ADP1877 Reference Design

Reference Design **PRD 01135**

FEATURES

Four Output Voltages: 1.2V, 1.8V, 3.3V, 5V

Output Current: 1A to 2.2A

Input Voltage: 10.8-13.2V

DESCRIPTION

This ADP1877 Reference Design uses 10.8 V to 13.2 V for the input voltage. The output voltages and currents are as follows:

- V_{OUT1} = 1.2 V with a maximum output current of 2 A,
- V_{OUT2} = 1.8 V with a maximum output current of 1.8 A,
- V_{OUT3} = 3.3 V with a maximum output current of 1 A,
- V_{OUT4} = 5.0 V with a maximum output current of 2.2 A,

Design criteria are for simultaneous enable with coincidental tracking of V_{OUT1}, V_{OUT2} and V_{OUT4} with V_{OUT3} for turn on and enable turn off. The ripple and transient assumptions are 50 mV peak to peak voltage ripple and 5% deviation due to 50% instantaneous load step. The switching frequency is fixed at 650 kHz for V_{OUT1} and V_{OUT2}, 1000kHz for V_{OUT3} and V_{OUT4}. The design is optimized for additional output capacitance on each rail to simulate system usage and can be recompensated easily for changes in the output capacitance.

ADP1877

The ADP1877 is a current mode dual-phase step-down switching controller with integrated drivers that drive Nchannel synchronous power MOSFETs. The two PWM outputs are phase shifted 180º, which reduces the input RMS current thus minimizing required input capacitance.

The boost diodes are built into the ADP1877, thus lowering the overall system cost and component count. The ADP1877 can be set to operate in pulse skip high efficiency mode under light load or in forced PWM (continuous conduction mode).

The ADP1877 includes programmable soft start, output overvoltage protection, programmable current limit, power good, tracking function, and programmable oscillator frequency that ranges from 200 kHz to 1.5 MHz. The ADP1877 provides an output voltage accuracy of ±1% over temperature, superior transient response and reduced output capacitance. This part can be powered from a 2.75V to 15V supply and is available in 32 pin LFCSP package.

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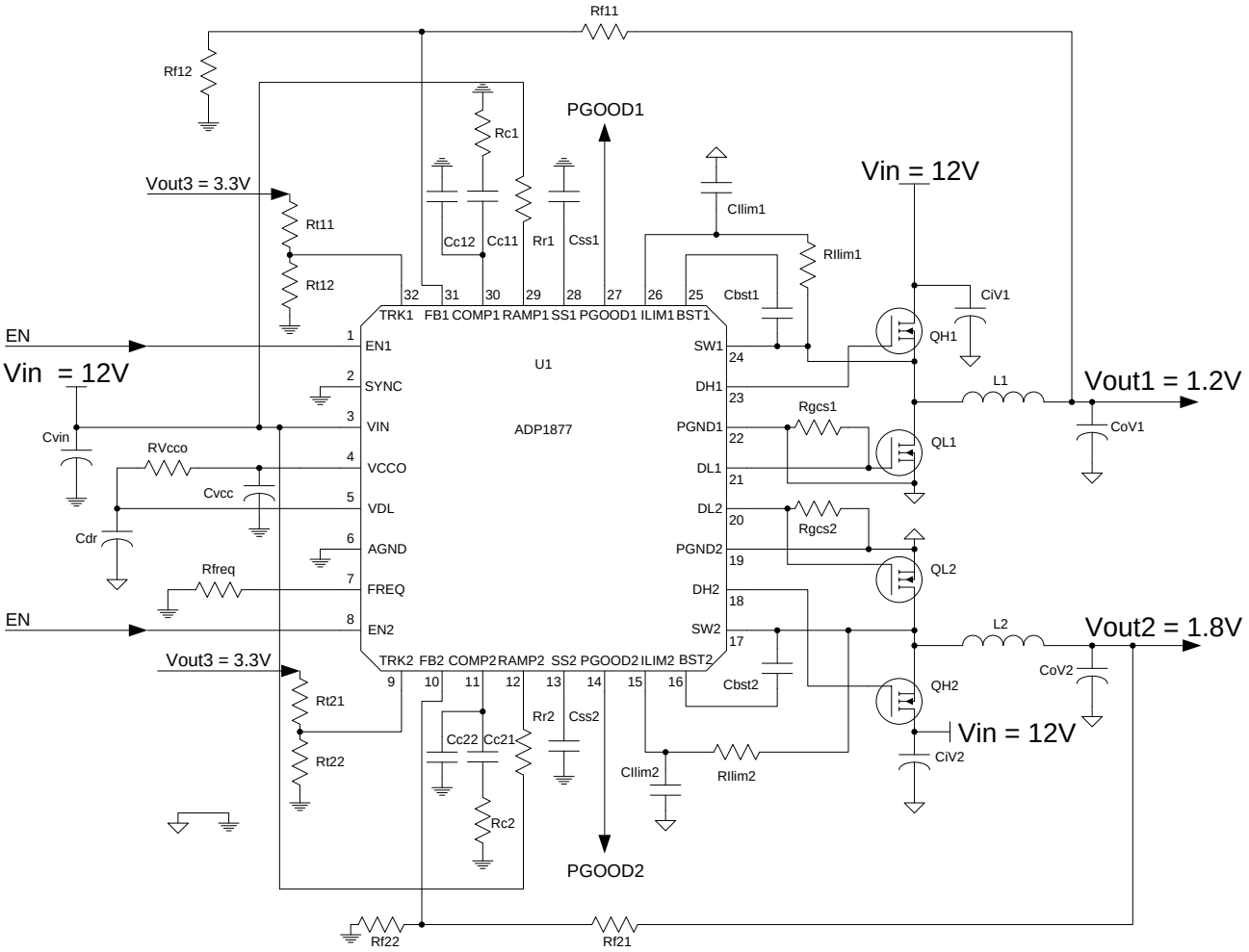
REVISION HISTORY

5/11/2007—Revision 1: Initial Version
8/14/2008—Revision 2: Provided Descriptions
4/22/2009—Revision 3: Changed to standard Windows fonts and sizes

