Introduction

The DeCAPitator is designed to reduce the number of bulk capacitors required at the output of a switching DC/DC converter powering a microprocessor in a portable computer. It contains two high-speed linear regulators which are only active if the processor core voltage is disturbed by a fast moving load transient. Figure 1 shows the HIP6200 in its typical application. Refer to the HIP6200 data sheet [1] for detailed specifications.

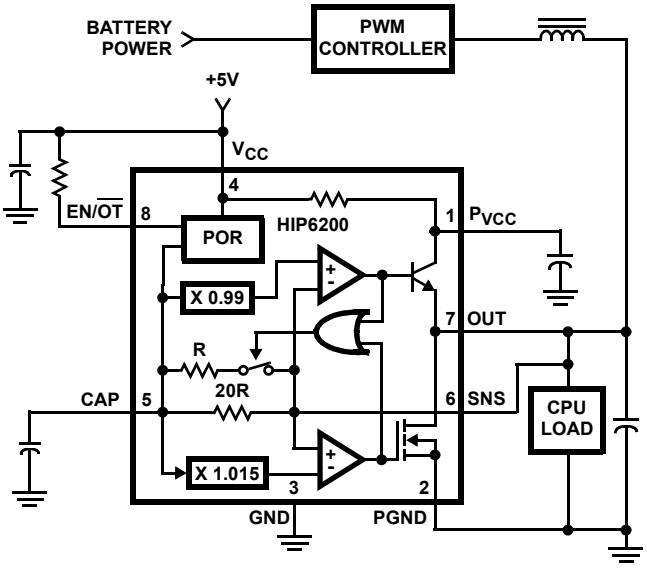


FIGURE 1. DeCAPitator IN A TYPICAL APPLICATION - PORTABLE CPU DYNAMIC REGULATOR

DeCAPitator Evaluation Tool

The HIP6200EVAL1 is an evaluation board which demonstrates the DeCAPitator's effectiveness in dealing with high-speed load transients. The board consists of a DC/DC converter with two different output stages: (1) a simple L-C filter containing eleven 220µF low-ESR tantalums, and (2) an L-C filter with only five 100µF low-ESR tantalums and the HIP6200 and its associated circuitry. On each output stage is a high edge-rate transient generator capable of producing 8A (or higher) transients. A block diagram of the evaluation board is shown in Figure 2 and the complete schematic, bill-of-materials, and board description is contained in the appendix.

Supporting Circuitry on the HIP6200EVAL1

The evaluation board has peripheral circuitry to enable the user to easily verify the performance and value of the HIP6200.

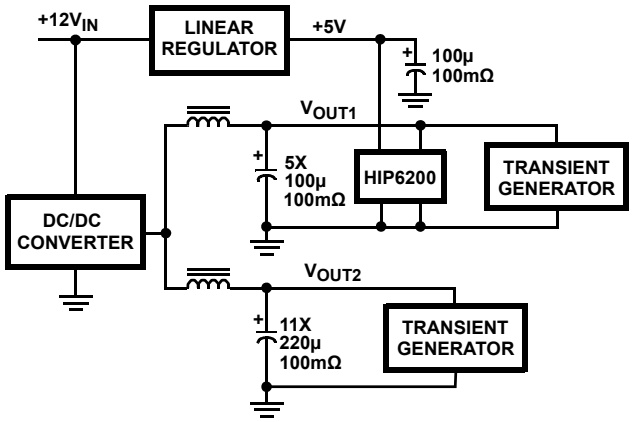


FIGURE 2. BLOCK DIAGRAM OF HIP6200EVAL1

DC/DC Converter

The DC/DC converter uses a Intersil HIP6004 PWM controller, which is suited for desktop applications. It contains a 5-bit DAC for output voltage programmability and uses voltage mode control. The evaluation board uses four of the five bits to allow the user to select outputs from 1.3V to 2.05V. Refer to Table 1 for the programming code. The evaluation board accepts 12V for its input power source; the HIP6004 can down convert 5V or less, but requires 12V for internal bias.

TABLE 1. DC/DC CONVERTER VOLTAGE PROGRAMMING

JUMPER SETTING				NOMINAL OUTPUT VOLTAGE
JP3	JP2	JP1	JP0	
1	1	1	1	1.30
1	1	1	0	1.35
1	1	0	1	1.40
1	1	0	0	1.45
1	0	1	1	1.50
1	0	1	0	1.55
1	0	0	1	1.60
1	0	0	0	1.65
0	1	1	5	1.70
0	1	1	0	1.75
0	1	0	1	1.80
0	1	0	0	1.85
0	0	1	1	1.90
0	0	1	0	1.95
0	0	0	1	2.00
0	0	0	0	2.05

NOTE: 1 = jumper open, 0 = jumper closed

Linear Regulator

The HIP6200 uses 5V for bias and also for its high-side device power source. For this reason, a Intersil ICL7663 linear regulator is included on board to provide a 5V source. Though this 5V source supplies up to 8A of current for short periods of time when the HIP6200 turns on its upper amplifier, its average current is small due to the low frequency of the transient events and the low duty-cycle of the current being sourced from the 5V rail.

The linear regulator is included on the evaluation board for user convenience only. It allows the HIP6200EVAL1 to be powered from a single 12V supply voltage.

Transient Generator

The HIP6200EVAL1 includes a high di/dt transient load generator for each output stage. The transient generator is set for approximately an 8A load step when the converter output voltage is 1.7V and the edge-rates are set for about 40A/µs. The load pulse is about 350µs at a 70Hz repetition rate.

