

## APPLICATION NOTE 3943

## $\pm 15V$ or $\pm 12V$ Output Switch-Mode Power Supply Has Wide Input-Voltage Range

*Abstract: This application note illustrates how to use the MAX668 boost circuit and the MAX1846 inverting circuit to implement a switch-mode power supply that provides a  $\pm 12V$  or  $\pm 15V$  at 0.5A output from a 4.5V to 12V input.*

### Overview

The switch-mode power-supply circuits illustrated in this application note provide a  $\pm 12V$  or  $\pm 15V$  at 0.5A output from a 4.5V to 12V input. This wide input-voltage range allows the device to be powered from a regulated DC voltage or even an unregulated DC voltage, such as the rectified output of an inexpensive AC "wall wart" step-down transformer. This design may be preferred to Maxim's older MAX742 design, which requires a larger overall circuit.

The power supply consists of a [MAX668](#) boost circuit or a [MAX1846](#) inverting circuit. Each circuit operates at a 300kHz switching frequency, balancing cost, size, and performance. The circuits limit the maximum switch current, which ultimately limits output current for a given input voltage; however, maximum output current increases with increased input voltage.

### The MAX668 Circuit

**Figure 1** illustrates how to use the MAX668 boost circuit to implement a switch-mode power supply that provides a +15V at 0.5A output from a 4.5V to 12V input. This MAX668 circuit adds a few components to the minimum circuit implementation. C7 adds a pole to compensate for the ESR-zero of the output capacitor. R5 and C8 filter the current-sense voltage to prevent high-frequency switching noise from prematurely tripping the current limit. This functionality is in addition to the MAX668's internal 60ns current-sense blanking time.

The MAX668 output voltage can be changed to +12V by changing the value of the R2 resistor to 86.6k $\Omega$ . This change reduces the minimum input voltage to approximately 10V. Since the MAX668 provides internal compensation, no other changes are required for +12V output.

The output ripple voltage due to switching can be reduced an order of magnitude with a secondary output filter set to one-tenth of the switching frequency. A 1 $\Omega$ , 0.5W resistor in series with a 10 $\mu F$ , 25V capacitor with less than 100m $\Omega$  ESR introduces a 0.5V decrease in output voltage at a 0.5A load. The feedback voltage must be sensed before it reaches the secondary filter for the MAX668 to maintain stability.

### The MAX1846 Circuit

**Figure 2** uses the MAX1846 inverting circuit to implement a switch-mode power supply that provides a -15V at 0.5A output from a 4.5V to 12V input. This MAX1846 circuit also adds a few components to the minimum circuit implementation. C20 adds a pole to compensate for the ESR-zero of the output capacitor, while R16 and C22 filter the current-sense voltage to prevent high-frequency switching noise from tripping the current limit. This functionality is in addition to the MAX1846's internal 100ns current-sense blanking time. The MAX1846 EXT pin implements controlled slew rate, which helps limit high-frequency switching noise.

The MAX1846 output voltage can be changed to -12V by changing the value of R13 to 97.6k $\Omega$  and R10 to 91k $\Omega$ . The maximum input voltage does not decrease, although duty cycle jitter increases somewhere between 10V and 12V input. Again, the output ripple voltage due to switching can be reduced an order of magnitude with the same secondary filter described in the MAX668 circuit above. As with the MAX668, the feedback voltage for the MAX1846 must be sensed before it reaches the secondary filter for the voltage inverter to work properly.