SCHEMATIC

Figure 1. Schematic: V_{out1} and V_{out2} (built on eval board 1)



Note: Tracking resistors are on motherboard, not the eval board

Figure 2. Schematic: V_{out3} and V_{out4} (built on eval board 2)

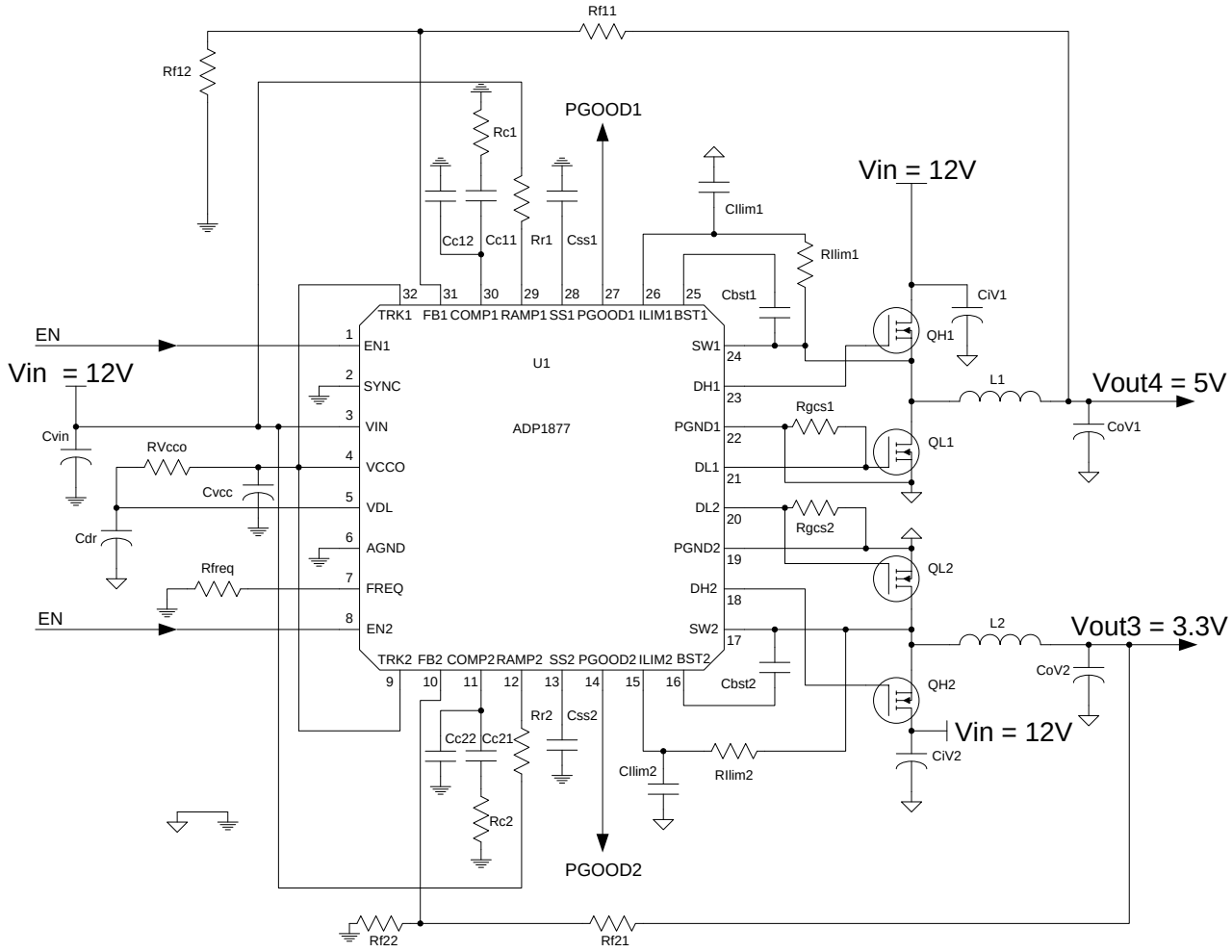
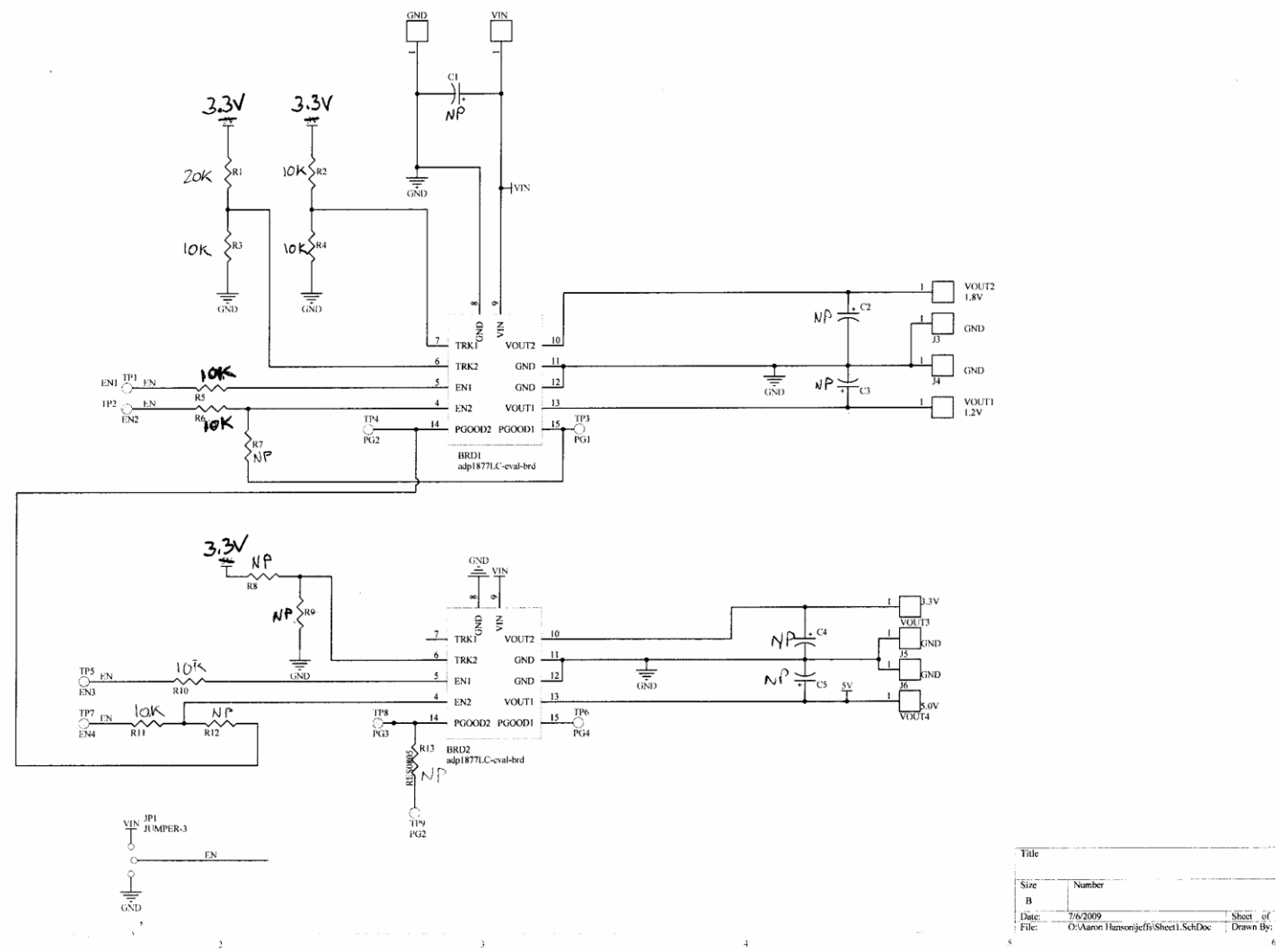