The load step size can be modified by adding or removing load resistors (R_{6-17} and R_{24-35} in Figure 7). This process is necessary to maintain an approximately 8A step size with a V_{OUT} other than 1.7V. The number of load resistors required as a function of V_{OUT} and load transient step size (I_{STEP}) can be approximated by:

$$N = \frac{2}{\left(\frac{V_{OUT}}{I_{STEP}} - r_{DSON}\right)} \quad \text{(EQ. 1)}$$

where:

N = number of 2Ω load resistors

$r_{DS(ON)}$ = on-resistance of MOSFET (Q_3 or Q_5)

After calculating N, the number should be rounded to the nearest integer.

Operational Modes

The HIP6200EVAL1 allows the user to verify the DeCAPitator's value by comparing the output response to a load transient under three different situations. Two switches (S_1 and S_2) provide the user with the ability to exercise the evaluation board in all three operational modes. Table 2 details the switch positions required for each mode. Refer to the board description in the appendix for the board orientation in reference to the up/down switch position. In addition, there is a third switch provided (S_3) to disable the DC/DC converter.

Always disable the converter before changing operational mode.

TABLE 2. HIP6200EVAL1 SWITCH POSITIONS

SWITCH POSITION		OPERATIONAL MODE	OUTPUT VOLTAGE	HIP6200 POWERED
S_1	S_2			
Up	Up	1	V_{OUT1}	No
Up	Down	2	V_{OUT1}	Yes
Down	Don't Care	3	V_{OUT2}	No

Switch 1 selects which output is regulated and dynamically loaded by routing the correct output voltage to feedback and also selecting the correct transient generator to receive bias power. S_2 simply enables or disables the HIP6200.

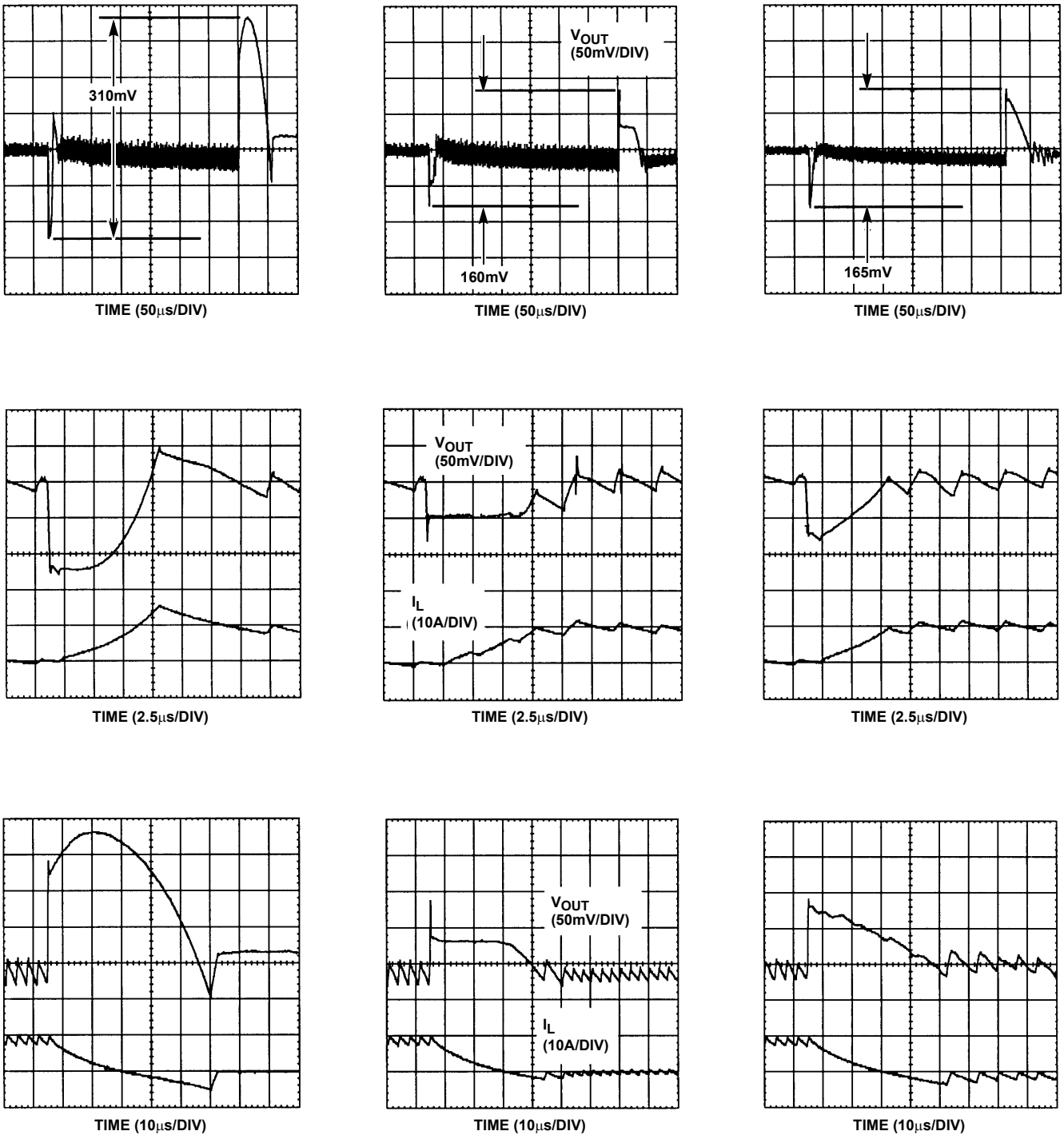
DeCAPitator Performance

The DeCAPitator allows equivalent converter transient response with much less bulk output capacitance. This is witnessed in Figure 3, which displays the results which are attained by exercising the evaluation board in its three different modes of operation. The top row of oscilloscope photos show the peak-to-peak voltage excursion resulting from both the 0 to 8A and 8 to 0A load transients. Both the leading and falling edges of the transient step are approximately 40A/µs. The middle row details the leading edge and the bottom row shows the falling edge.