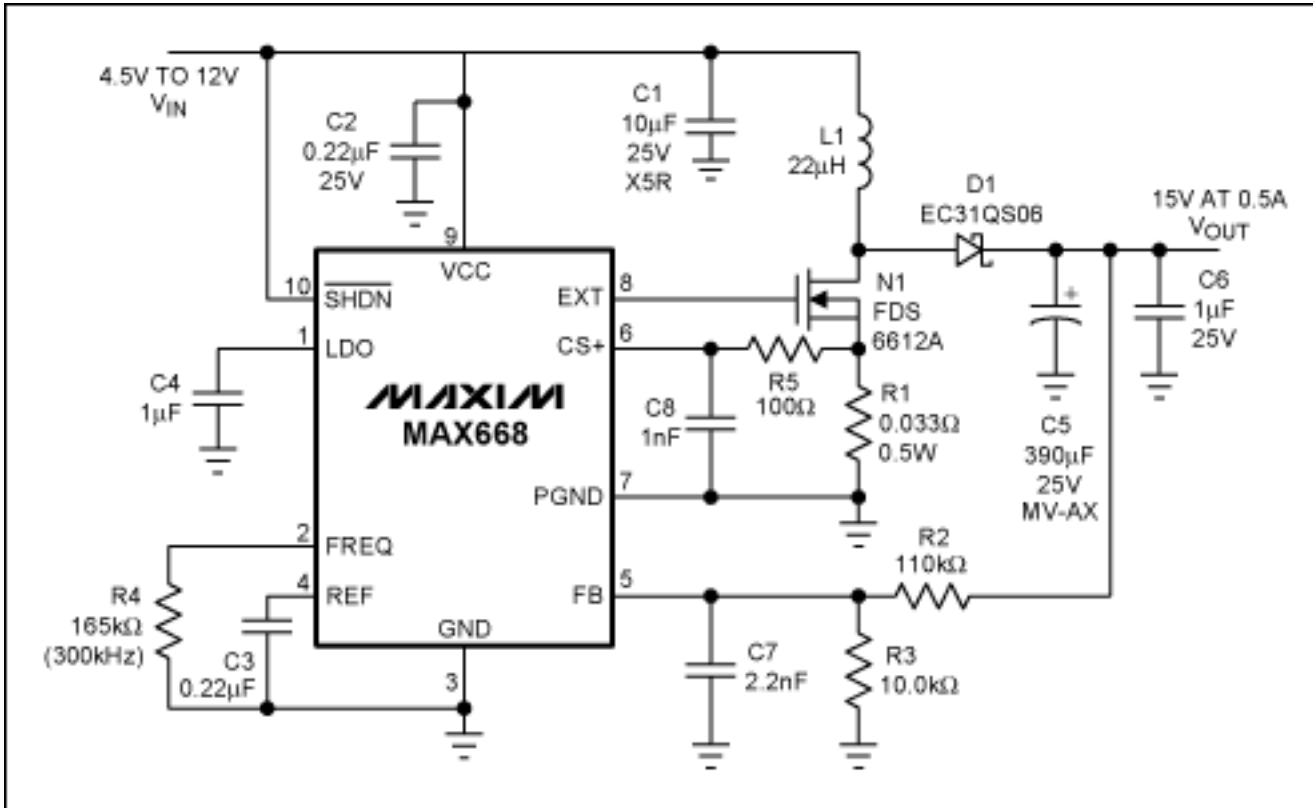


Figure 1. This diagram uses the MAX668 boost circuit to implement a +15V at 0.5A output from a 4.5V to 12V input.

Table 1. Performance Data for the MAX668 Circuit

$V_{IN}$ (V)	$I_{IN}$ (A)	$V_{OUT}$ (V)	$I_{OUT}$ (A)	Efficiency
5.00	0.0007	15.11	0	
5.00	1.597	14.81	0.50	0.927
6.00	1.318	14.85	0.50	0.939
8.00	0.981	14.91	0.50	0.950
10.00	0.781	14.96	0.50	0.958
11.00	0.708	14.98	0.50	0.962
12.00	0.648	15.01	0.50	0.965
4.47	1.800	14.78	0.50	0.918
20MHz BW		240mV <sub>p-p</sub>		
4.46	2.556	14.70	0.70	0.903
Current Limit			~0.71	

**Table 2. The Bill of Materials for the MAX668 Switch-Mode Power-Supply Circuit 4.5V to 10V Input, 15V at 0.5A Output (12/23/05)**