Figure 3. Schematic: Motherboard



Tracking resistors and enable jumpers are populated on the motherboard instead of the eval boards. Most of the assumed extra output capacitance is also soldered on the motherboard.

Bill of Materials

Table 1. Bill of Materials, Vout1 and Vout2 (1.2V and 1.8V) (Eval board 1)

Designator	Part Number	Manufacturer	Value	Package	Comment	Quantity
U1	ADP1877	Analog Devices		40pin LFCSP	Dual Current Mode Controller	1
QH1	Si3446ADV	ON-Semi		SOT23-6	Single 60mOhm 20V N-FET	1
QH2	Si3446ADV	ON-Semi		SOT23-6	Single 60mOhm 20V N-FET	1
QL1	Si3446ADV	ON-Semi		SOT23-6	Single 60mOhm 20V N-FET	1
QL2	Si3446ADV	ON-Semi		SOT23-6	Single 60mOhm 20V N-FET	1
L1	DO1813H-222	Coilcraft	2.2uH	Unshielded Drum Core	Ferrite	1
L2	DO1813H-222	Coilcraft	2.2uH	Unshielded Drum Core	Ferrite	1
CoV1	JMK212BJ106MG-T **JMK212BJ106MG-T**	Taiyo Yuden **Taiyo Yuden**	10uF **10uF**	0805 **0805**	MLCC / X5R / 6.3V **MLCC / X5R / 6.3V**	3 **1**
CoV2	JMK212BJ106MG-T **JMK212BJ106MG-T**	Taiyo Yuden **Taiyo Yuden**	10uF **10uF**	0805 **0805**	MLCC / X5R / 6.3V **MLCC / X5R / 6.3V**	2 **15**
CiV1	EMK212BJ106KG-T	Taiyo Yuden	10uF	0805	MLCC / X5R / 16V	1
CiV2	EMK212BJ106KG-T	Taiyo Yuden	10uF	0805	MLCC / X5R / 16V	1
Cvin	GRM21BR71C105K	Murata	1uF	0805	MLCC / X7R / 16V	1
Cbst1, Cbst2	Generic 10%	Vishay	100nF	0805	Boost Capacitor / COG or X7R	2
Css1	Generic 10%	Vishay	10nF	0805	Soft Start Capacitor / COG or X7R	1
Css2	Generic 10%	Vishay	10nF	0805	Soft Start Capacitor / COG or X7R	1
CIlim1	Generic 10%	Vishay	33pF	0805	Current Limit Capacitor	1
CIlim2	Generic 10%	Vishay	33pF	0805	Current Limit Capacitor	1
Cdr	GRM185R60J105KE21	Murata	1uF	0603	MLCC / X5R / 6.3V	1
Cvcc	GRM185R60J105KE21	Murata	1uF	0603	MLCC / X5R / 6.3V	1
Cc11	Generic 10%	Vishay	1.5nF	0603	Compensation Capacitor - CH1	1
Cc12	Generic 10%	Vishay	5pF	0603	Compensation Capacitor - CH1	1
Cc21	Generic 10%	Vishay	2.2nF	0603	Compensation Capacitor - CH2	1
Cc22	Generic 10%	Vishay	5pF	0603	Compensation Capacitor - CH2	1
RIlim1	Generic 1%	Vishay	3.32k	0603	Current Limit Resistor	1
RIlim2	Generic 1%	Vishay	2.74k	0603	Current Limit Resistor	1
Rgcs1	Generic 1%	Vishay	22k	0603	Current Sense Gain Set - 6V/V	1
Rgcs2	No Pop	Vishay		0603	Current Sense Gain Set - 12V/V	1
Rfreq	Generic 5%	Vishay	97.6k	0603	Frequency Set Resistor - 650kHz	1
Rvcco	Generic 10%	Vishay	1 Ohm	0603	Decoupling Resistor	1
Rr1	Generic 10%	Vishay	249k	0603	Vout 1 Ramp Resistor	1
Rr2	Generic 10%	Vishay	432k	0603	Vout 2 Ramp Resistor	1
Rc1	Generic 10%	Vishay	16.9k	0603	Compensation Resistor	1
Rc2	Generic 10%	Vishay	71.5k	0603	Compensation Resistor	1
Rf11	Generic 1%	Vishay	10k	0603	Feedback Resistor - CH1	1
Rf12	Generic 1%	Vishay	10k	0603	Feedback Resistor - CH1	1
Rf21	Generic 1%	Vishay	20k	0603	Feedback Resistor - CH2	1
Rf22	Generic 1%	Vishay	10k	0603	Feedback Resistor - CH2	1
Rt11	Generic 1%	Vishay	10k	0603	Voltage track Resistor - CH1	1
Rt12	Generic 1%	Vishay	10k	0603	Voltage track Resistor - CH1	1
Rt21	Generic 1%	Vishay	20k	0603	Voltage track Resistor - CH2	1
Rt22	Generic 1%	Vishay	10k	0603	Voltage track Resistor - CH2	1

