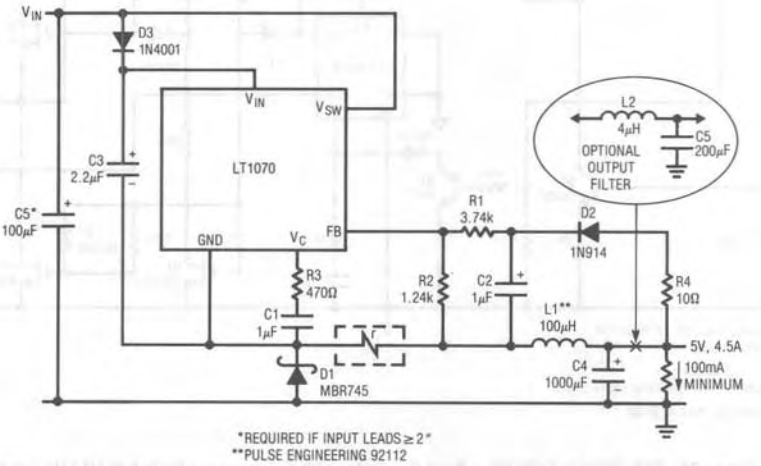


Figure 20. Positive Buck Converter

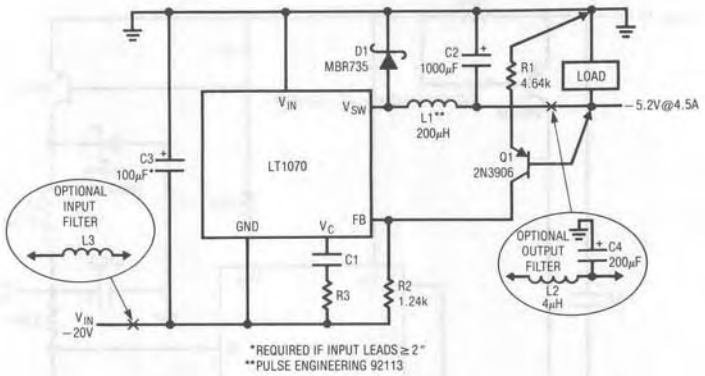


Figure 21. Negative Buck Converter (– 20V to – 5.2V)

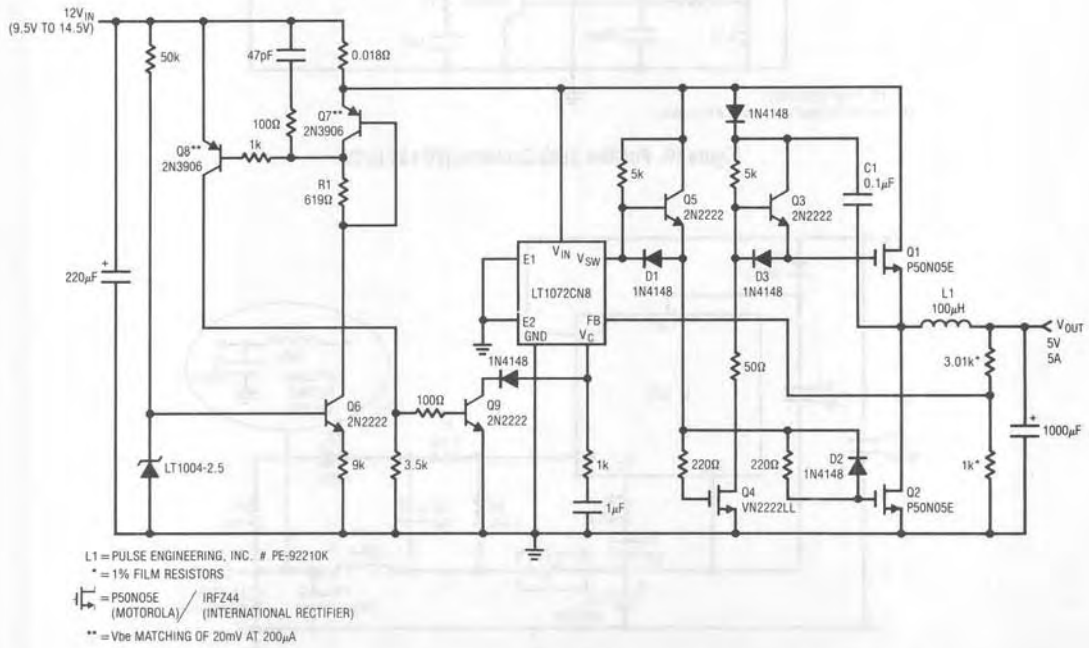


Figure 22. 90% Efficiency Positive Buck Converter with Synchronous Switch (9.5V-14V to 5V)

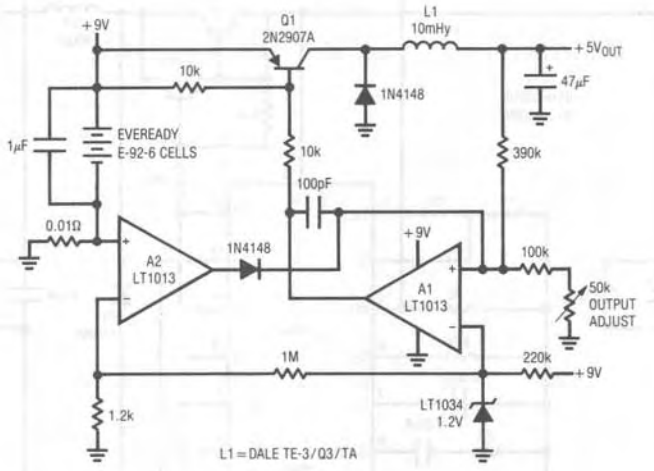


Figure 23. Low Power Switching Regulator (9V to 5V)

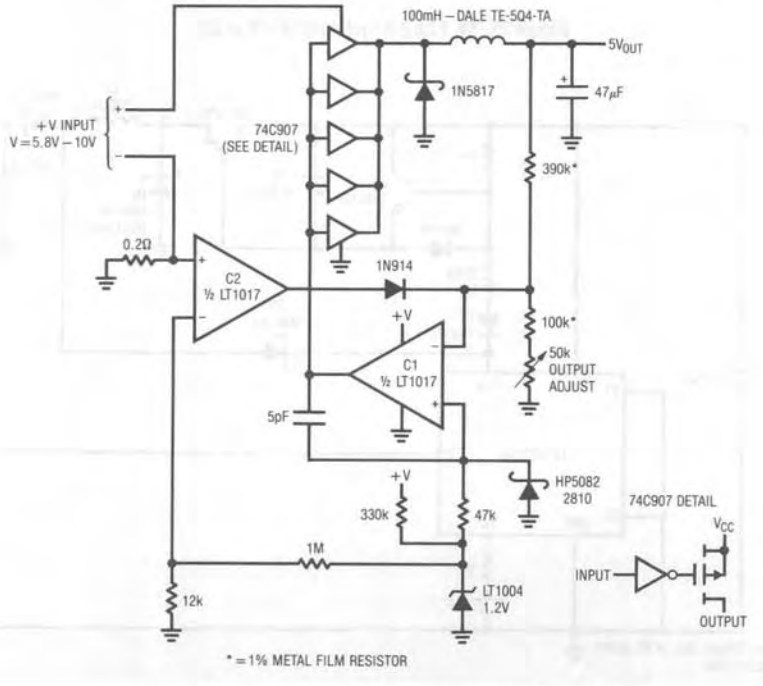


Figure 24. Micropower Switching Regulator (5.8V-10V to 5V)

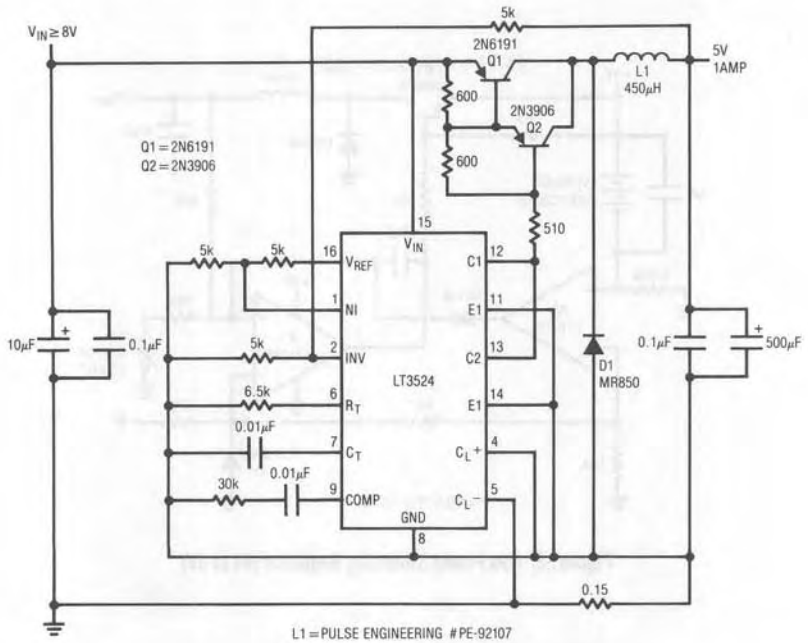


Figure 25. 5V, 1 Amp Regulator (8V-30V to 5V)

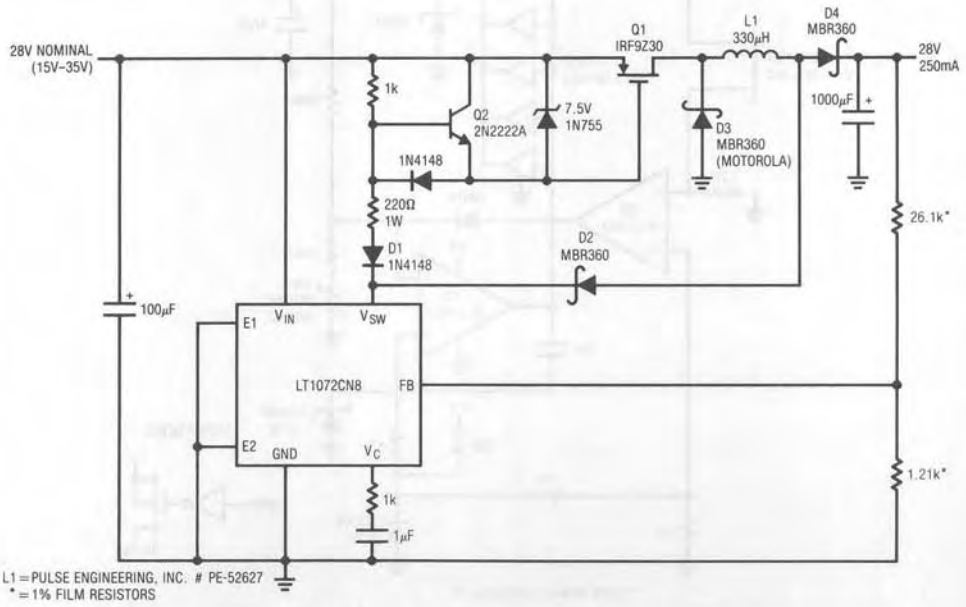


Figure 26. Positive Buck-Boost Converter (15V-35V to 28V)

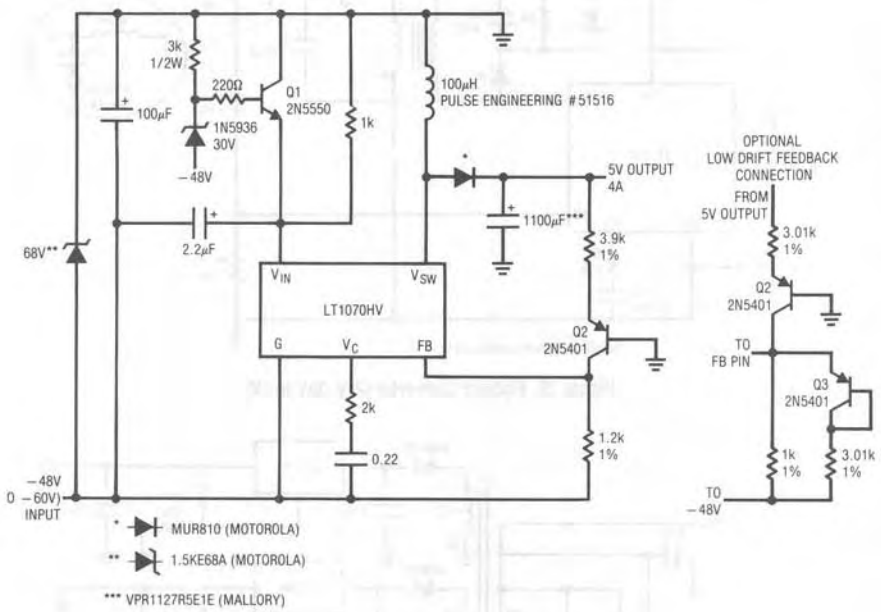


Figure 27. Non-Isolated Regulator (– 48V to 5V)