The HIP6200's effectiveness is readily seen by comparing column 2 vs. column 1 and its value is better judged by comparing column 2 vs. column 3. The output voltage response is equivalent or better for mode 2 in comparison to mode 3. Mode 2 uses 600µF of capacitance (including +5V cap) versus 2420µF for mode 3.

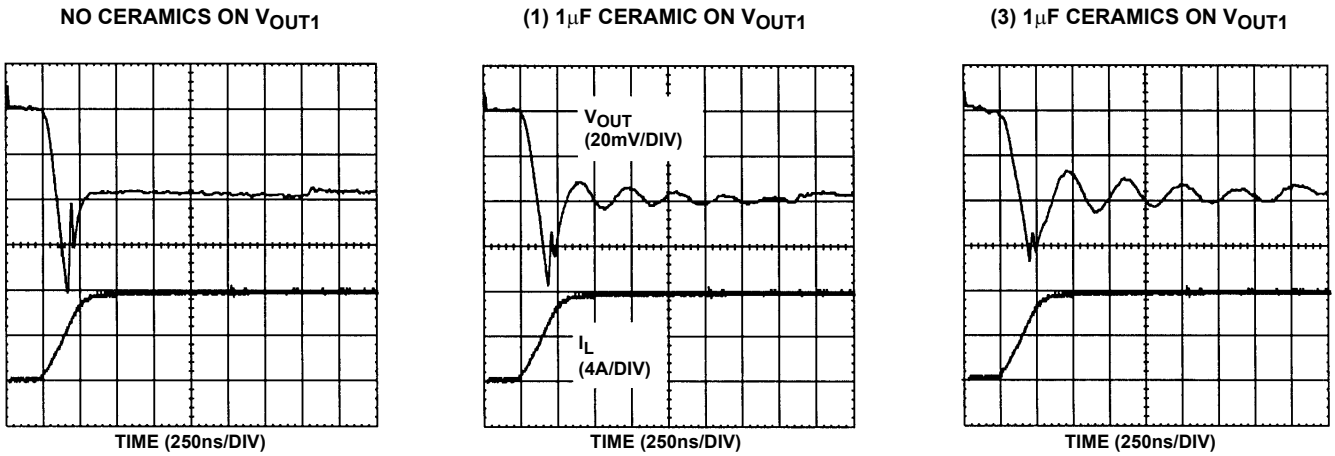
The HIP6200EVAL1 has component locations available for up to three 1µF ceramic capacitors on V_{OUT1}. As evidenced by Figure 3, the DeCAPitator does an excellent job of handling the edges of the load transient without any ceramic capacitors on the output. With some ceramics, it is able to reduce the voltage deviation further. Figure 4 shows the leading edge of the transient with no ceramic caps, with (1) 1µF ceramic, and with (3) 1µF ceramics. The three additional ceramic capacitors reduce the leading-edge voltage deviation by about 14mV.

OPERATIONAL MODE 1	OPERATIONAL MODE 2	OPERATIONAL MODE 3
C_{OUT} = (5) 100µF, No DeCAPitator	C_{OUT} = (5) 100µF DeCAPitator (with (1) 100µF +5V Cap)	C_{OUT} = (11) 220µF, No DeCAPitator



NOTE: V_{OUT} = 1.7V, Load Transient = 8A with di/dt = 40A/µs.

FIGURE 3. TRANSIENT RESPONSE WAVEFORMS



NOTE: Ceramic capacitors enhance the HIP6200's ability to handle fast edge-rate transients.