Table 2. Bill of Materials, Vout3 and Vout4 (3.3V and 5.0V)

Designator	Part Number	Manufacturer	Value	Package	Comment	Quantity
U1	ADP1877	Analog Devices		40pin LFCSP	Dual Current Mode Controller	1
QH1	NTGS3446G	ON-Semi		SOT23-6	Single 60mOhm 20V N-FET	1
QH2	NTGS3446G	ON-Semi		SOT23-6	Single 60mOhm 20V N-FET	1
QL1	NTGS3446G	ON-Semi		SOT23-6	Single 60mOhm 20V N-FET	1
QL2	NTGS3446G	ON-Semi		SOT23-6	Single 60mOhm 20V N-FET	1
L1	MSS1048-682	Coilcraft	6.8uH	Shielded Drum Core	Ferrite	1
L2	MSS1048-682	Coilcraft	6.8uH	Shielded Drum Core	Ferrite	1
CoV1	JMK212BJ106MG-T **JMK212BJ106MG**-T **6CE100KX**	Taiyo Yuden **Taiyo Yuden** **Sanyo**	10uF **10uF** **100uF**	0805 **0805** **6.3x6mm SMT**	MLCC / X5R / 6.3V **MLCC / X5R / 6.3V** **Aluminum Electrolytic**	1 **2** **3**
CoV2	JMK212BJ106MG-T **GRM31CR60J107ME** **GRM31CR60J226K** **35CE10KX**	Taiyo Yuden **Murata** **Murata** **Sanyo**	10uF **100uF** **22uF** **10uF**	0805 **1206** **1206** **5x6mm SMT**	MLCC / X5R / 6.3V **MLCC / X5R / 6.3V** **MLCC / X5R / 6.3V** **Aluminum Electrolytic**	1 **2** **1** **4**
CiV1	EMK212BJ106KG-T	Taiyo Yuden	10uF	0805	MLCC / X5R / 16V	1
CiV2	EMK212BJ106KG-T	Taiyo Yuden	10uF	0805	MLCC / X5R / 16V	1
Cvin	GRM21BR71C105K	Murata	1uF	0805	MLCC / X7R / 16V	1
Cbst1, Cbst2	Generic 10%	Vishay	100nF	0805	Boost Capacitor / COG or X7R	2
Css1	Generic 10%	Vishay	100nF	0805	Soft Start Capacitor / COG or X7R	1
Css2	Generic 10%	Vishay	10nF	0805	Soft Start Capacitor / COG or X7R	1
CIlim1	Generic 10%	Vishay	33pF	0805	Current Limit Capacitor	1
CIlim2	Generic 10%	Vishay	33pF	0805	Current Limit Capacitor	1
Cdr	GRM185R60J105KE21	Murata	1uF	0603	MLCC / X5R / 6.3V	1
Cvcc	GRM185R60J105KE21	Murata	1uF	0603	MLCC / X5R / 6.3V	1
Cc11	Generic 10%	Vishay	68pF	0603	Compensation Capacitor - CH1	1
Cc12	Generic 10%	Vishay	5pF	0603	Compensation Capacitor - CH1	1
Cc21	Generic 10%	Vishay	220pF	0603	Compensation Capacitor - CH2	1
Cc22	Generic 10%	Vishay	5pF	0603	Compensation Capacitor - CH2	1
RIlim1	Generic 1%	Vishay	3.32k	0603	Current Limit Resistor	1
RIlim2	Generic 1%	Vishay	3.01k	0603	Current Limit Resistor	1
Rgcs1	Generic 1%	Vishay	22k	0603	Current Sense Gain Set - 6V/V	1
Rgcs2	No Pop	Vishay		0603	Current Sense Gain Set - 12V/V	1
Rfreq	Generic 5%	Vishay	61.9k	0603	Frequency Set Resistor – 1MHz	1
Rvcco	Generic 10%	Vishay	1 Ohm	0603	Decoupling Resistor	1
Rr1	Generic 10%	Vishay	1.00M	0603	Vout 1 Ramp Resistor	1
Rr2	Generic 10%	Vishay	750k	0603	Vout 2 Ramp Resistor	1
Rc1	Generic 10%	Vishay	26.1k	0603	Compensation Resistor	1
Rc2	Generic 10%	Vishay	249k	0603	Compensation Resistor	1
Rf11	Generic 1%	Vishay	11.0k	0603	Feedback Resistor - CH1	1
Rf12	Generic 1%	Vishay	1.50k	0603	Feedback Resistor - CH1	1
Rf21	Generic 1%	Vishay	10k	0603	Feedback Resistor - CH2	1
Rf22	Generic 1%	Vishay	2.21k	0603	Feedback Resistor - CH2	1

BOM items in **bold** are assumed additional system capacitance.

NOTES

Reference designators shown on the schematic but not listed on the Bill of Materials are place holders for possible design adjustments (snubbers, additional decoupling capacitors and clamp diodes). These components should be put in the layout, but not populated unless after testing it is deemed necessary.

If a different number, or different type of output capacitors are used on the switching outputs the loop compensation components may need adjustment. The assumed additional output caps are listed in **bold** type in the BOM.