DESIGNATION	QTY	DESCRIPTION
C1	1	10 $\mu$ F 25V X5R ceramic capacitor (1210) Taiyo Yuden TMK325BJ106MM
C2	1	0.22 $\mu$ F 25V ceramic capacitor (0805) Taiyo Yuden UMK212BJ224MG
C3	1	0.22 $\mu$ F 10V ceramic capacitor (0603) Taiyo Yuden EMK107BJ224MA
C4	1	1 $\mu$ F 10V X5R ceramic capacitor (0603) Taiyo Yuden LMK107BJ105MA
C5	1	390 $\mu$ F 25V aluminum electrolytic capacitor Sanyo 25MV390AX
C6	1	1 $\mu$ F 25V X5R ceramic capacitor (1206)
C7	1	2.2nF ceramic capacitor (0603)
C8	1	1nF ceramic capacitor (0603)
D1	1	3A 60V Schottky diode Nihon EC31QS06
L1	1	22 $\mu$ H 6A power inductor Coilcraft DO5022P-223
N1	1	30m $\Omega$ 30V n-ch MOSFET (SO-8) Fairchild FDS6612A
R1	1	0.033 $\Omega$ 0.5W 5% resistor (2012)
R2	1	110k $\Omega$ 1% resistor (0603)
R3	1	10.0k $\Omega$ 1% resistor (0603)
R4	1	165k $\Omega$ 1% resistor (0603)
R5	1	100 $\Omega$ 5% resistor (0603)
U1	1	MAX668EUB (10- $\mu$ MAX <sup>®</sup> )