FIGURE 4. EXPANDED VIEW OF LEADING EDGE OF LOAD TRANSIENT

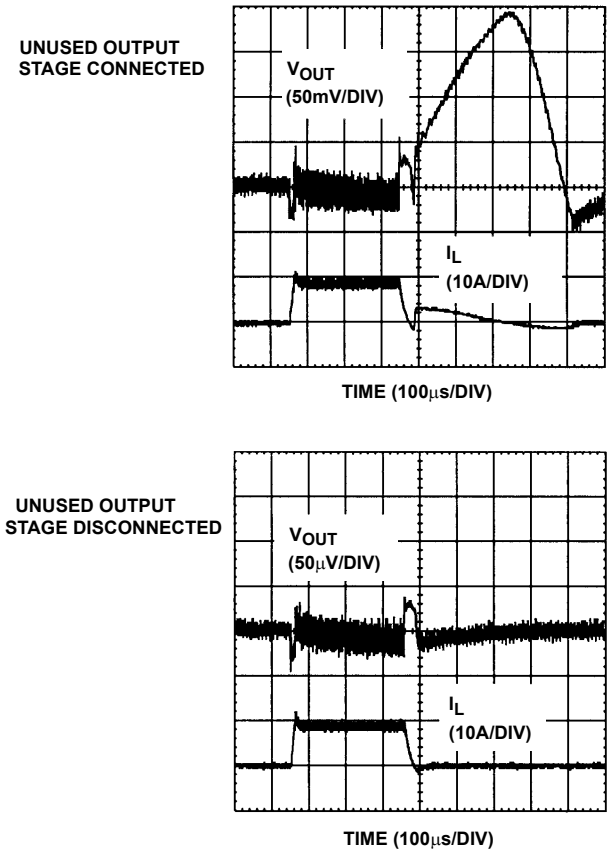


FIGURE 5. COMPARISON OF V_{OUT1} RESPONSE WITH AND WITHOUT V_{OUT2} OUTPUT STAGE PHYSICALLY CONNECTED

Because the evaluation board uses two output stages, there is some cross conduction between the two outputs unless the unloaded output is physically disconnected from the circuit. A good way to do this is by unsoldering one lead of the current looker wires of the unloaded side. Figure 5 shows how the unloaded output can affect the output under test if the unloaded output is connected. The HIP6200 remains off due to this cross-conduction because the output voltage deviation is slow moving.

The evaluation board is shipped with the output stages physically connected for user convenience in comparing performance of the different operational modes of the board. It is important to note that the board provides the important information if the unloaded output is connected. The user should be aware that the loaded output may look like it is misbehaving if the unloaded output is not disconnected.

+5V Bus

Since the DeCAPitator supplies current from a 5V source when its upper amplifier is on, it is important to verify that the 5V bus is not disturbed greatly. Figure 6 shows both V_{CC} and P_{VCC} in response to the 0-8A load transient. In a system implementation, V_{CC} will be tied to the system 5V bus and P_{VCC} will remain local to the HIP6200. P_{VCC} and V_{CC} are connected through an on-chip 10Ω (typical) resistor.

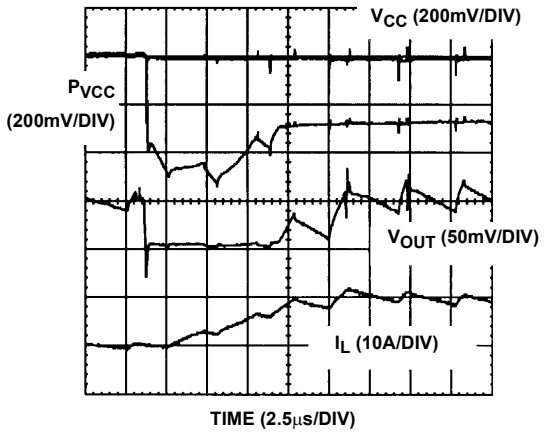


FIGURE 6. DeCAPitator DISTURBS +5V BUS (V_{CC}) MINIMALLY

Power Dissipation/Thermal

Measuring the power dissipation of the HIP6200 in its intended application is very difficult. The output current of the DeCAPitator must be monitored to measure its power. However, most current sensing elements will dramatically affect the performance of the part, and hence the power dissipation. We can monitor the case temperature of the IC with reasonable accuracy, providing us some indication of the power dissipation.

Figure 7 plots the measured DeCAPitator case temperature and a predicted junction temperature versus transient frequency. The measured data was taken on the HIP6200EVAL1 at room temperature at five distinct transient frequencies by varying the value of C_{36} and R_{22}. The $10^{o}C$ temperature rise at low transient frequencies is attributed to the PC board self-heating due to the transient load resistors.

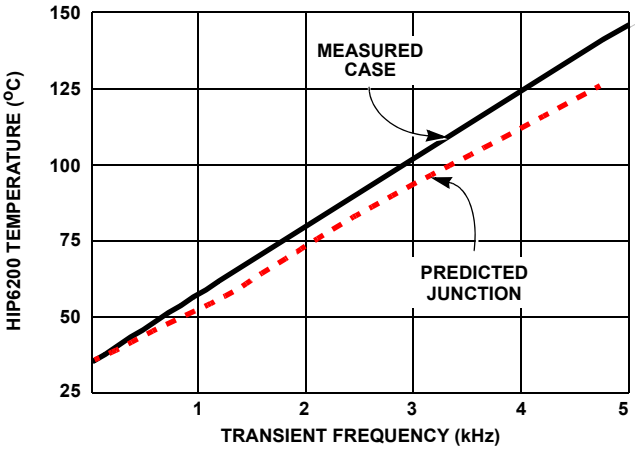


FIGURE 7. PREDICTED AND MEASURED DECAPITATOR TEMPERATURE RISE

The predicted junction temperature is based on an approximation of power dissipation (Equations 3-7 in the HIP6200 datasheet) and the parameters of the evaluation board:

I_{STEP} = 8.3A

T_{R1} = 6.5µs

T_{R2} = 24µs

θ_{JA} = $85^{o}C/W$

The above parameters were measured on the evaluation board. The thermal impedance was derived in a separate experiment where the DeCAPitator was biased ‘on’ with a small DC load. No external airflow was provided to achieve the $85^{o}C/W$ number.

In most microprocessor applications, severe load transient excursions will take place at frequencies well below 1kHz, thus rendering thermal considerations a non-issue.

Conclusion

The Intersil HIP6200 DeCAPitator is a very high-speed device containing two part-time linear regulators. It can reduce DC/DC converter output capacitor requirements in microprocessor applications where the core voltage is 2V or less. The HIP6200EVAL1 is an evaluation vehicle which demonstrates the value of the DeCAPitator in a simulated processor application.

Reference

For Intersil documents available on the web, see http://www.intersil.com.