FETs and other components with quantities greater than 1 are connected in parallel with the other FETs / components of the same reference designator. Paralleled FETs should be placed physically close together and have large power planes connecting all the drains together and large power planes connecting all the sources together. Gate drive resistors may be used if there is concern about possible paralleling issues.

Ground symbols with multiple parallel lines (not the triangle symbol) designator should be connected together with one small plane and tied to the power ground plane (triangle symbol) at one point near the IC. Each IC should have its own signal ground pour. The PGND1 and PGND2 pins should be connected directly to the source of the lowside MOSFET for that channel with short wide traces. They should not connect into the main ground plane except at the MOSFET sources.

Except for the feedback resistors (Rfxx), E24 values may be substituted for the E96 values specified. The feedback resistors need to be as specified.

GRAPHS

Figure 4. Vout1 (1.2V) Efficiency

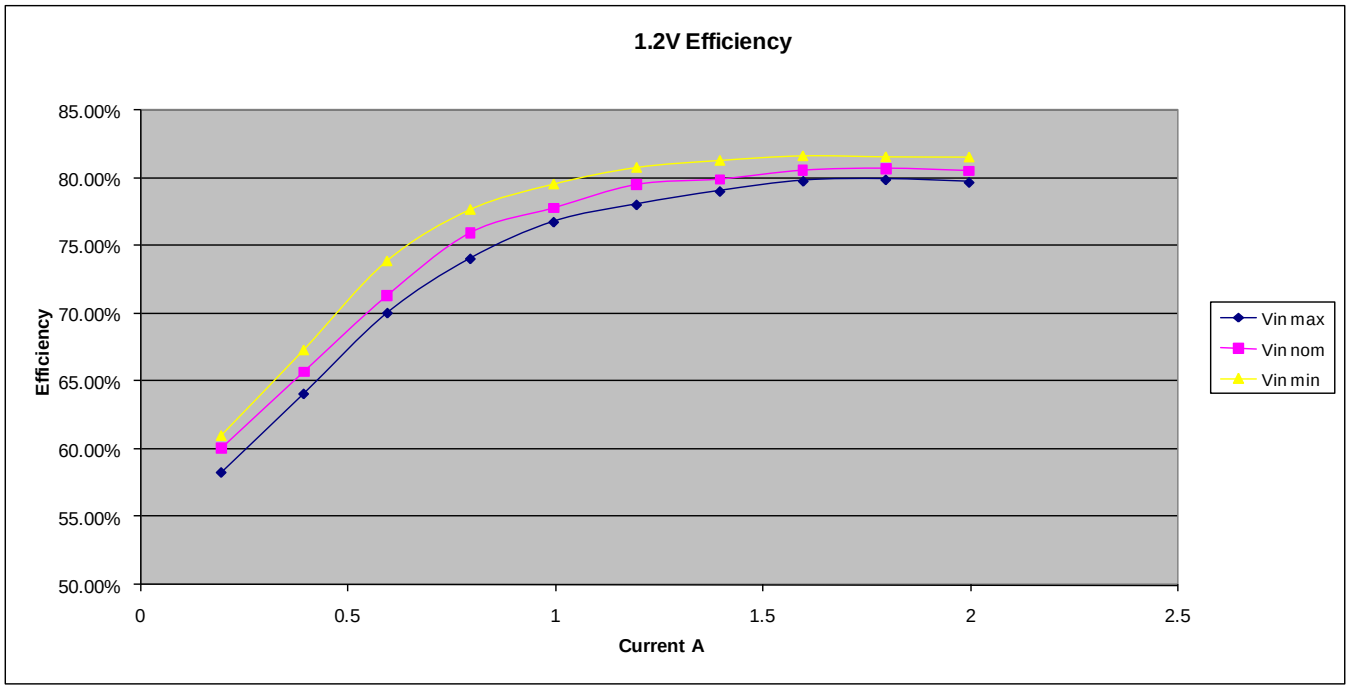


Figure 5. Vout2 (1.8V) Efficiency

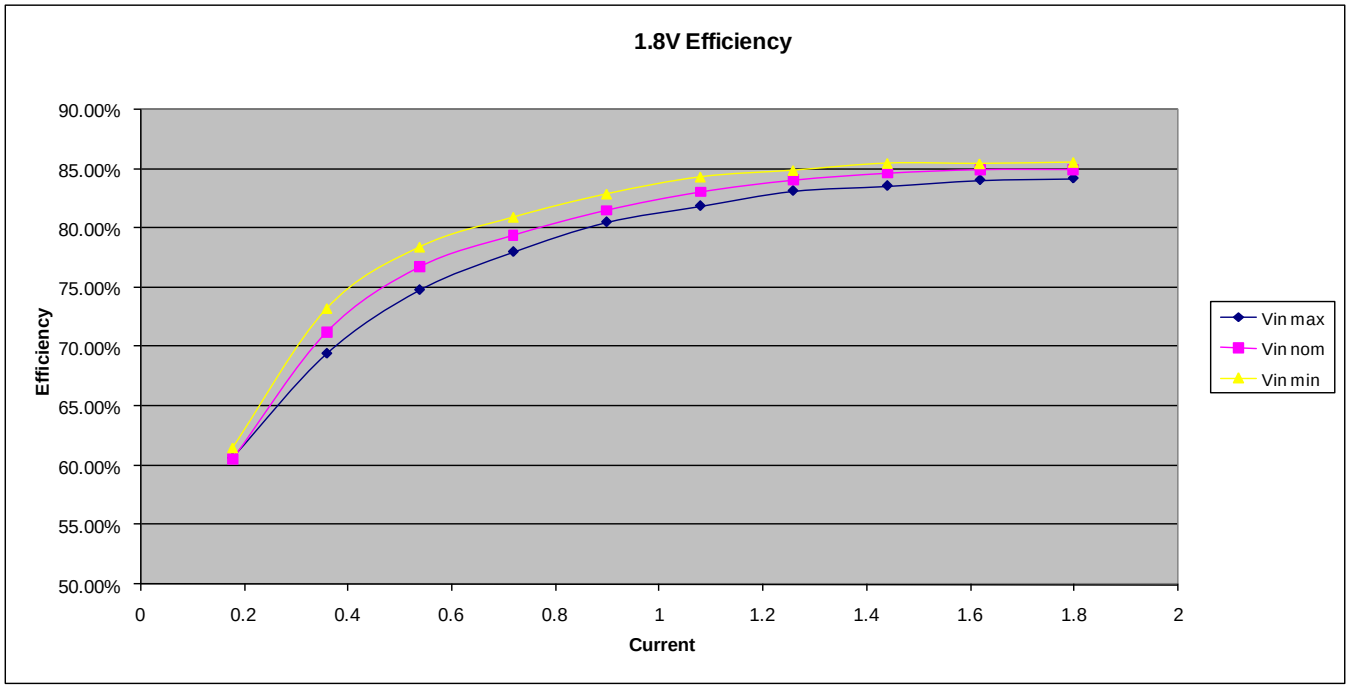


Figure 6. Vout3 (3.3V) Efficiency

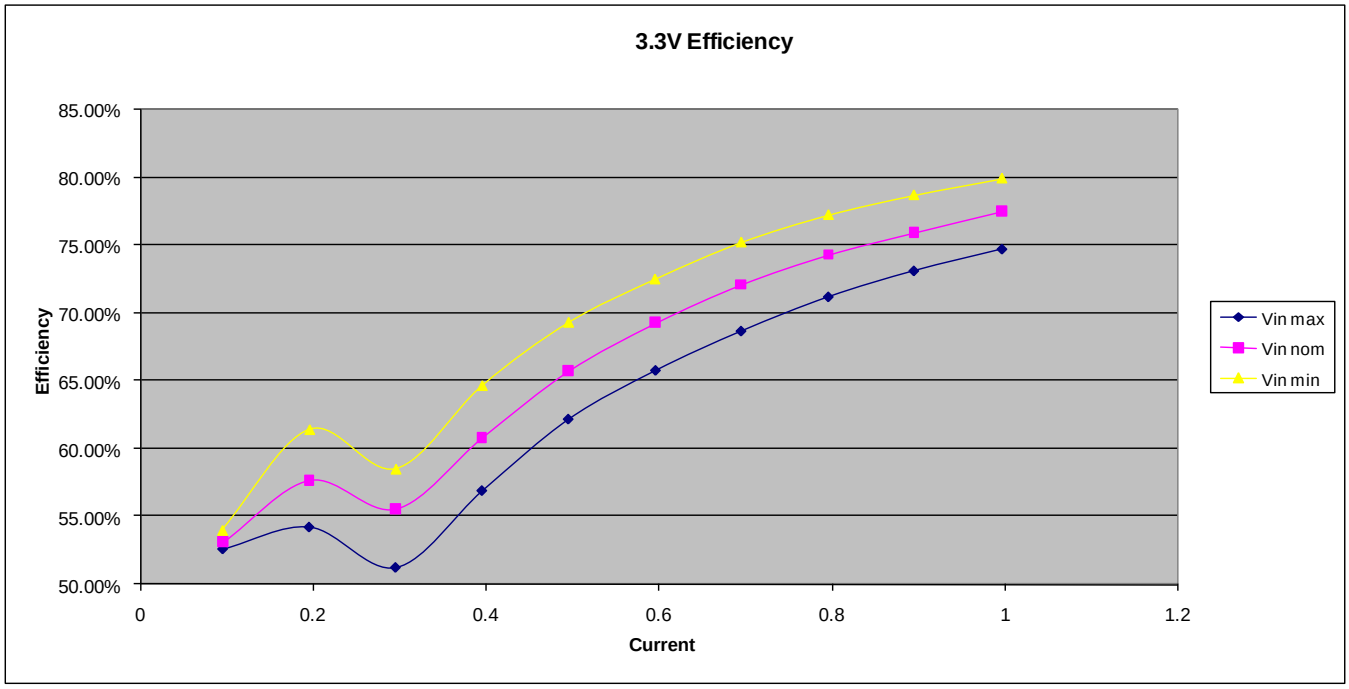


Figure 7. Vout4 (5.0V) Efficiency

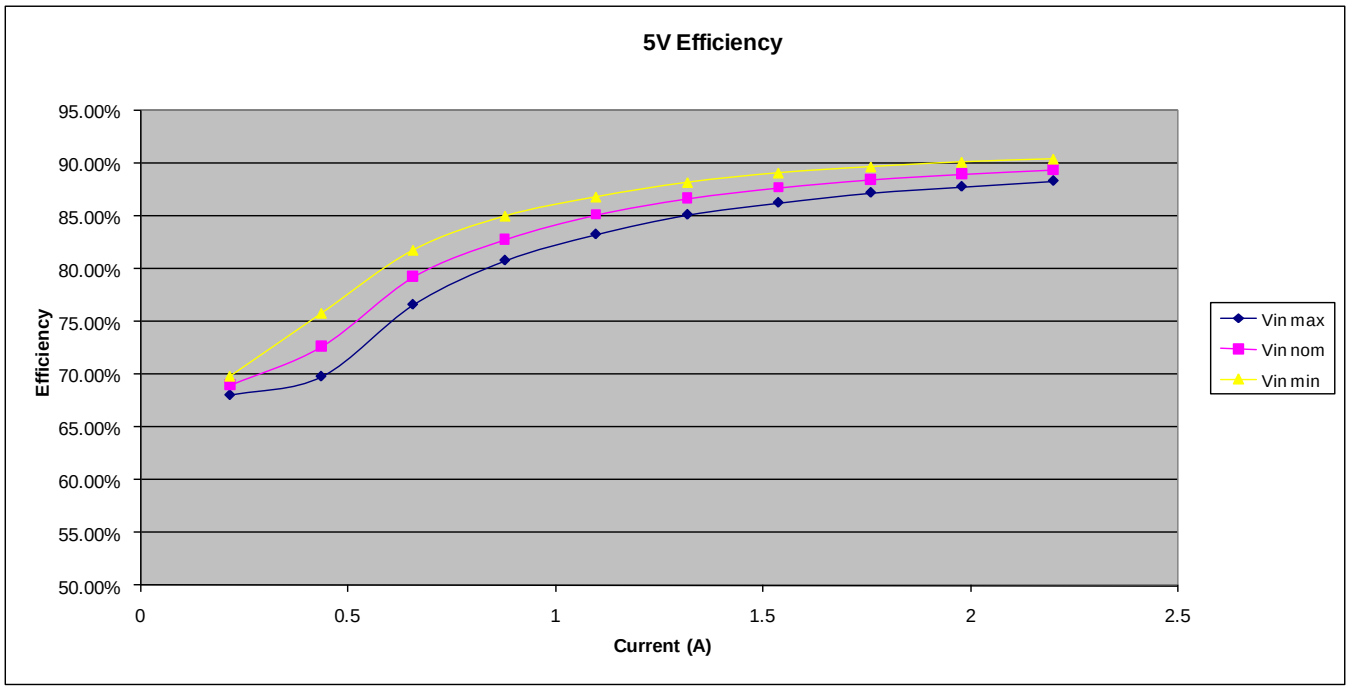


Figure 8. Enable Waveforms

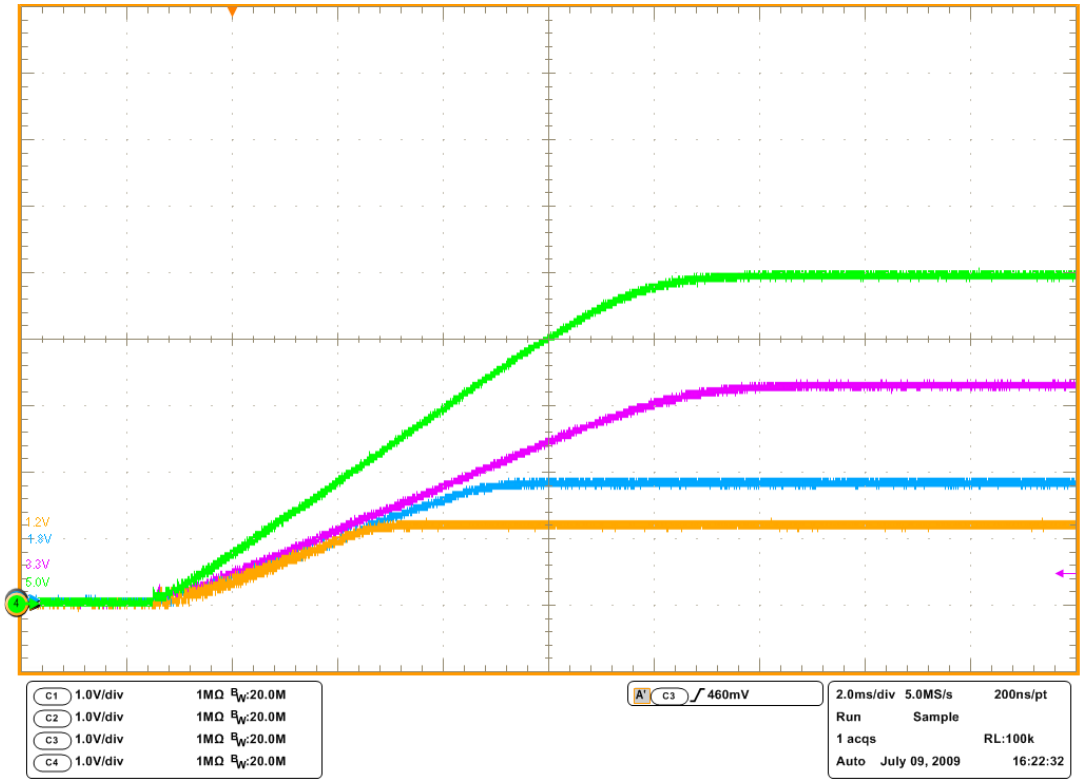


Figure 9. Disable Waveforms (full load)

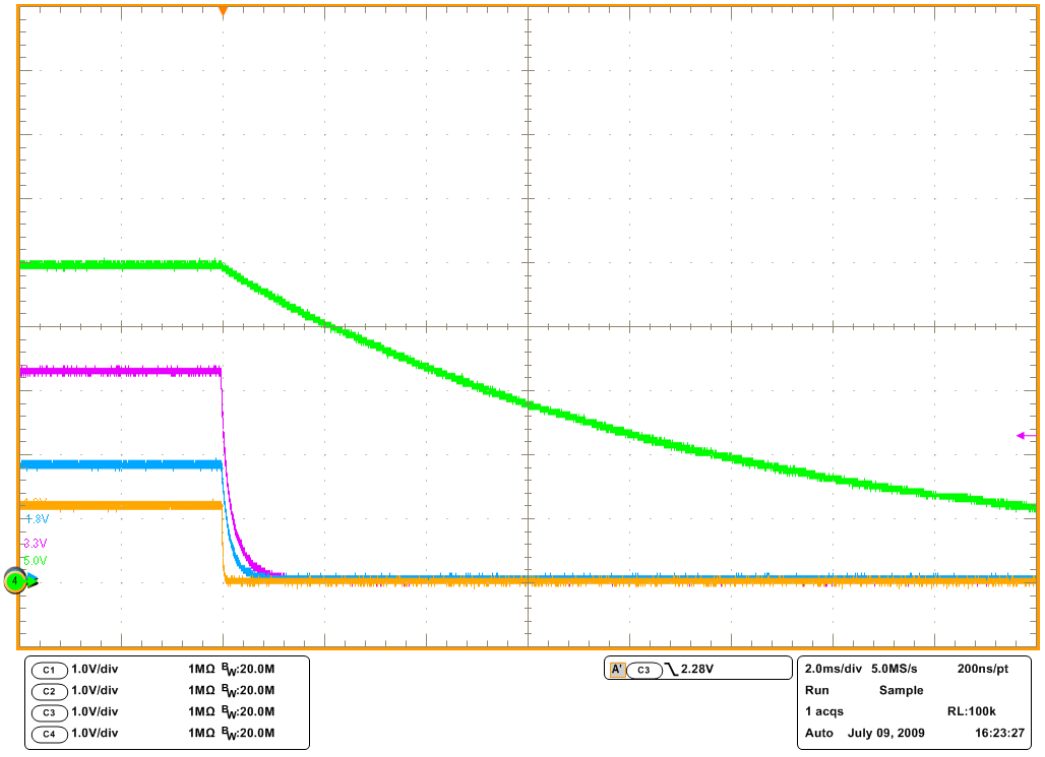


Figure 10. Ripple Waveforms (full load)