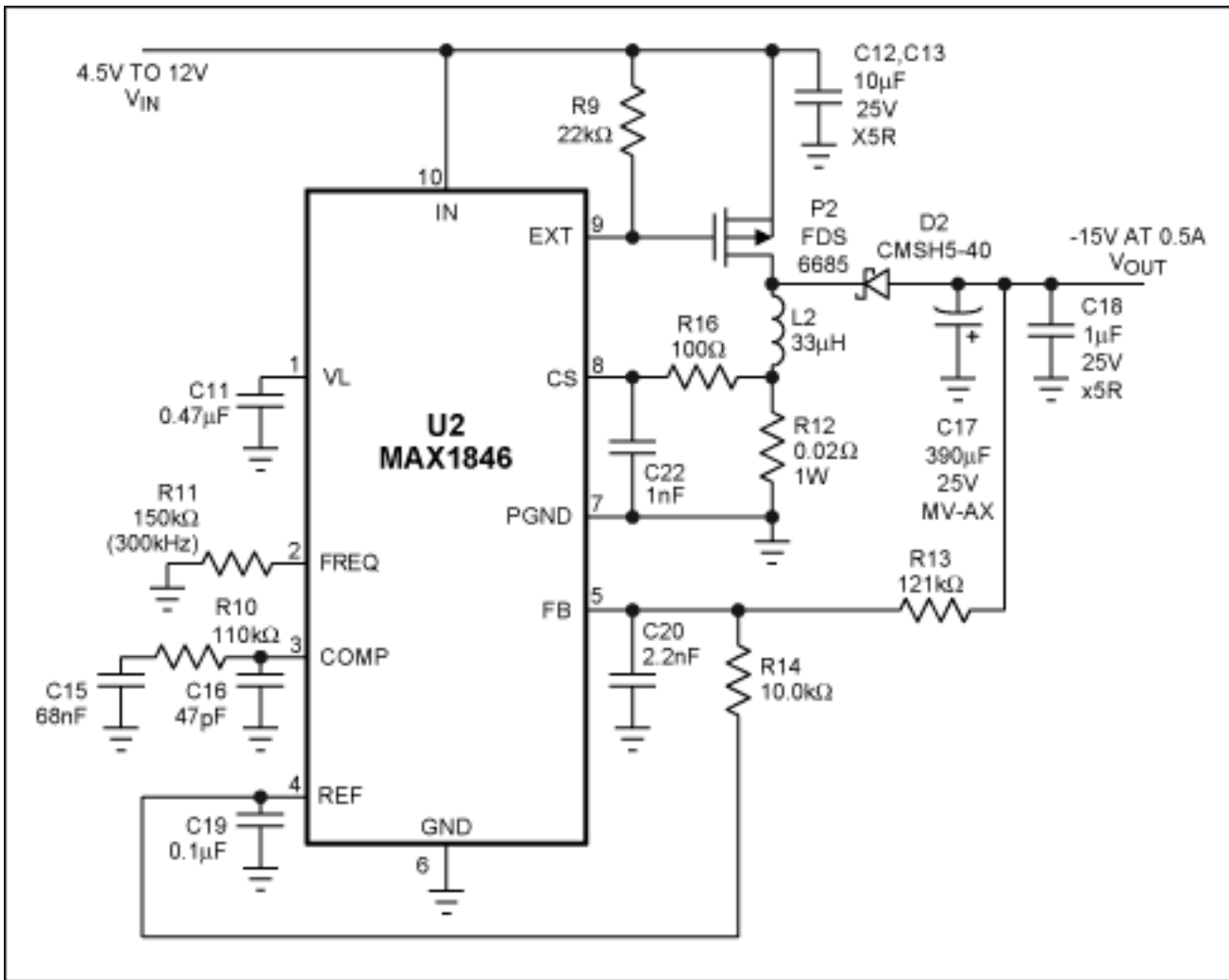


Figure 2. This diagram utilizes the MAX1846 inverting circuit to implement a -15V at 0.5A output from a 4.5V to 12V input.

Table 3. Performance Data for the MAX1846 Circuit

$V_{IN}$ (V)	$I_{IN}$ (A)	$V_{OUT}$ (V)	$I_{OUT}$ (A)	Efficiency
5.00	0.0077	-15.15	0	
5.00	1.76	-15.15	0.50	0.861
6.01	1.42	-15.15	0.50	0.888
8.01	1.05	-15.15	0.50	0.901
10.00	0.84	-15.15	0.50	0.902
12.00	0.70	-15.15	0.50	0.902
4.48	2.04	-15.15	0.50	0.829
20MHz BW		360mV <sub>p,p</sub>		
4.48	3.63	-15.15	0.80	0.745
Current Limit			-0.81	

**Table 4. The Bill of Materials for the MAX1846 Switch-Mode Power-Supply Circuit 4.5V to 12V Input, -15V at 0.5A Output (12/23/05)**

DESIGNATION	QTY	DESCRIPTION
C11	1	0.47 $\mu$ F ceramic capacitor (0603)
C12, C13	2	10 $\mu$ F 25V X5R ceramic capacitor (1210) Taiyo Yuden TMK325BJ106MM
C15	1	68nF ceramic capacitor (0603)
C16	1	47pF ceramic capacitor (0603)
C17	1	390 $\mu$ F 25V aluminum electrolytic capacitor Sanyo 25MV390AX
C18	1	1 $\mu$ F 25V X5R ceramic capacitor (1206)
C19	1	0.1 $\mu$ F ceramic capacitor (0603)
C20	1	2.2nF ceramic capacitor (0603)
C22	1	1nF ceramic capacitor (0603)
D2	1	5A 40V Schottky diode Central Semiconductor CMSH5-40
L2	1	33 $\mu$ H 5A inductor Coilcraft DS5022P-333
P2	1	35m $\Omega$ -30V p-ch MOSFET (SO-8) Fairchild FDS6685
R9	1	22k $\Omega$ 5% resistor (0603)
R10	1	110k $\Omega$ 5% resistor (0603)
R11	1	150k $\Omega$ 5% resistor (0603)
R12	1	0.02 $\Omega$ 1W 1% resistor (2512) Dale WSL-2512-R020-F
R13	1	121k $\Omega$ 1% resistor (0603)
R14	1	10.0k $\Omega$ 1% resistor (0603)
R16	1	100 $\Omega$ 5% resistor (0603)
U2	1	MAX1846EUB (10- $\mu$ MAX)

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Application Note 3943: [www.maxim-ic.com/an3943](http://www.maxim-ic.com/an3943)

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#### Related Parts

MAX1846: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX668: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

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