[1] *HIP6200, HIP6201 Datasheet,* Intersil Corporation.

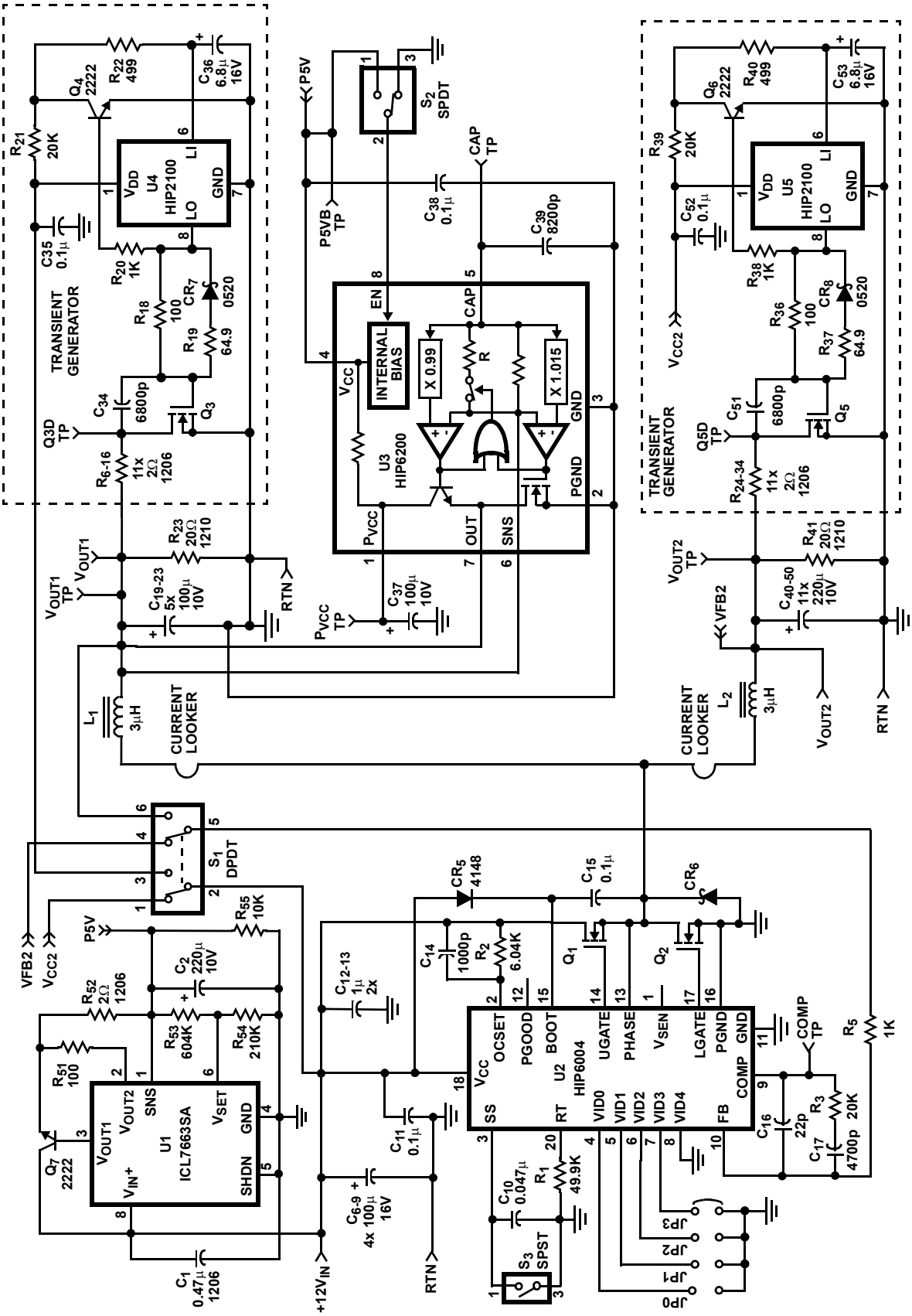

TRANSIENT GENERATOR
INTERNAL BIAS
CURRENT LOOKER
CURRENT LOOKER
TRANSIENT GENERATOR
HIP2100
HIP6200
HIP6004
ICL7663SA
S1 DPDT
S2 SPDT
S3 SPST
X 0.99
X 1.015
+12VIN
RTN
VOUT1
VOUT2
VCC2
P5V
P5VB
PVCC
VFB2
COMP
CAP
L1 3µH
L2 3µH
R1 49.9K
R2 6.04K
R3 20K
R5 1K
R53 604K
R54 210K
R55 10K
C1 0.47µ 1206
C2 220µ 10V
C10 0.047µ
C11 0.1µ
C12-13 1µ 2x
C14 1000p
C15 0.1µ
C16 22p
C17 4700p
C35 0.1µ
C38 0.1µ
C39 8200p
C52 0.1µ
C53 6.8µ 16V
C6-9 4x 100µ 16V
C19-23 5x 100µ 10V
C37 100µ 10V
C40-50 11x 220µ 10V
C34 6800p
C51 6800p
R6-16 11x 2Ω 1206
R24-34 11x 2Ω 1206
R23 20Ω 1210
R41 20Ω 1210
R18 100
R19 64.9
R36 100
R37 64.9
R20 1K
R38 1K
R21 20K
R39 20K
R22 499
R40 499
R51 100
R52 2Ω 1206
CR7 0520
CR8 0520
CR5 4148
CR6
Q1
Q2
Q3
Q4 2222
Q5
Q6 2222
Q7 2222
JP0
JP1
JP2
JP3
Q3D TP
Q5D TP
VOUT1 TP
VOUT2 TP
PVCC TP
P5VB TP
CAP TP
COMP TP

FIGURE 8.