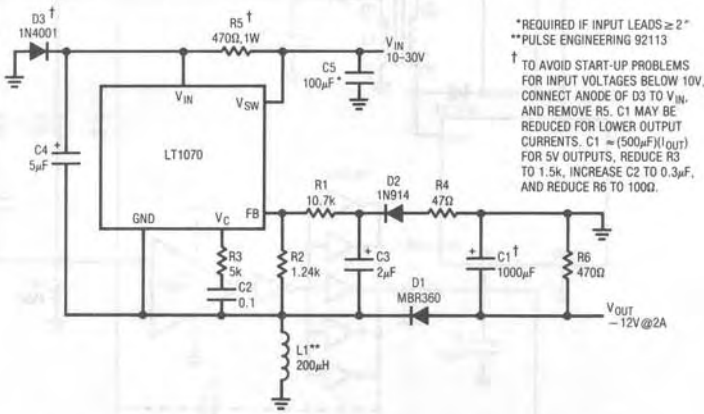


Figure 28. Positive to Negative Buck-Boost Converter (10V-30V to – 12V)

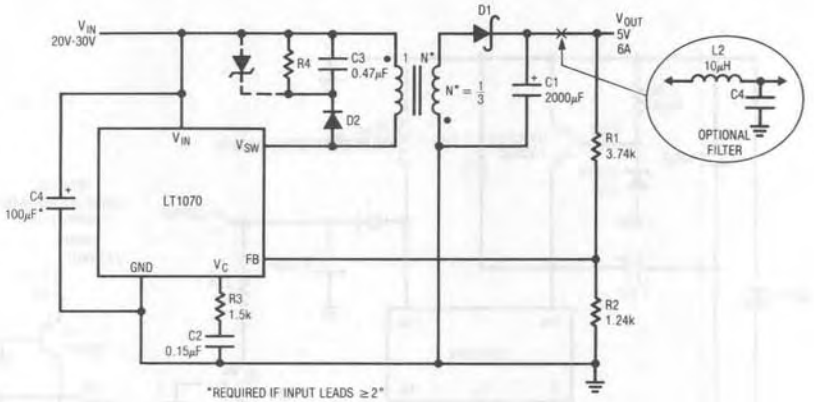


Figure 29. Flyback Converter (20V-30V to 5V)

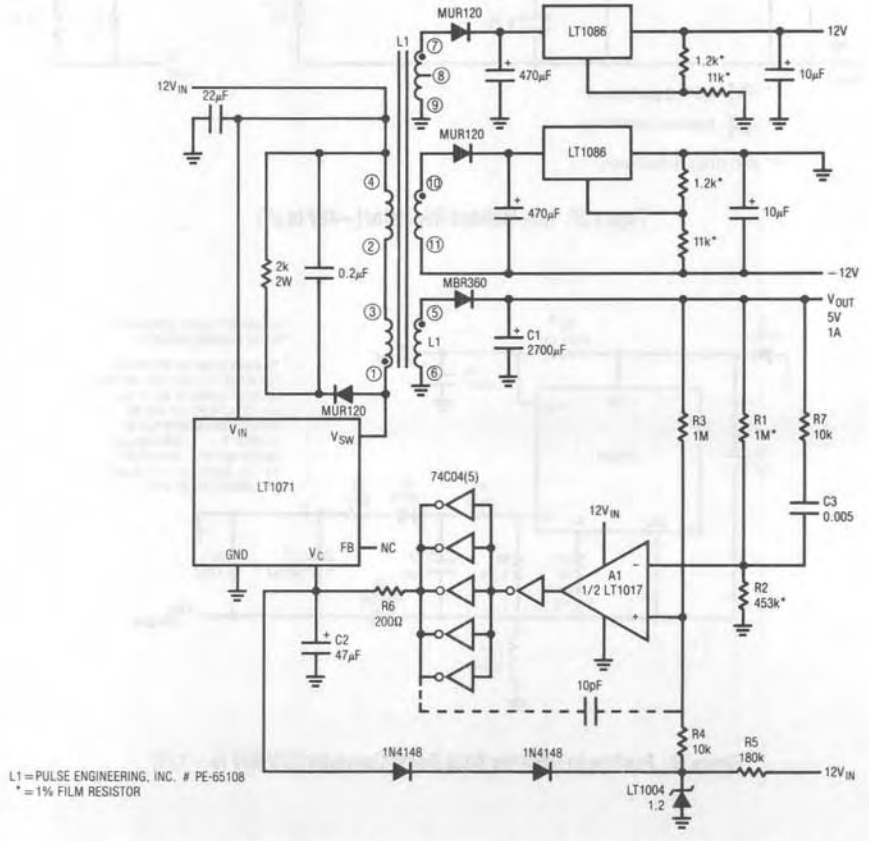


Figure 30. Transformer Coupled Low Quiescent Current Converter (12V to 5V, ± 12V)

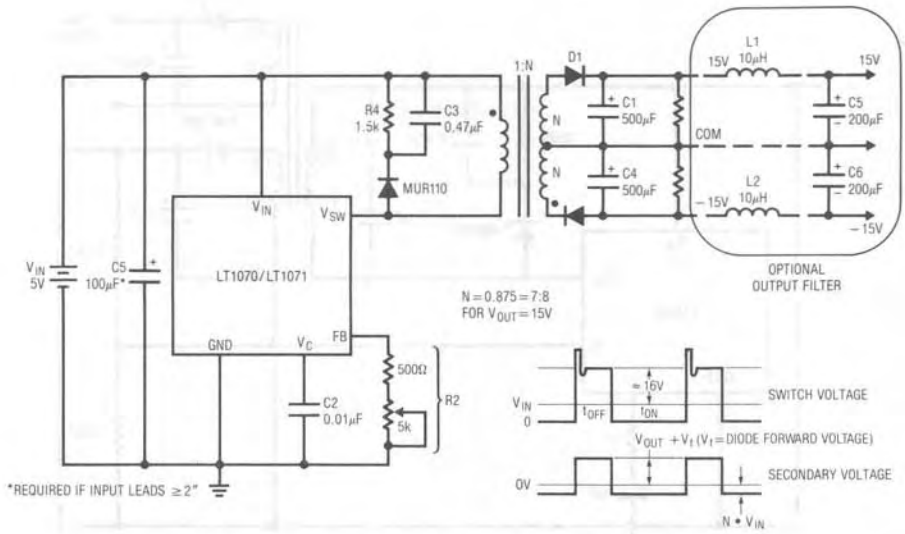


Figure 31. Totally Isolated Converter (5V to ± 15V)

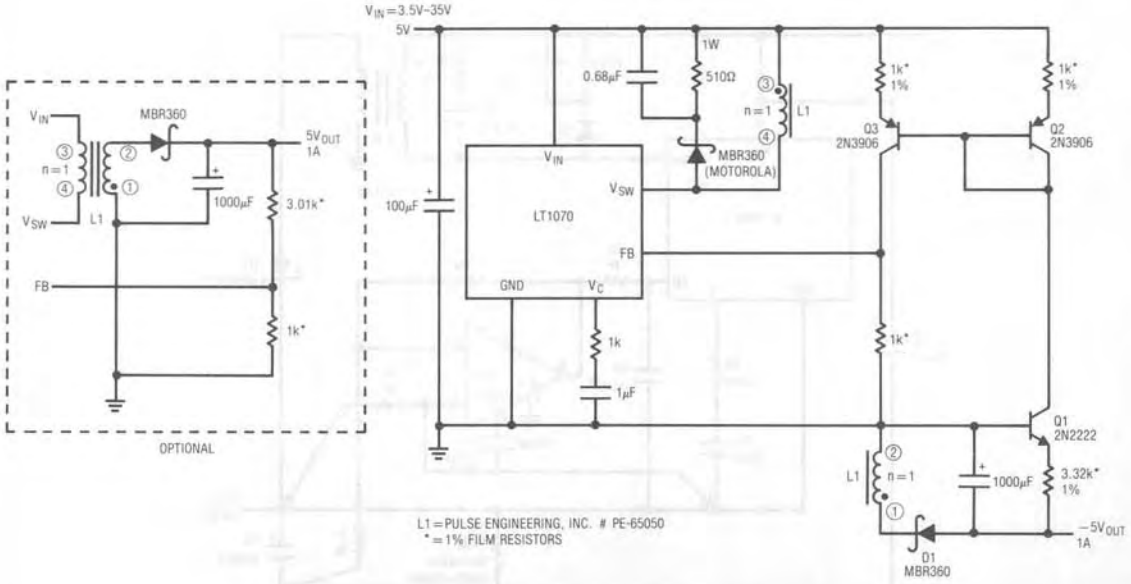


Figure 32. Input Positive Output Negative Flyback Converter (3.5V-35V to – 5V)

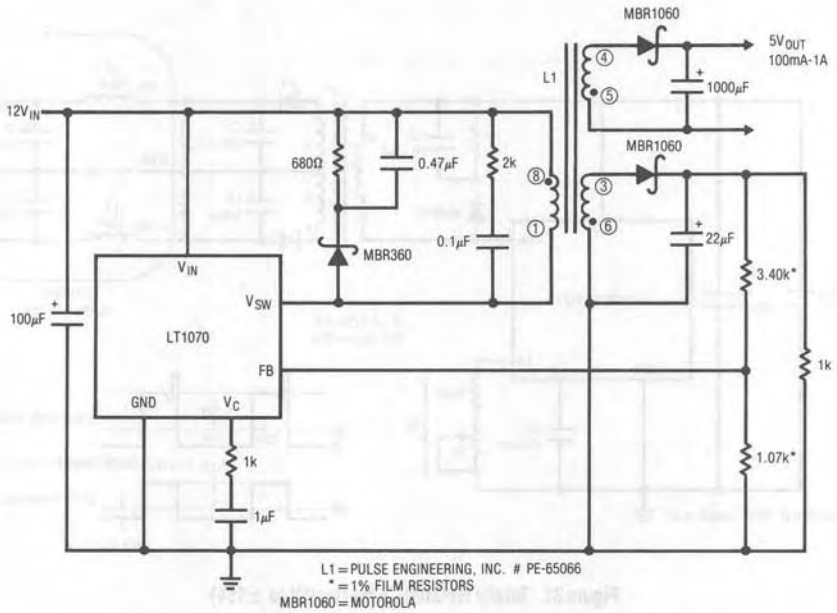


Figure 33. High Efficiency Flux Sensed Isolated Converter (12V to 5V)

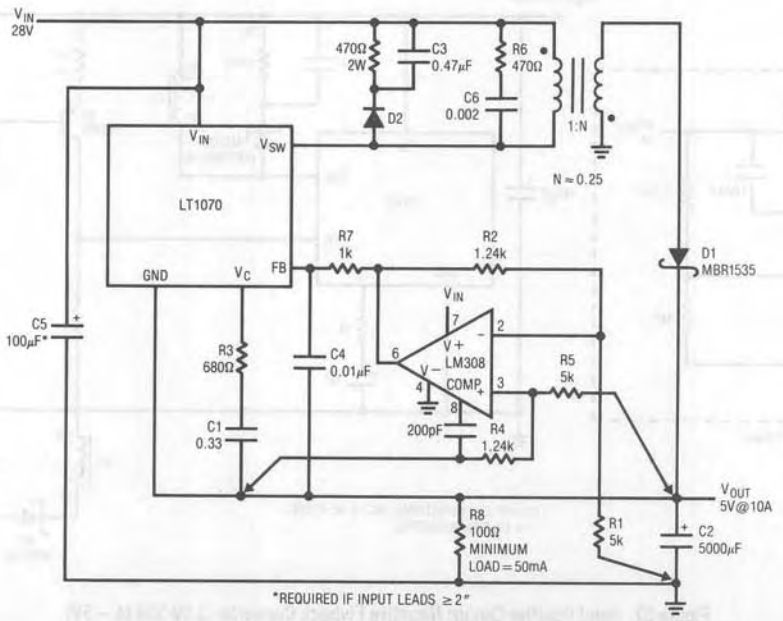


Figure 34. Positive Current Boosted Buck Converter (28V to 5V)

