

APPLICATION NOTE 3046

All-Ceramic Capacitor Step-Down/Inverter Supplies $\pm 5V$ at 3A

Abstract: A MAX8538 dual synchronous buck controller supplies both +5V and -5V outputs at 3A. One controller operates as a synchronous rectified step-down (buck) converter while the second controller runs a transformer driven inverter. The circuit also features soft start and soft stop.

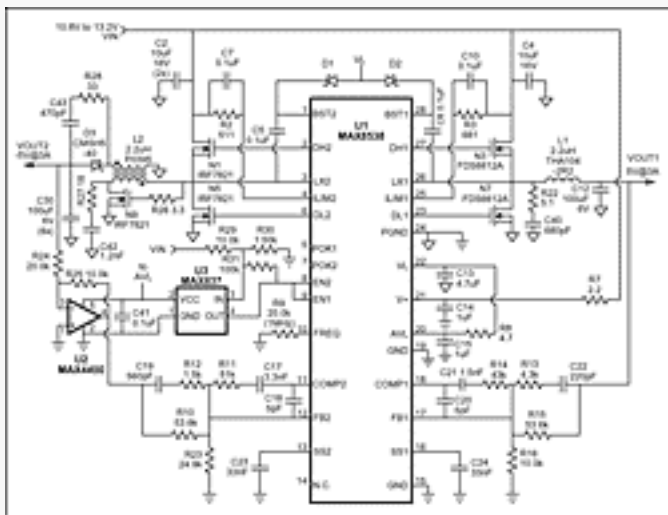
This 1MHz all-ceramic capacitor design uses the [MAX8538](#) dual synchronous buck controller to provide soft-start and soft-stop functions for the +5V and -5V rails at the same time. One controller output is configured as a synchronous buck converter to provide +5V at 3A. The second buck controller is configured as a flyback inverter with a 1:1 transformer to provide -5V at 3A.

The negative output voltage is controlled by a MAX4400 op amp with an inverting gain of one-half. The op amp is biased from the MAX8538's on-board 5V VL regulator. With the gain of -1/2 the op-amp output is within its range and within the common-mode range of the error amp.

The control gain of a buck converter is $V_{OUT}/V_{IN} = \text{duty cycle}$. The control gain of a 1:1 flyback inverter is $V_{OUT}/V_{IN} = \text{duty cycle}/(1 - \text{duty cycle})$, which increases with duty cycle. For a 1:1 flyback inverter, $\text{duty cycle} = V_{OUT}/(V_{IN} + V_{OUT}) = 5V/(10.8V + 5V) = 0.317$. Then the extra control gain is $1/(1 - 0.317) = 1.464$. This extra gain is factored into the design equations for Type 3 compensation by reducing the designed cross-over frequency a factor of 1.464. The op-amp inverting gain is compensated by adjusting R23 without affecting the rest of the compensation network.

A [MAX837](#) voltage monitor provides under-voltage lockout. The MAX8538 is turned on when V_{IN} reaches 9.2V.

R31 introduces 75mV of positive feedback (hysteresis) for noise-free switching to allow a clean soft-start and soft-stop with a low V_{IN} slew-rate. Note that since the flyback inverter has discontinuous transformer current, getting the -5V soft-stop to be symmetric with the +5V rail will depend on the load on the -5V rail. Also the -5V side's discontinuous transformer current requires larger output filter capacitance than the +5V side.



[For Larger Image](#)

Figure 1.

Table 1.

V_{IN}	I_{IN}	$V1$	$I1$	$V2$	$I2$	Efficiency
12.00	0.044	5.083	0	-5.043	0	
10.77	3.41	5.078	3	-5.038	3	0.826
12.00	3.06	5.080	3	-5.040	3	0.827
13.23	2.79	5.080	3	-5.040	3	0.823
		20mV _{p-p} ripple in 20MHz BW		25mV _{p-p} ripple in 20MHz BW		

Table 2. Bill of Materials**10.8V to 13.2V Input; -5V at 3A, 5V at 3A Output**

Designation	QTY	Description
C2, C4	3	10 μ F 16V X5R ceramic capacitor (1210) Taiyo Yuden EMK325BJ106MN
C5, C6, C7, C10, C41	5	0.1 μ F ceramic capacitor (0603)
C12, C30	7	100 μ F 6V Y5U ceramic capacitor (1210) Taiyo Yuden JMK325E107MM
C13	1	4.7 μ F 6V X5R ceramic capacitor (0805) Taiyo Yuden JMK212BJ475MG
C14	1	1 μ F 25V X5R ceramic capacitor (1206) Taiyo Yuden TMK316BJ105ML
C15	1	1 μ F 6V X5R ceramic capacitor (0603) Taiyo Yuden JMK107BJ105MA
C17	1	3.3nF ceramic capacitor (0603)
C18, C20	2	5pF ceramic capacitor (0603)
C19	1	560pF ceramic capacitor (0603)
C21	1	1.5nF ceramic capacitor (0603)
C22	1	220pF ceramic capacitor (0603)
C23, C24	2	33nF ceramic capacitor (0603)
C40	1	680pF ceramic capacitor (0603)
C42	1	1.2nF ceramic capacitor (0603)
C43	1	470pF ceramic capacitor (0603)
D1, D2	2	100mA 30V Schottky diode (SOD-323) Central Semi CMDSH-3
D3	1	5A 40V Schottky diode Central Semi CMSH5-40
L1	1	2.2 μ H 10A Power Inductor Delta THA104-2R2
L2	1	2.2 μ H 14.4A Dual Power Inductor Pulse P0395
N1, N5, N9	3	30V 13m Ω N-ch MOSFET (SO-8) International Rectifier IRF7821
N3, N7	2	30V 30m Ω N-ch MOSFET (SO-8) Fairchild FDS6612A
R2	1	511 Ω 1% resistor (0603)
R3	1	681 Ω 1% resistor (0603)
R7	1	2.2 Ω 5% resistor (0603)
R8	1	4.7 Ω 5% resistor (0603)
R9, R24	2	20.0k Ω 1% resistor (0603)
R10, R15	2	53.6k Ω 1% resistor (0603)
R11	1	51k Ω 5% resistor (0603)
R12	1	1.5k Ω 5% resistor (0603)
R13	1	4.3k Ω 5% resistor (0603)
R14	1	43k Ω 5% resistor (0603)
R16, R25	2	10.0k Ω 1% resistor (0603)

R22	1	5.1Ω 0.125W 5% resistor (1206)
R23	1	24.9kΩ 1% resistor (0603)
R26	1	3.3Ω 0.25W 5% resistor (1210)
R27	1	18Ω 5% resistor (0603)
R28	1	33Ω 5% resistor (0603)
R29	1	10.0kΩ 1% resistor (0603)
R30	1	1.50kΩ 1% resistor (0603)
R31	1	100kΩ 1% resistor (0603)
U1	1	MAX8538EEI (28 QSOP)
U2	1	MAX4400AXK (5 SC70)
U3	1	MAX837EUS (4 SOT143)

Application note 3046: www.maxim-ic.com/an3046

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