Parts List for HIP6200EVAL1

ITEM #	PART NUMBER	DESCRIPTION	PACKAGE	QTY	REF	VENDOR
1	ICL7663SACBA	CMOS Voltage Regulator	SOIC-8	1	U1	Intersil
2	HIP6004CB	Sync-Buck PWM Controller	SOIC-20	1	U2	Intersil
3	HIP6200	DeCAPitator Dynamic Regulator	SOIC-8	1	U3	Intersil
4	HIP2100IB	Half-Bridge Driver	SOIC-8	2	U4-5	Intersil
5	RF1K49157	MOSFET, 30MΩ, 30V	SOIC-8	4	Q_{1-3}, Q_5	Intersil
6	MMBT2222ALT	Transistor, NPN, 40V	SOT-23	3	Q_4, Q_{6-7}	Motorola
7	GT21MSCKE	Switch, double-pole, double-throw		1	S_1	C&K
8	GT11MSCKE	Switch, single-pole, double-throw		1	S_2	C&K
9	GT12MSCKE	Switch, single-pole, single-throw		1	S_3	C&K
10	1N4148	Rectifier 75V	DO35	1	CR_5	Various
11	MBRS360T3	Rectifier, Schottky, 3A, 60V	DO-214AB	1	CR_6	Motorola
12	MBRS0520T1	Rectifier, Schottky, 0.5A, 20V	SOD-123	2	CR_{7-8}	Motorola
13	PO520	3uH, 8A Inductor	LCI-37	2	L_{1-2}	Pulse
14	0.47µ Ceramic	Cap, Ceramic, Y5V, 0.47µ, 16V	1206	1	C_1	AVX
15	0.1µ Ceramic	Cap, Ceramic, X7R, 0.1µ, 25V	0805	5	C_{11}, C_{15}, C_{35}, C_{38}, C_{52}	Various
16	TPSE107M016	Cap, TPS Tantalum, 16V, 100µ	E Case	4	C_{6-9}	AVX
17	0.047µ Ceramic	Cap, Ceramic, X7R, 0.047µ	0805	1	C_{10}	various
18	1206YZ105MAT1A	Cap, Ceramic, X7S, 1µ, 16V	1206	2	C_{12-13}	AVX
19	22p Ceramic	Cap, Ceramic, X7R, 22p	0805	1	C_{16}	Various
20	1000p Ceramic	Cap, Ceramic, X7R, 1000p	0805	1	C_{14}	Various
21	4700p Ceramic	Cap, Ceramic, X7R, 4700p	0805	1	C_{17}	Various
22	TPSD107M010	Cap, TPS Tantalum, 10V, 100µ	D Case	6	C_{19-23}, C_{37}	AVX
23	6800p Ceramic	Cap, Ceramic, X7R, 6800p	0805	2	C_{34}, C_{51}	Various
24	TAJC685M016	Cap, Tantalum, 6.8µ, 16V	C Case	2	C_{36}, C_{53}	AVX
25	8200p Ceramic	Cap, Ceramic, X7R, 8200p	0805	1	C_{39}	Various
26	TPSE227M010	Cap, TPS Tantalum, 10V, 220µ	E Case	12	C_2, C_{40-50}	AVX
27	49.9kΩ	Resistor, 49.9kΩ, 1% 0.1W	0805	1	R_1	Various
28	6.04kΩ	Resistor, 4.02kΩ, 1% 0.1W	0805	1	R_2	Various
29	1kΩ	Resistor, 1kΩ, 1% 0.1W	0805	3	R_5, R_{20}, R_{38}	Various
30	2Ω	Resistor, 2Ω, 1% 0.125W	1206	23	R_{6-16}, R_{24-34}, R_{52}	Various
31	20Ω	Resistor, 20Ω, 5% 0.25W	1210	2	R_{23}, R_{41}	Various
32	100Ω	Resistor, 100Ω, 1% 0.1W	0805	3	R_{18}, R_{36}, R_{51}	Various
33	64.9Ω	Resistor, 64.9Ω, 1% 0.1W	0805	2	R_{19}, R_{37}	Various
34	20kΩ	Resistor, 20kΩ, 1% 0.1W	0805	3	R_3, R_{21}, R_{39}	Various
35	499Ω	Resistor, 499Ω, 1% 0.1W	0805	2	R_{22}, R_{40}	Various
36	604kΩ	Resistor, 604kΩ, 1%, 0.1W	0805	1	R_{53}	Various
37	210kΩ	Resistor, 210kΩ, 1%, 0.1W	0805	1	R_{54}	Various
38	10kΩ	Resistor, 10kΩ, 5%, 0.1W	0805	1	R_{55}	Various
39	1514-2	Terminal Post		6	$+12V_{IN}$, V_{OUT1}, V_{OUT2}, RTN	Keystone
40	1314353-00	Scope Probe Test Point		2	V_{OUT1}, V_{OUT2}	Tektronix
41	SPCJ-123-01	Test Point		6	CAP, P5VB, Q_{3D}, Q_{5D}, COMP, P_{VCC}	Jolo