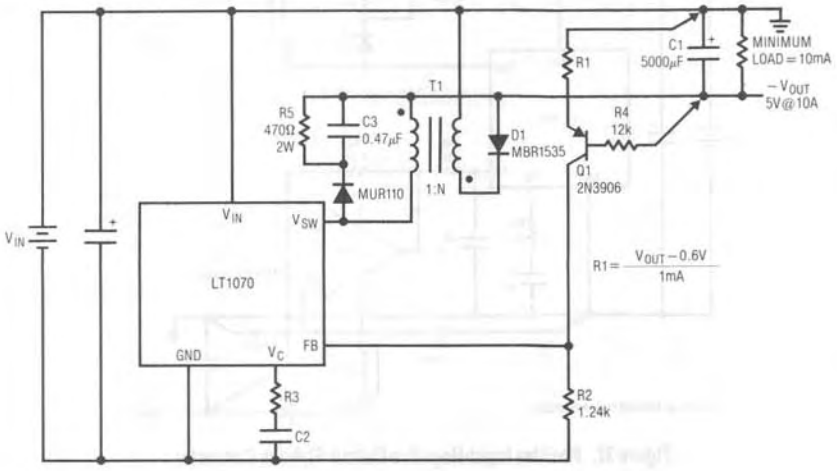


Figure 35. Negative Current Boosted Buck Converter

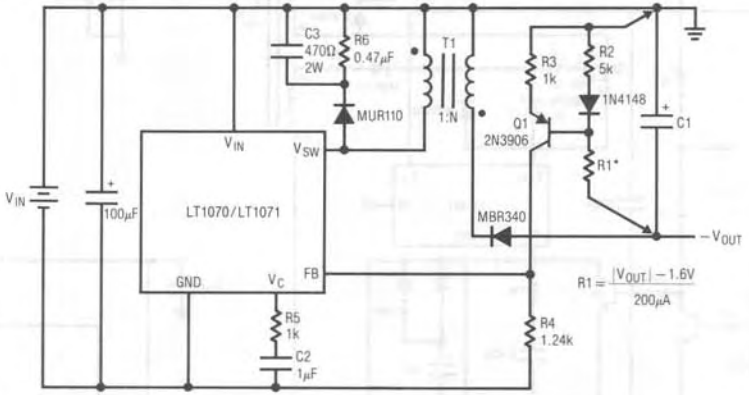


Figure 36. Negative Input-Negative Output Flyback Converter

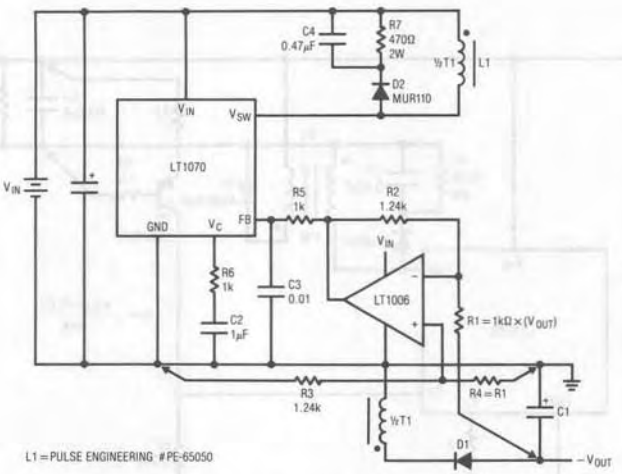


Figure 37. Positive Input-Negative Output Flyback Converter

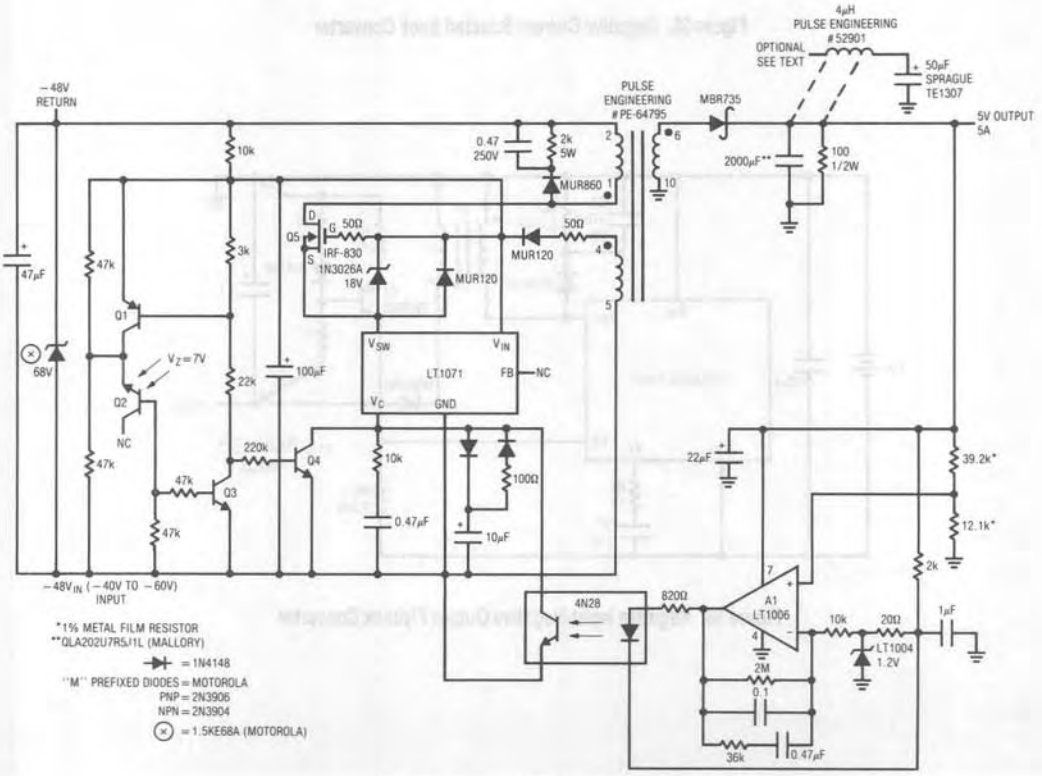


Figure 38. Fully Isolated Regulator (– 48V to 5V)

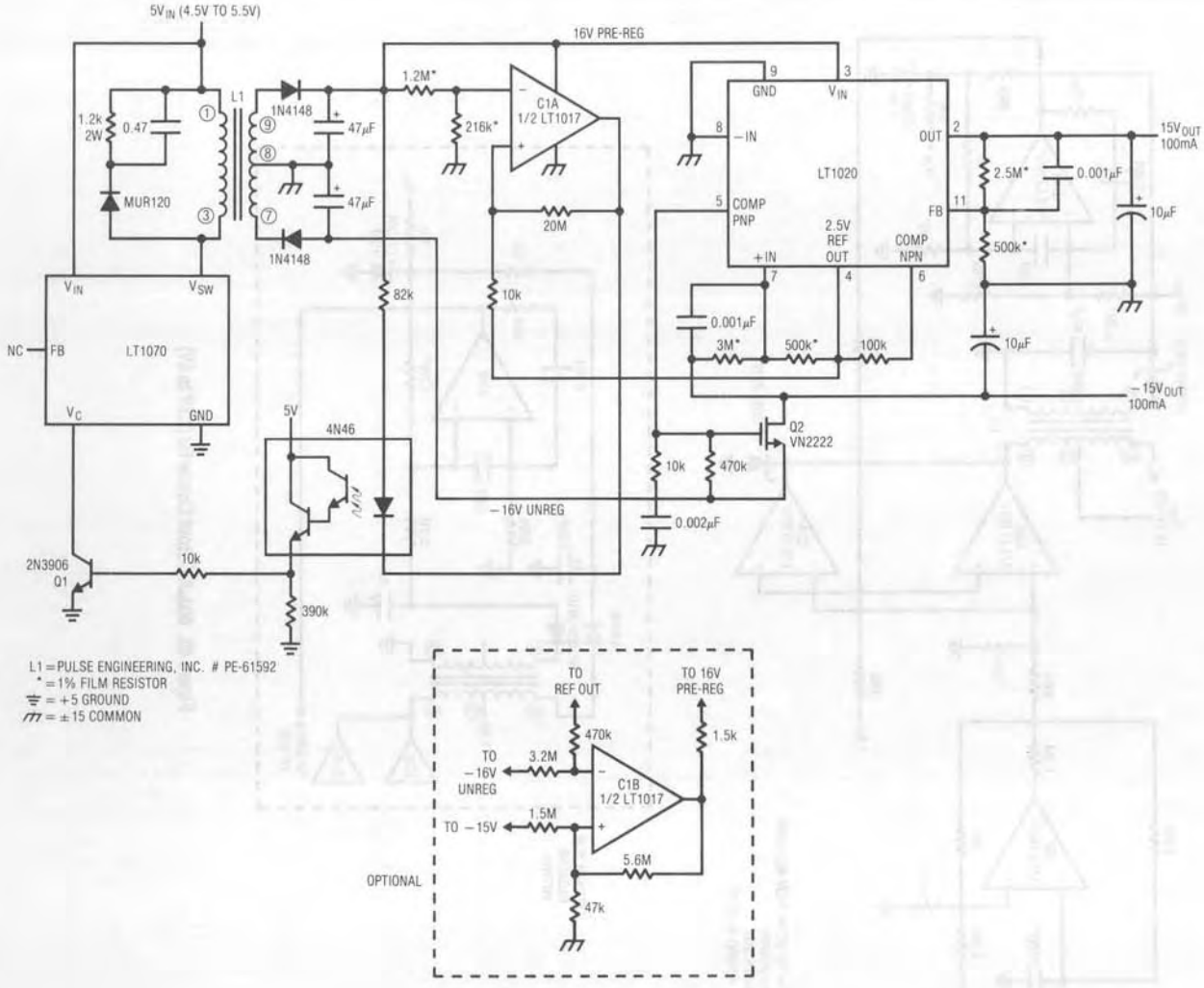


Figure 39. Low I_Q, Isolated Converter (5V to ± 15V)

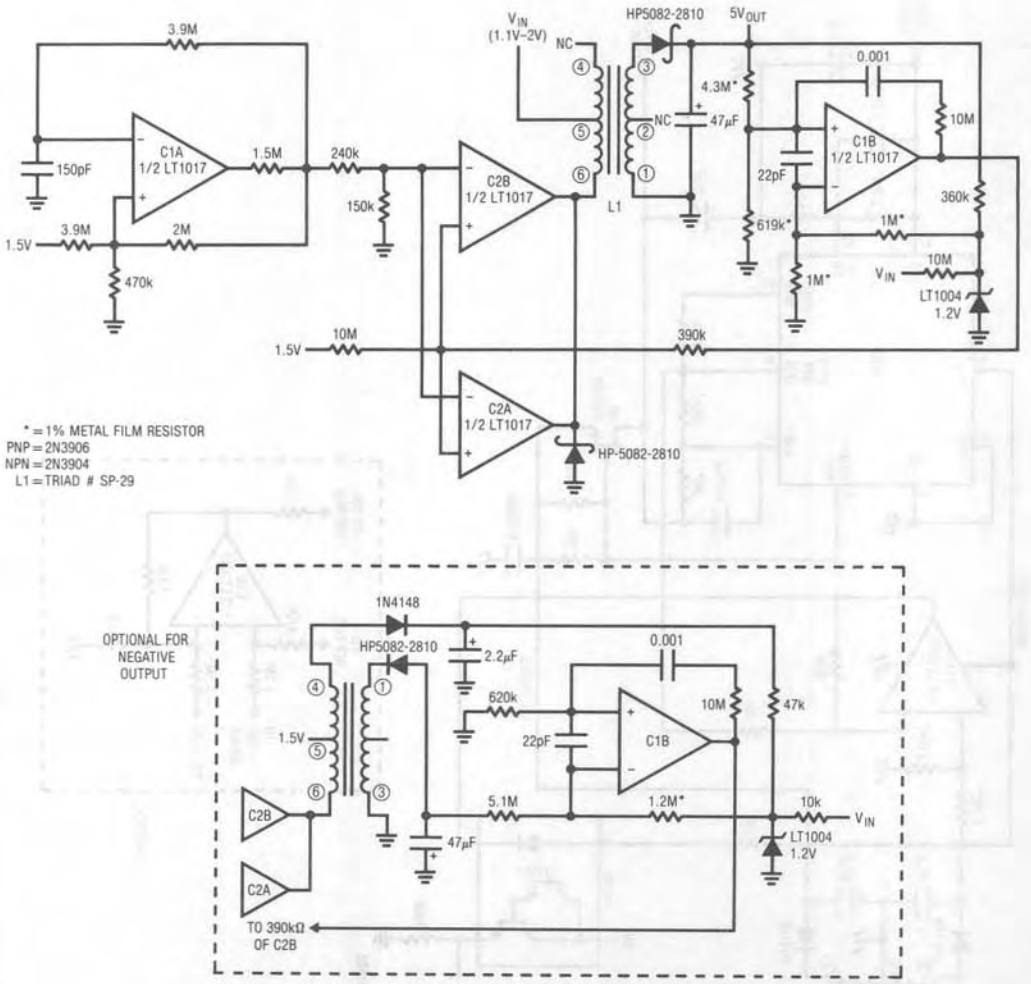


Figure 40. 800μA Output Converter (1.5V to 5V)