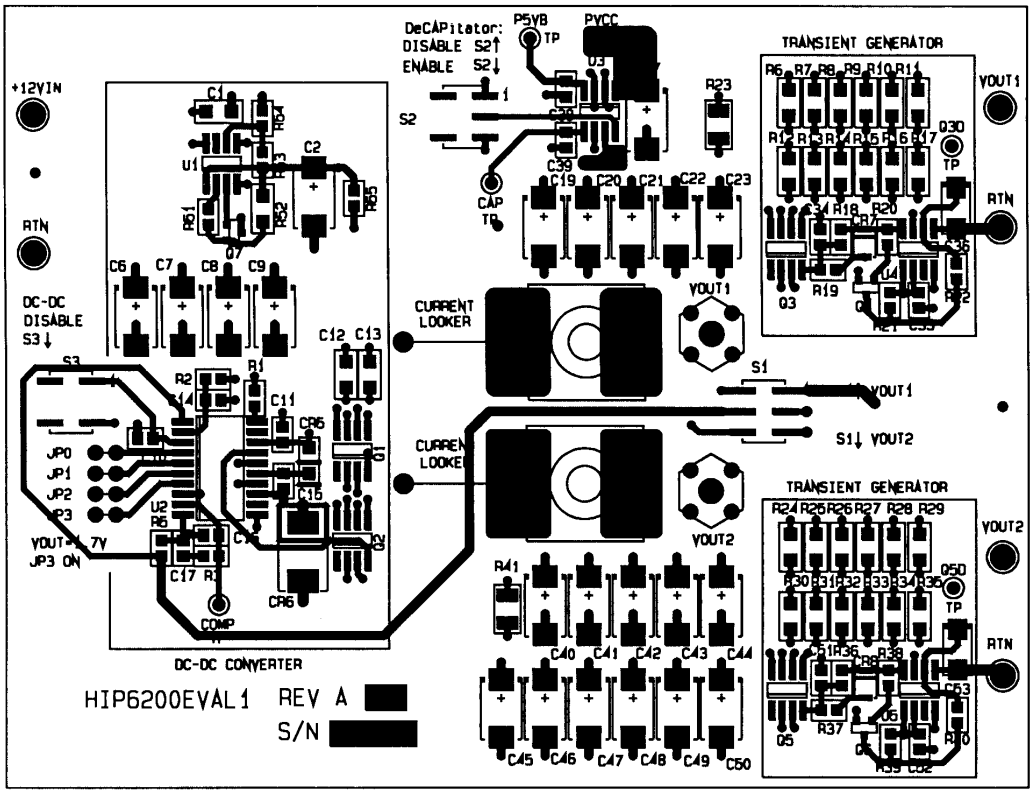


FIGURE 9. TOP - SILK SCREEN

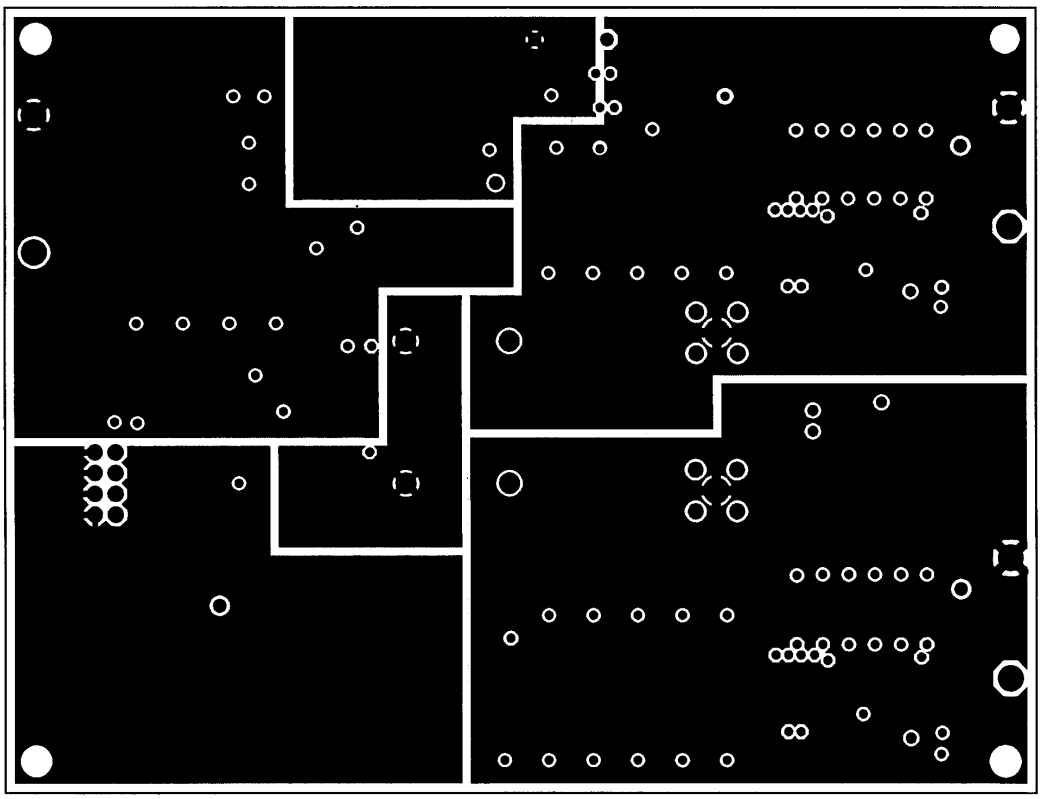


FIGURE 10. INTERNAL ONE

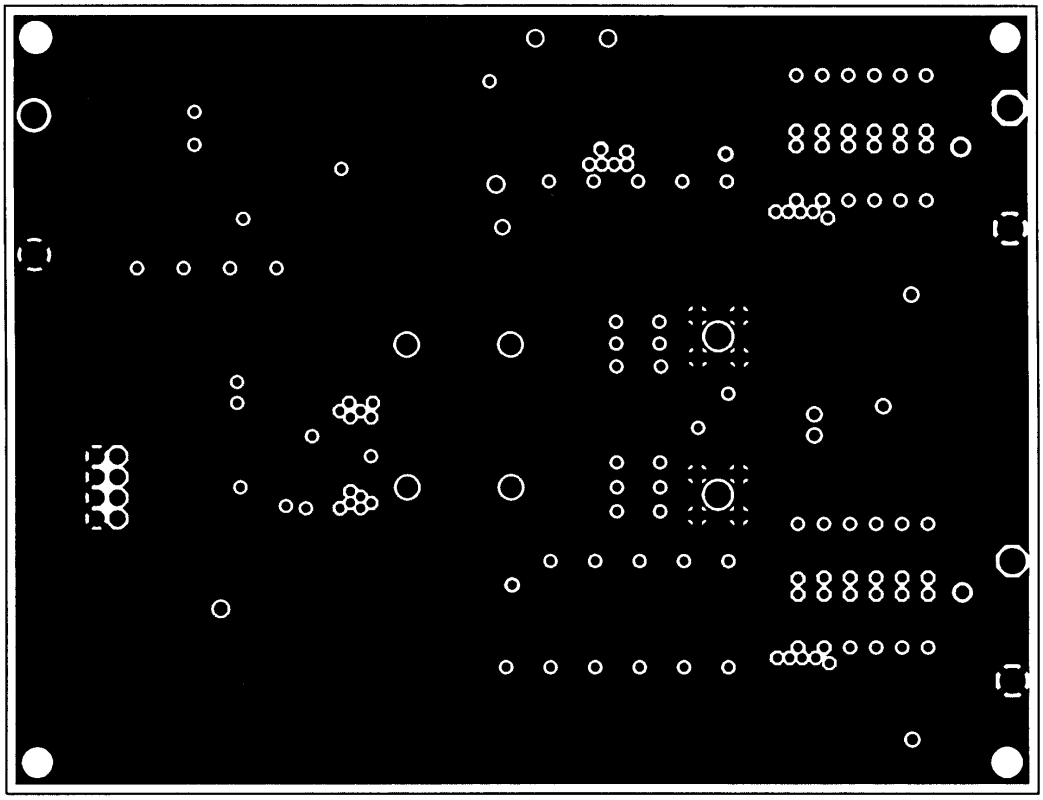


FIGURE 11. GND

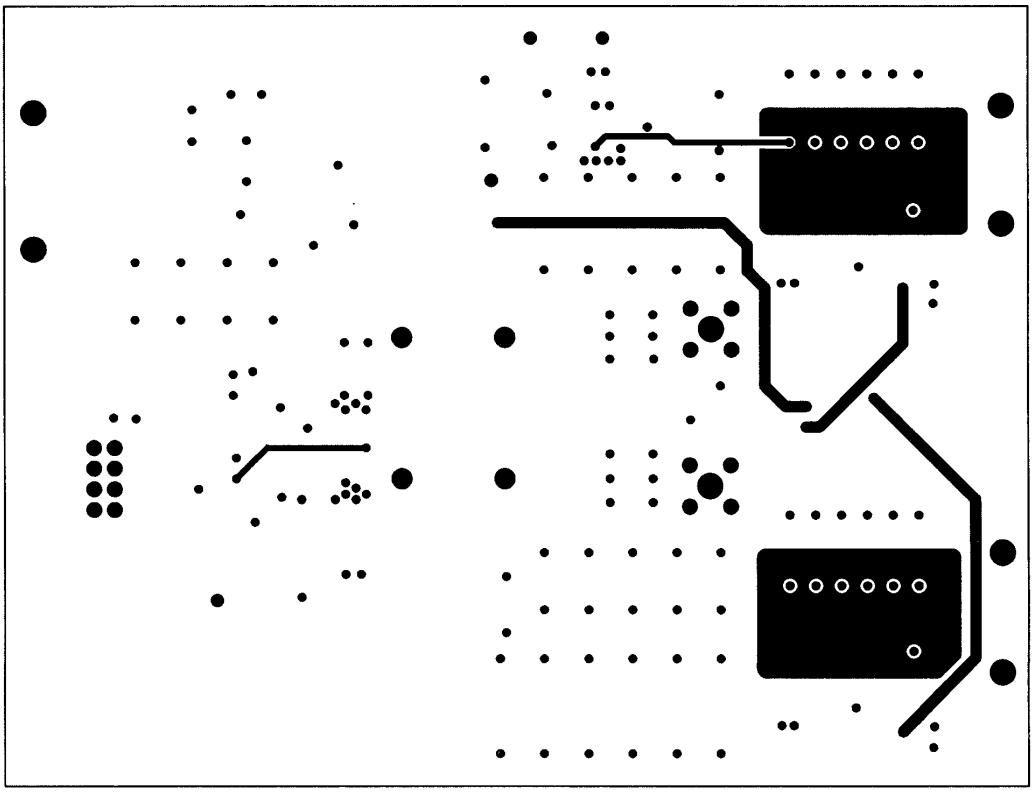


FIGURE 12. SOLDER SIDE