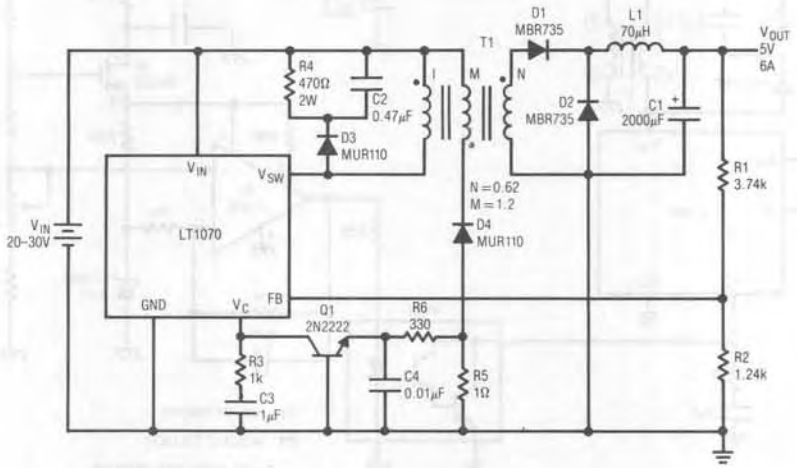


Figure 41. Foward Converter (20V-30V to 5V)

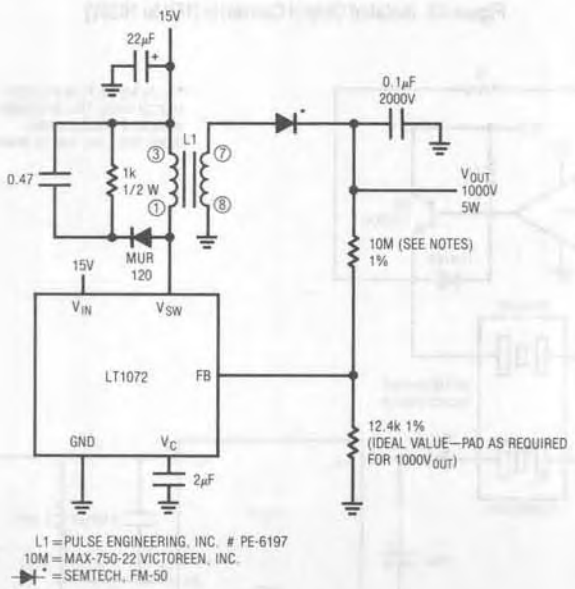


Figure 42. Non-Isolated Converter (15V to 1000V)

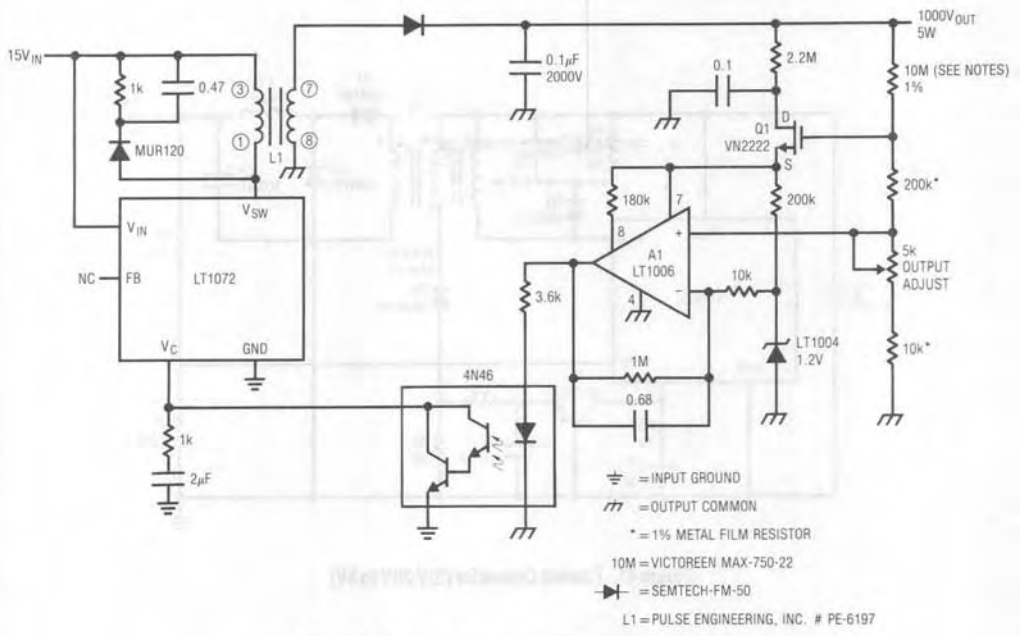


Figure 43. Isolated Output Converter (15V to 1000V)

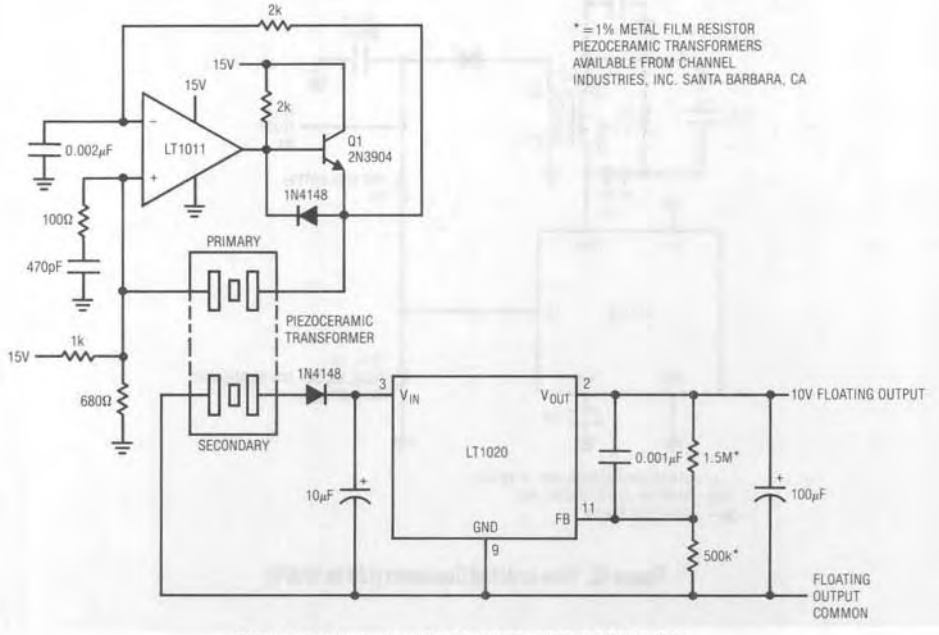


Figure 44. Converter with 20,000V Isolation (15V to 10V)

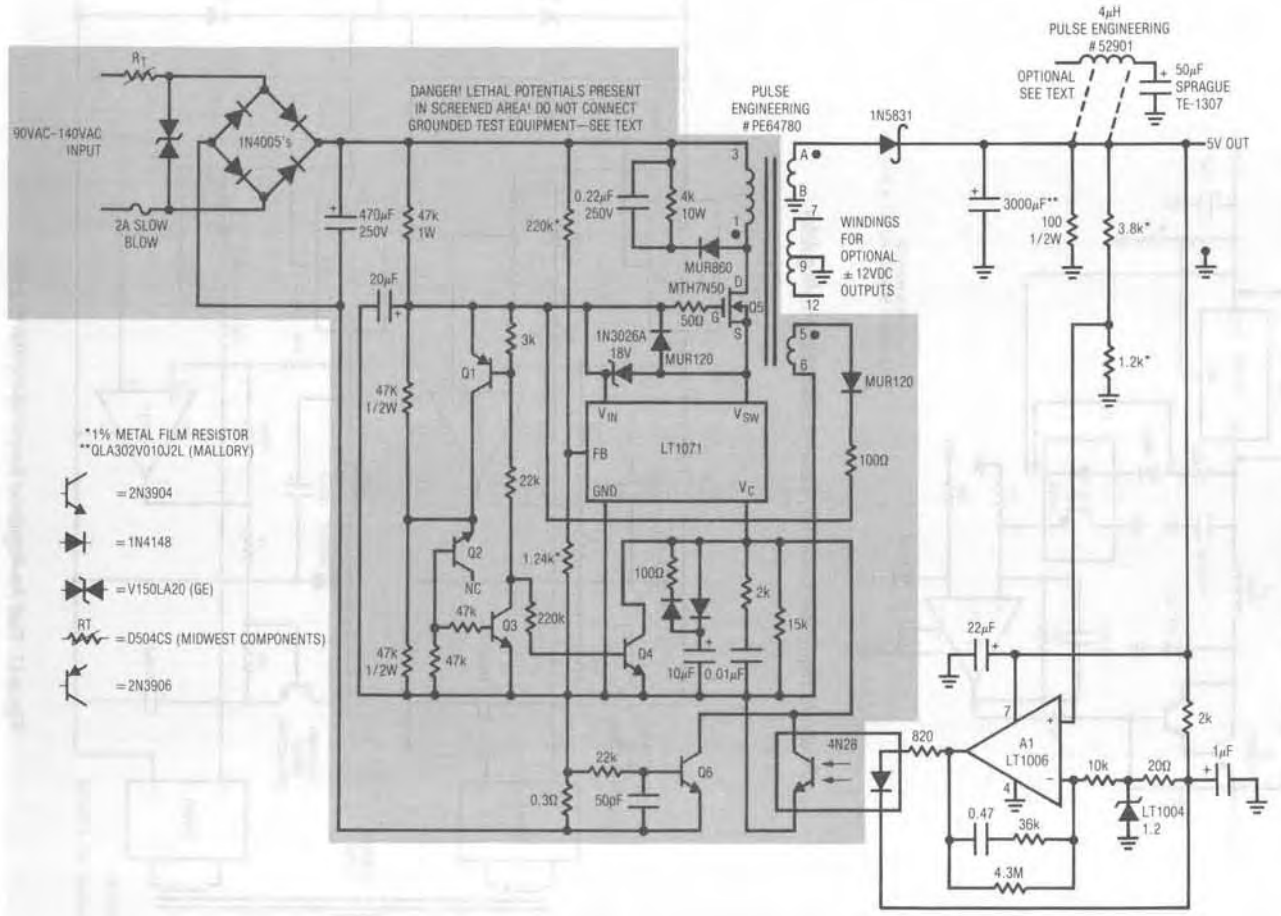


Figure 45. 100W Off-Line Switching Regulator. DANGER! Lethal Potentials Present.

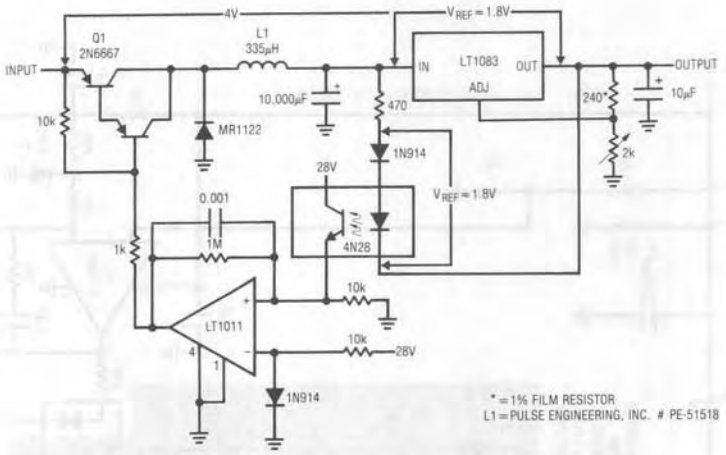


Figure 46. High Power Linear Regulator with Switching Pre-Regulator

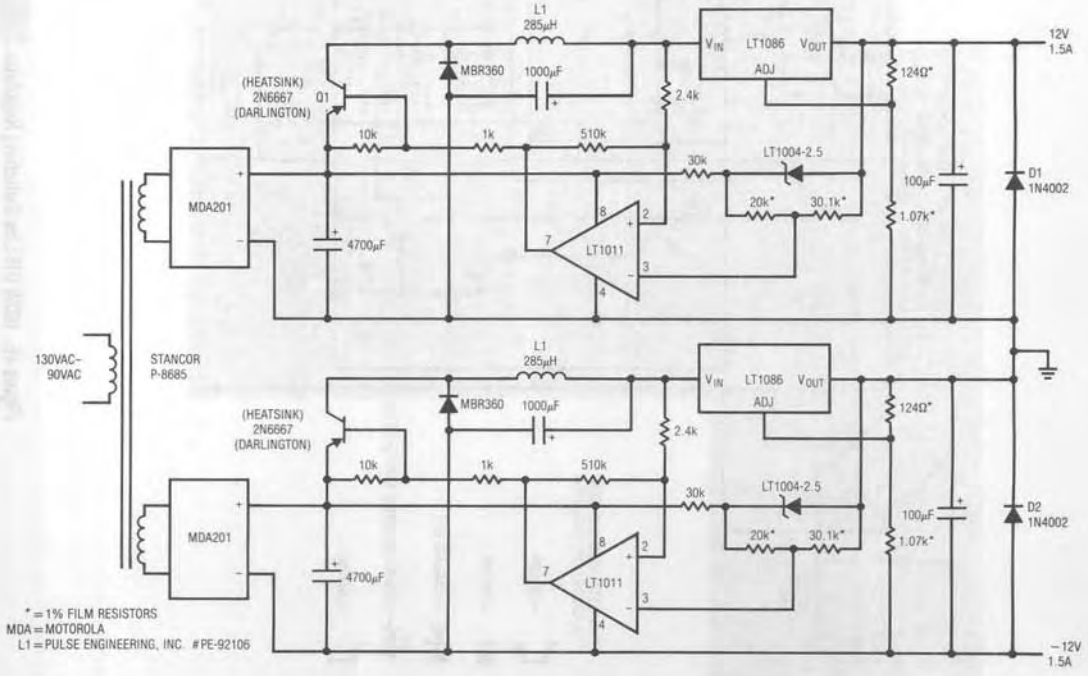


Figure 47. Dual Pre-Regulated Supply (90-130VAC to ± 12V)

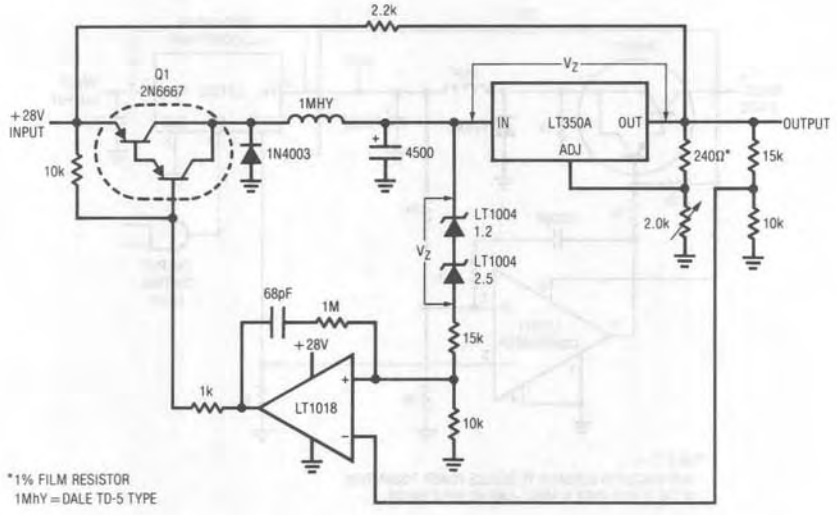


Figure 48. Linear Regulator with Switching Pre-Regulator

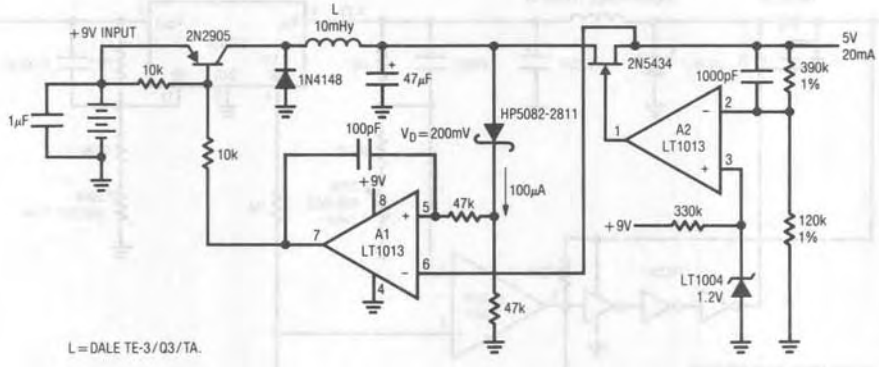


Figure 49. Switching Pre-Regulated Linear Regulator (9V to 5V)

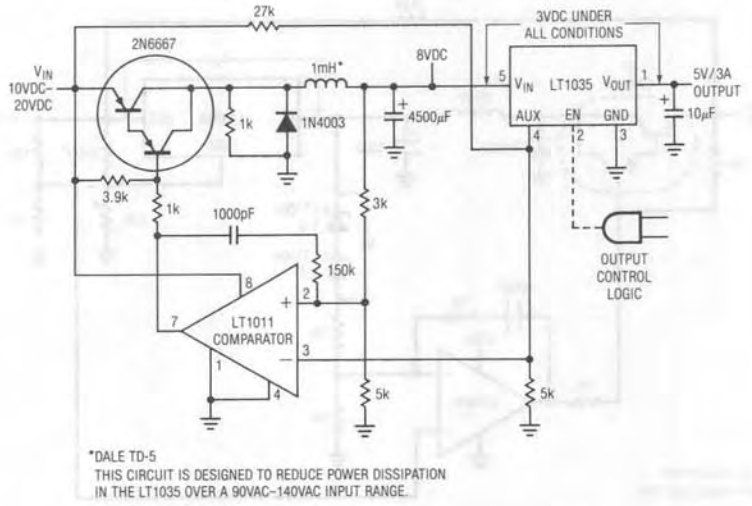


Figure 50. Low Dissipation Regulator (10V-20V to 5V)

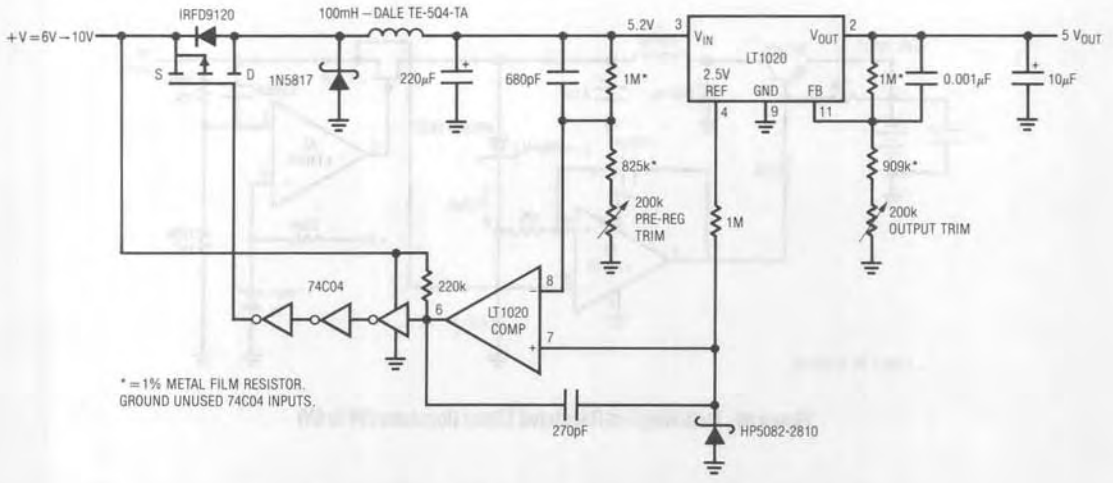


Figure 51. Micropower Post-Regulated Switching Regulator (6V-10V to 5V)

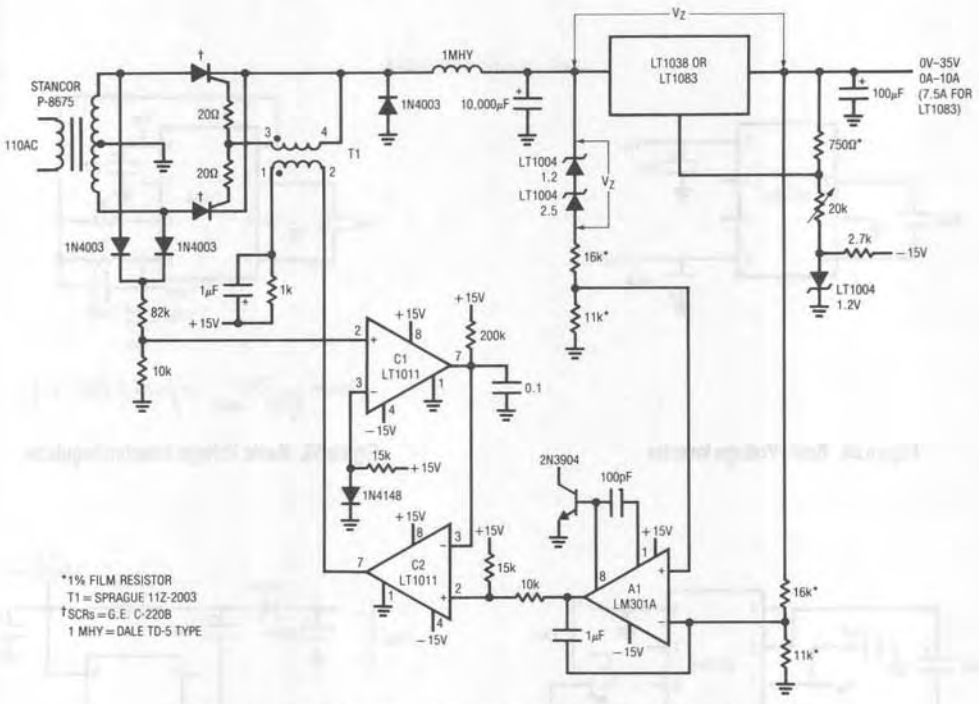


Figure 52. High Current Low Dissipation Pre-Regulated Linear Regulator

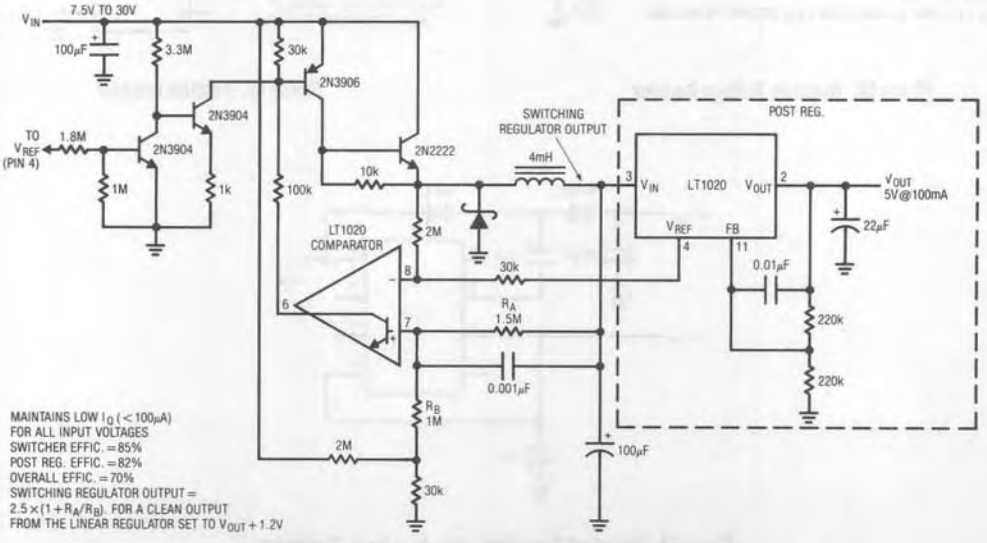


Figure 53. Switching Pre-Regulator for Wide Input Voltage Range (7.5V-30V to 5V)

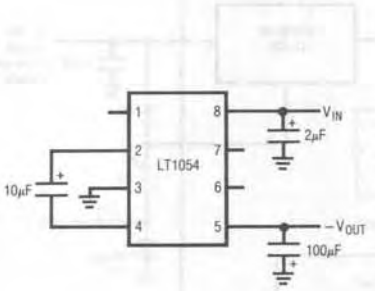


Figure 54. Basic Voltage Inverter

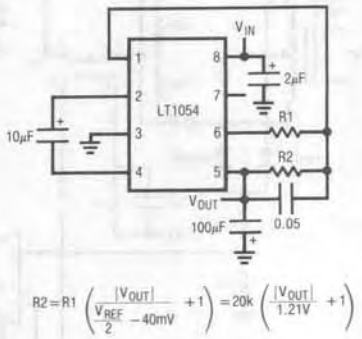


Figure 55. Basic Voltage Inverter/Regulator

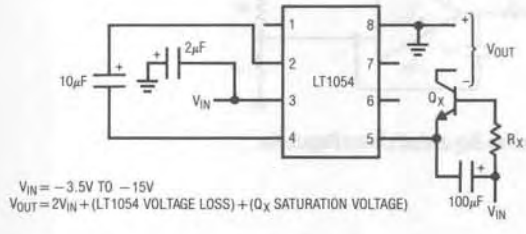


Figure 56. Negative Voltage Doubler

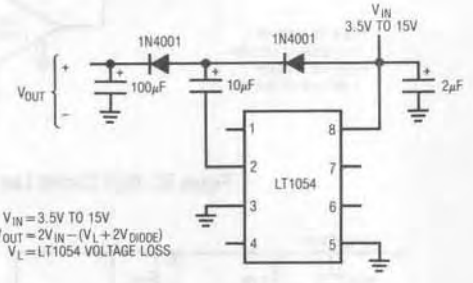


Figure 57. Positive Doubler

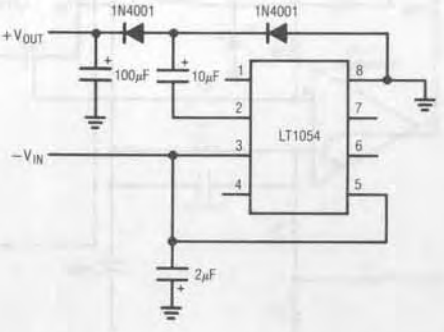


Figure 58. Switched Capacitor $-V_{IN}$ to $+V_{OUT}$ Converter

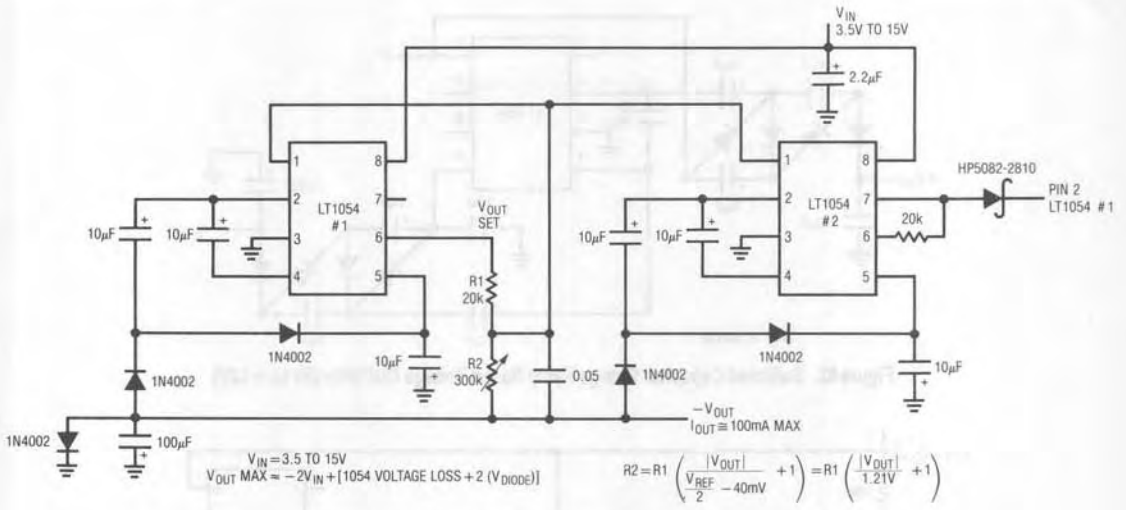


Figure 59. 100mA Regulating Negative Doubler

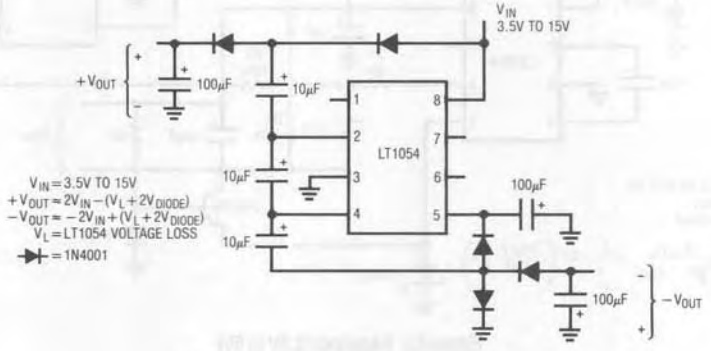


Figure 60. Dual Output Voltage Doubler

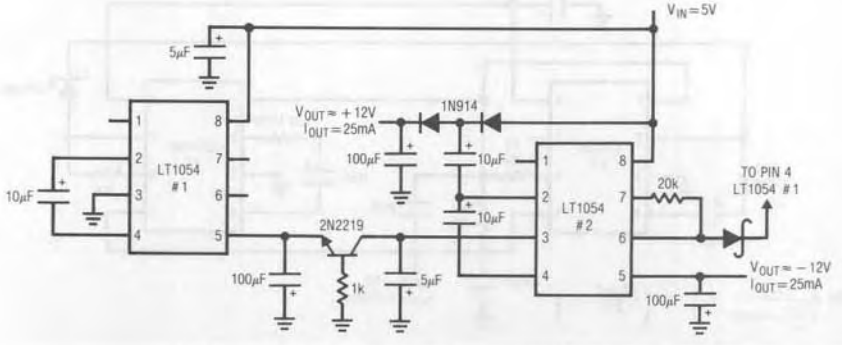


Figure 61. Switched Capacitor Converter (5V to ±12V)

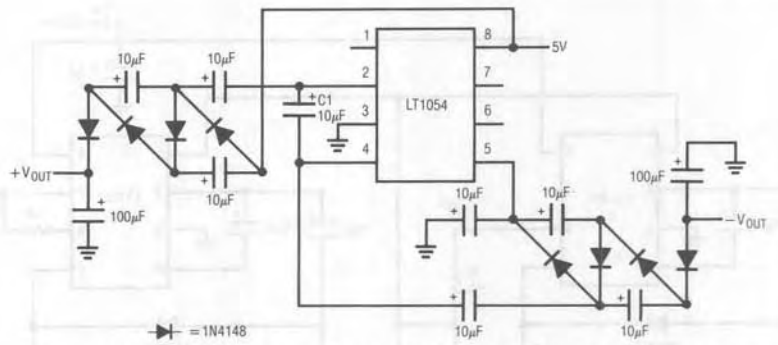


Figure 62. Switched Capacitor Charge Pump Based Voltage Multiplier (5V to ±12V)

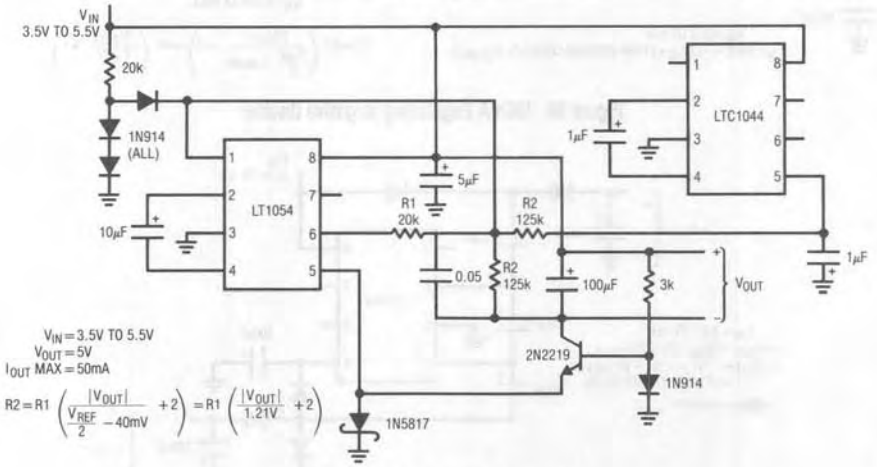


Figure 63. Regulator (3.5V to 5V)

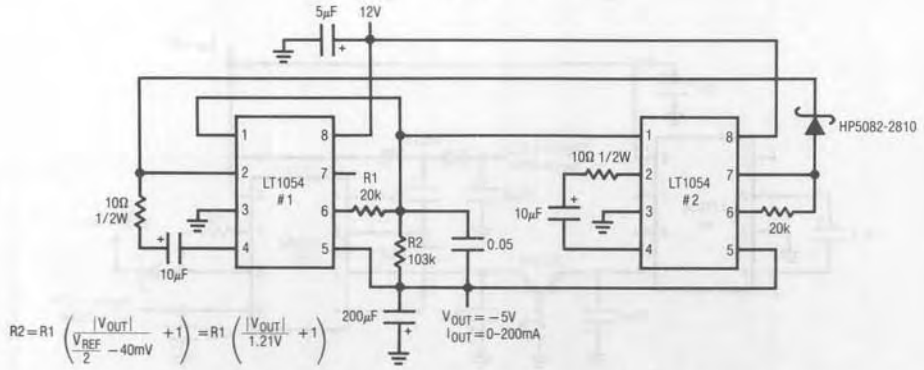


Figure 64. Regulating 200mA Converter (12V to –5V)

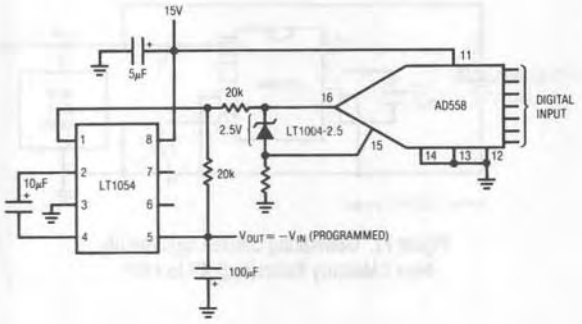


Figure 65. Digitally Programmable Negative Supply

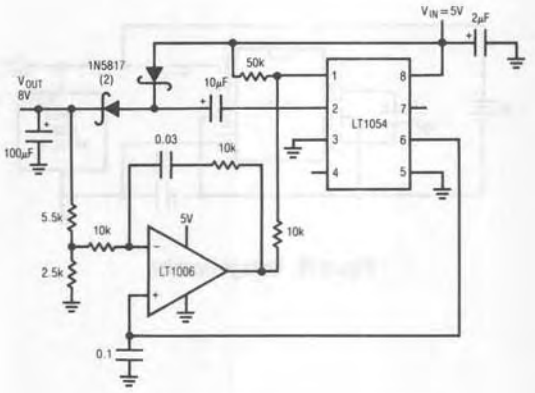


Figure 66. Positive Doubler with Regulation (5V to 8V)

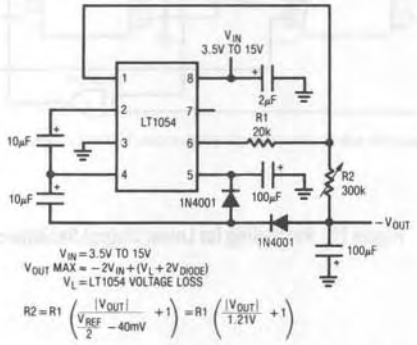


Figure 67. Negative Doubler with Regulator

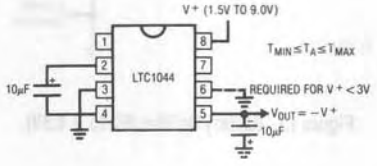


Figure 68. Negative Voltage Converter

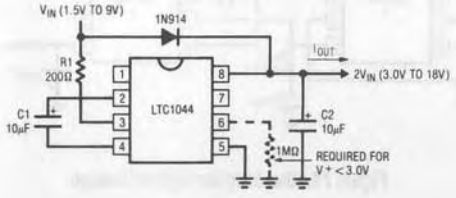


Figure 69. Voltage Doubler

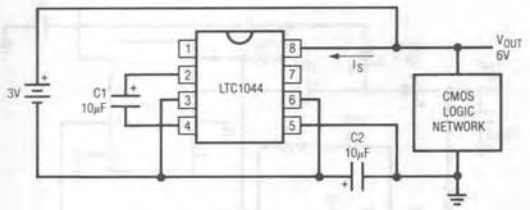


Figure 70. Voltage Doubler

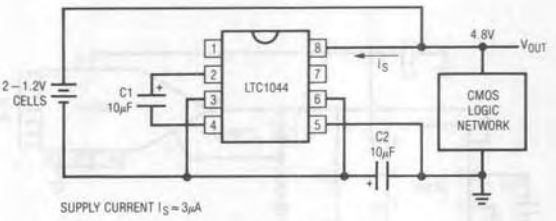


Figure 71. Generating CMOS Logic Supply from 2 Mercury Batteries (2.4V to 4.8V)

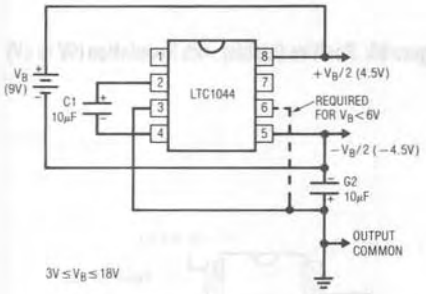


Figure 72. Battery Splitter (9V to ± 4.5V)

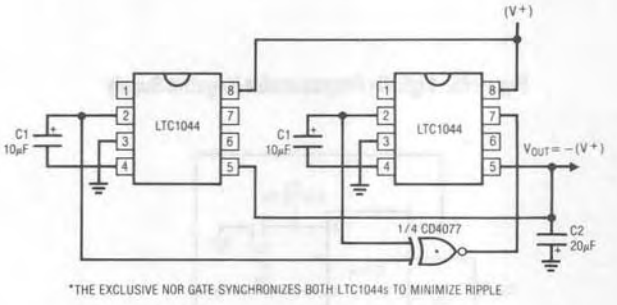


Figure 73. Paralleling for Lower Output Resistance

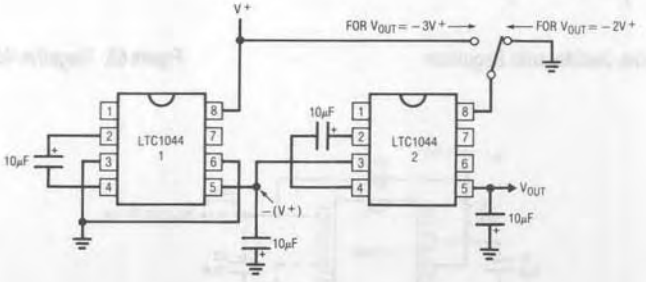


Figure 74. Stacking for Higher Voltage

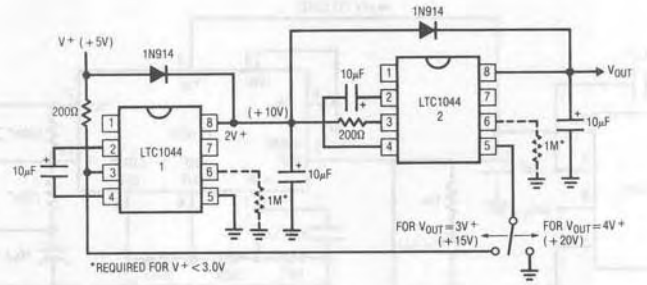


Figure 75. Voltage Tripler/Quadrupler

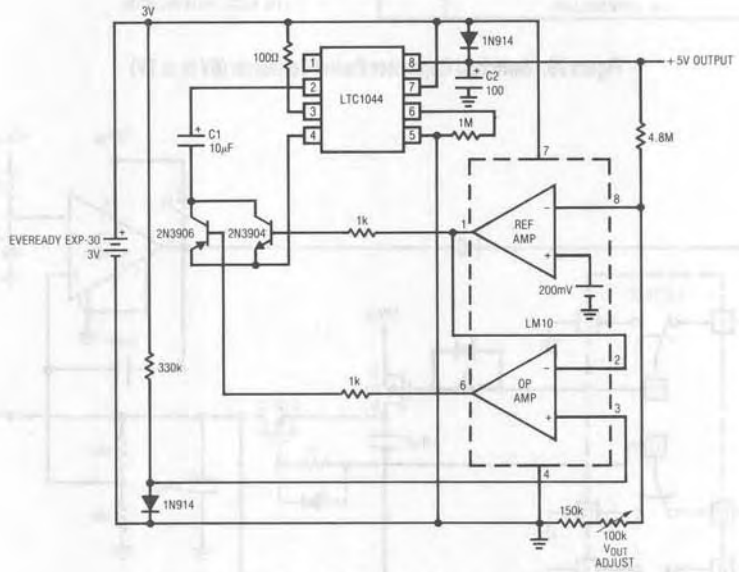


Figure 76. Regulated Voltage Up Converter (3V to 5V)

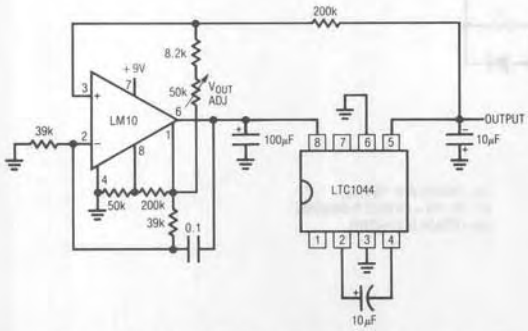


Figure 77. Regulated Negative Voltage Converter

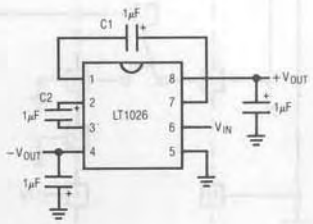


Figure 78. Dual Output Switched Capacitor Voltage Generator

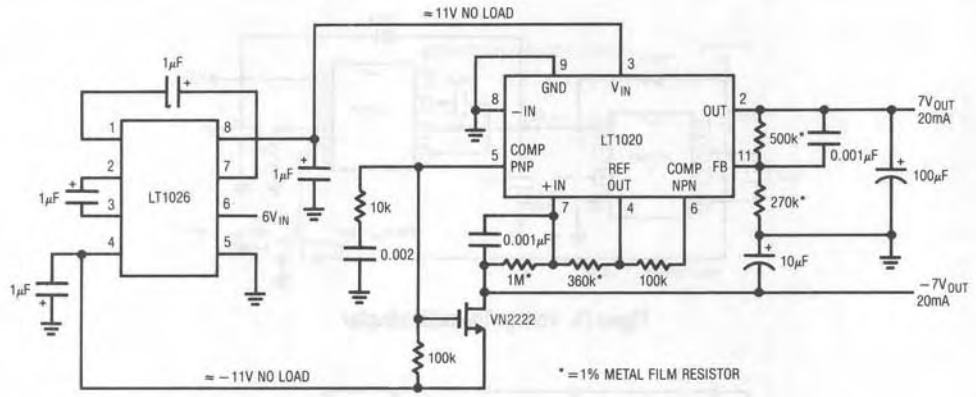


Figure 79. Switched Capacitor Based Converter (6V to ±7V)

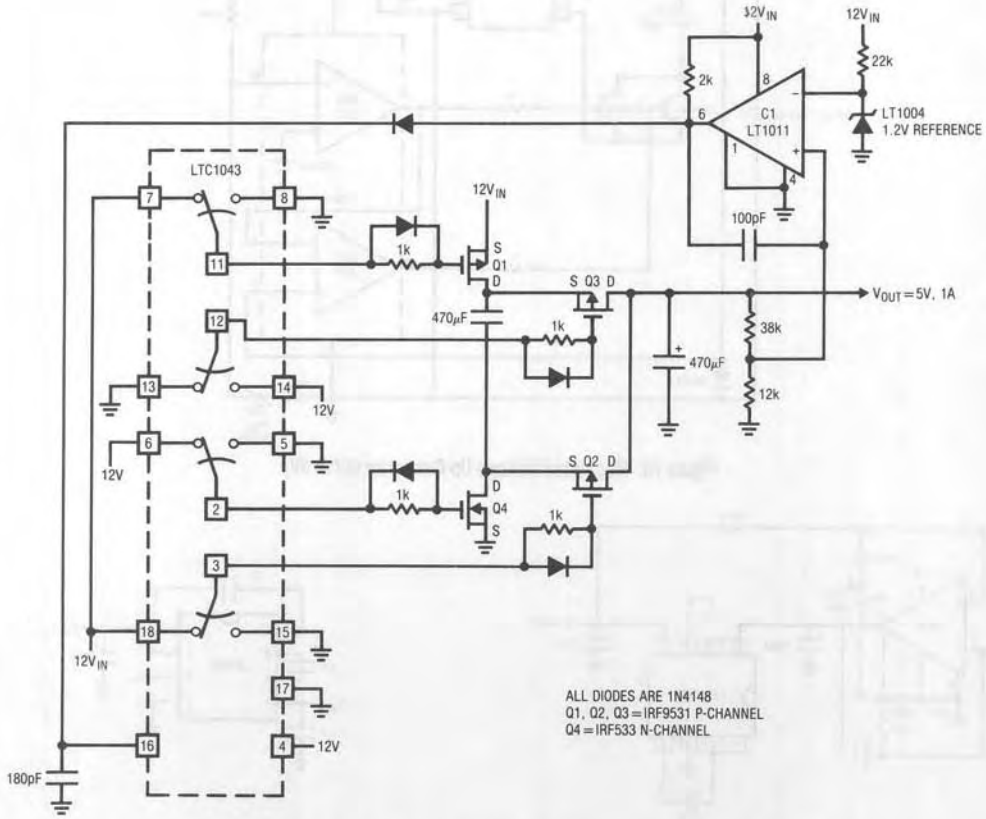


Figure 80. High Power Switched Capacitor Converter (12V to 5V)

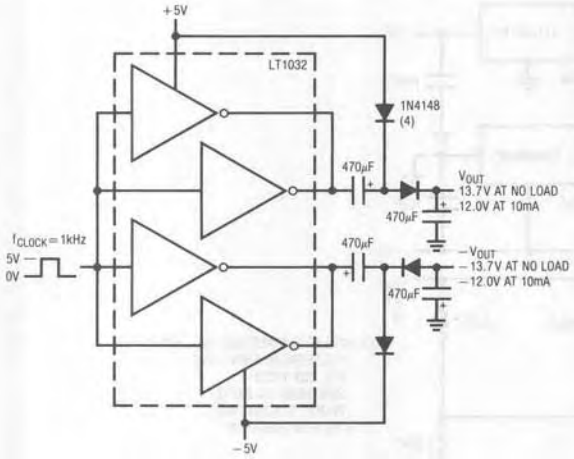


Figure 81. Voltage Multiplier (±5V to ±15V)

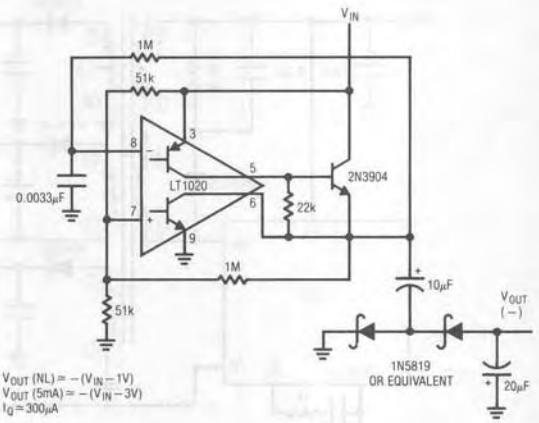


Figure 82. Charge-Pump Negative Voltage Generator

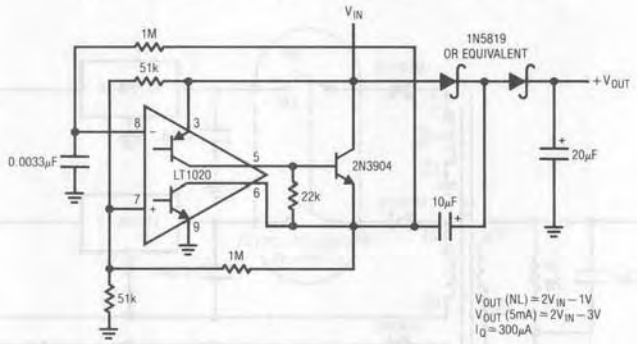


Figure 83. Charge-Pump Voltage Doubler

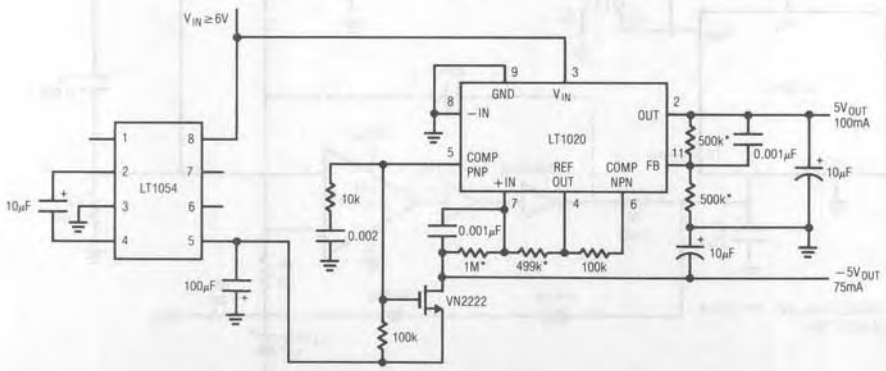


Figure 84. High Current Switched Capacitor Converter (6V to ±5V)

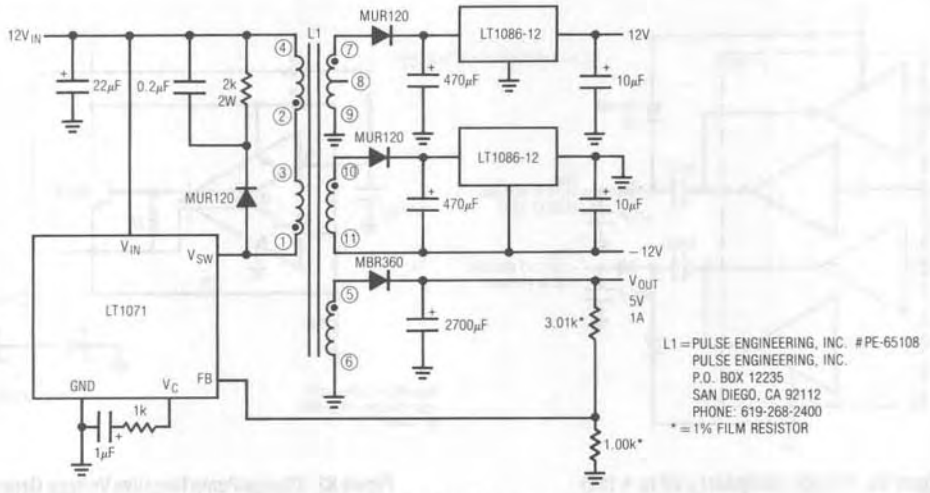


Figure 85. Multi-Output Flyback Converter (12V to 5V, ± 12V)

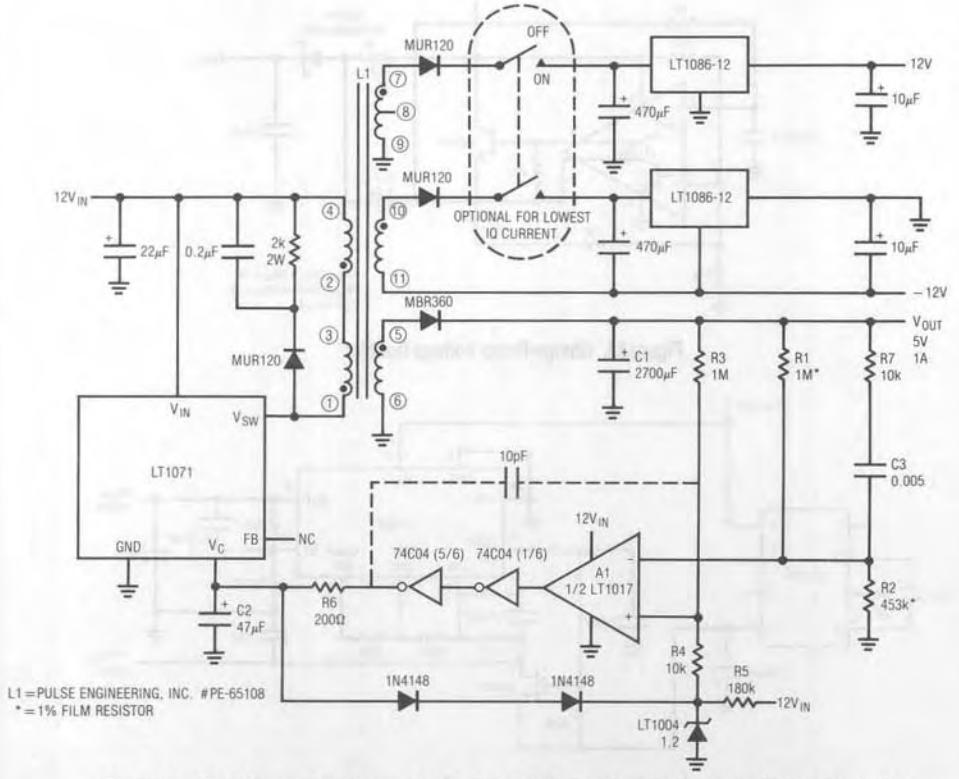


Figure 86. Multi-Output, Transformer Coupled Low Quiescent Current Converter (12V to 5V, ± 12V)

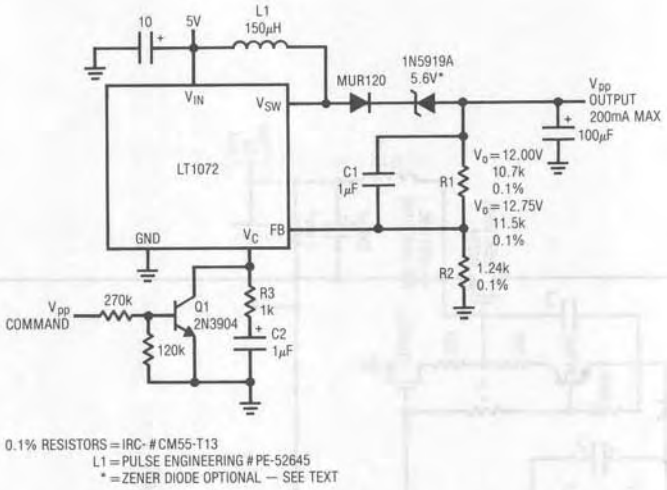


Figure 87. Basic Flash EPROM Vpp Pulse Generator (5V to 12.75V or 12.00V)

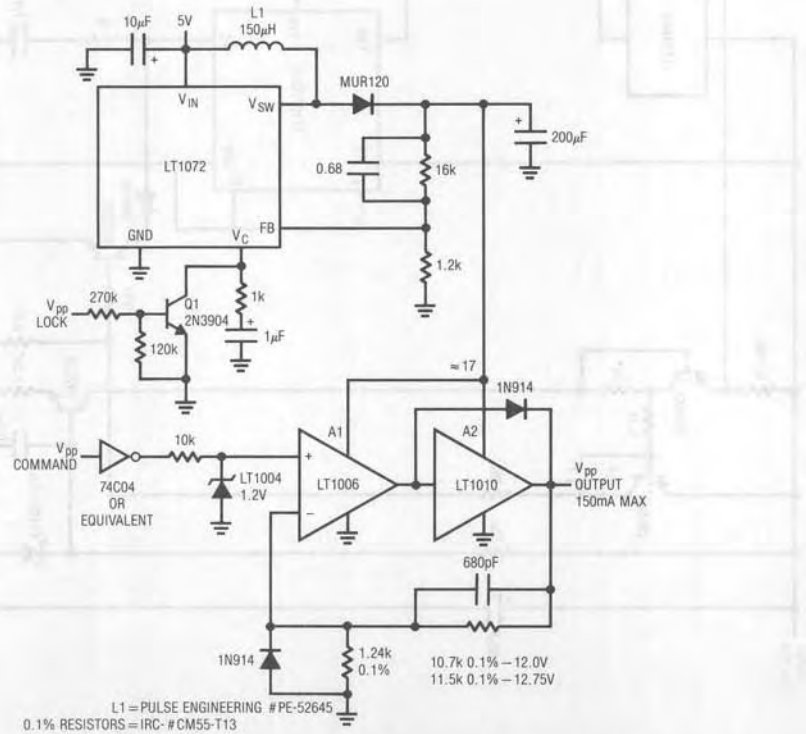
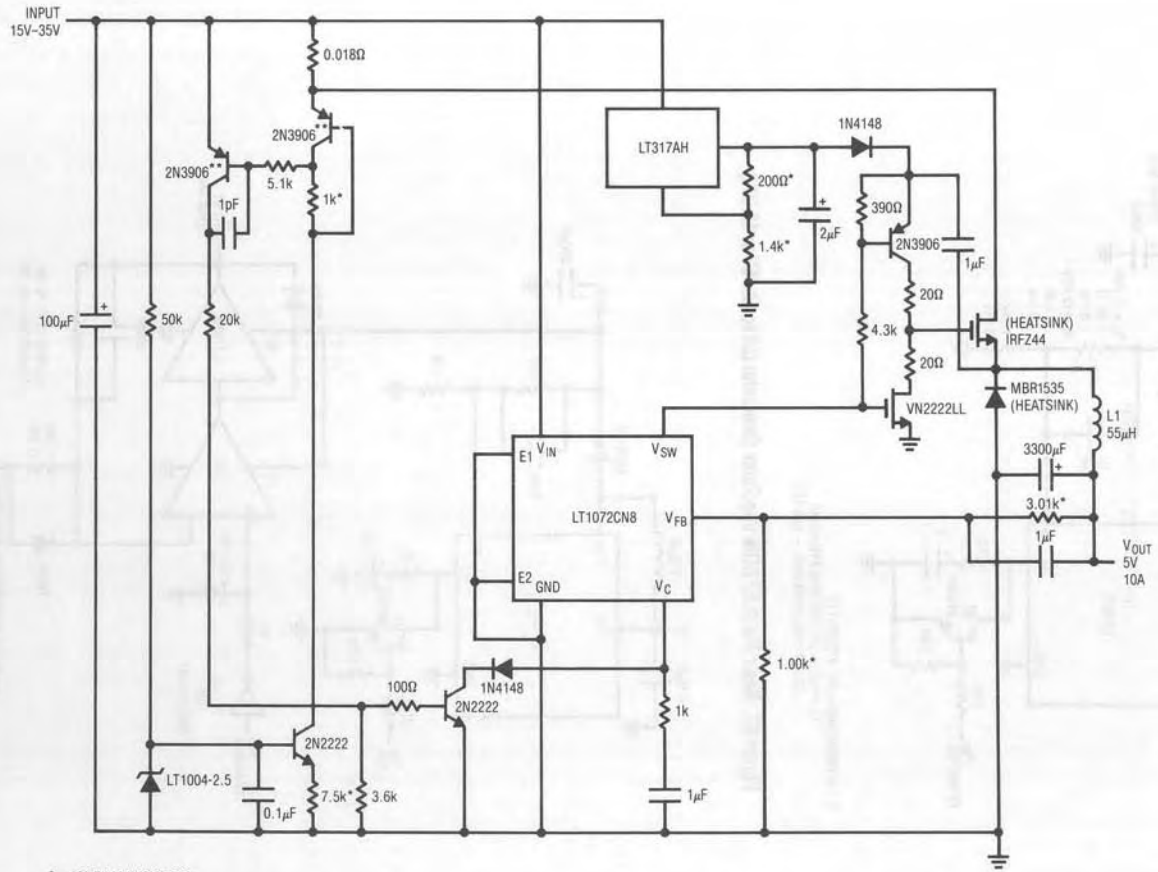


Figure 88. High Repetition Rate Vpp Pulse Generator (5V to 12.75V or 12.00V)



* = 1% FILM RESISTORS
IRFZ44 = INTERNATIONAL RECTIFIER
L1 = PULSE ENGINEERING, INC. #PE-92117
** = V_{be} MATCHING OF 20mV AT 240µA

Figure 89. High Current Positive Buck with Bootstrapped NMOS Gate Drive (15V-35V to 5V)