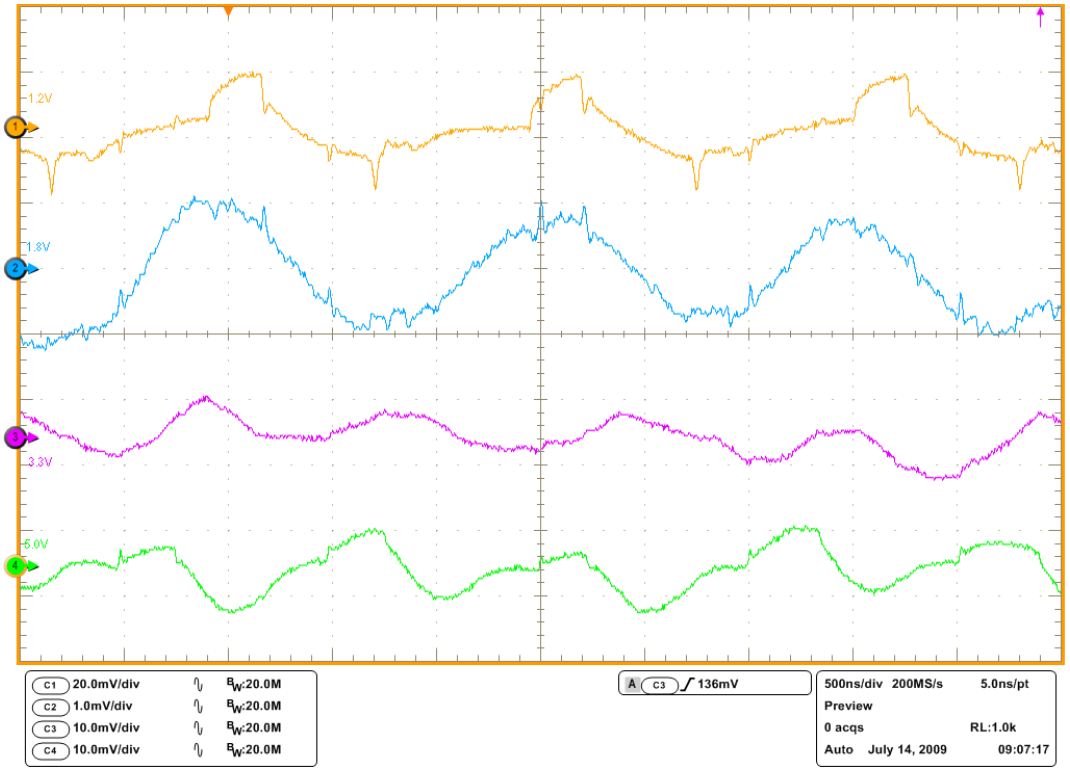


Figure 11. Vout1 and Vout2 Transient Response (50% step)

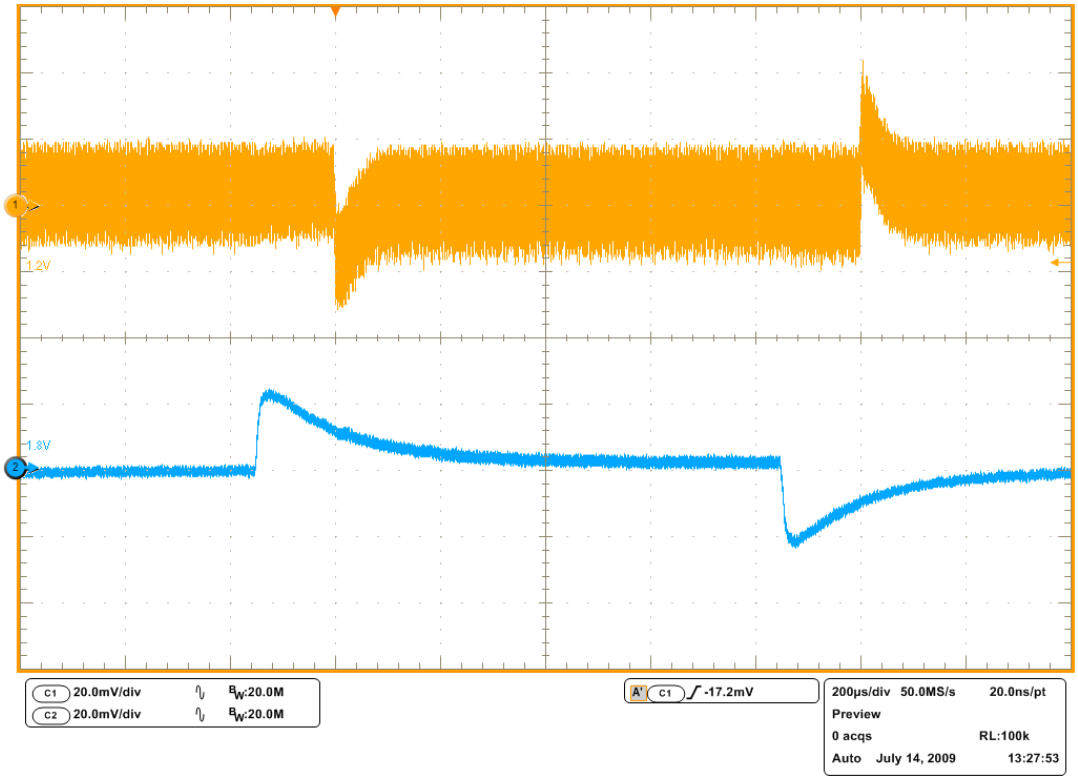
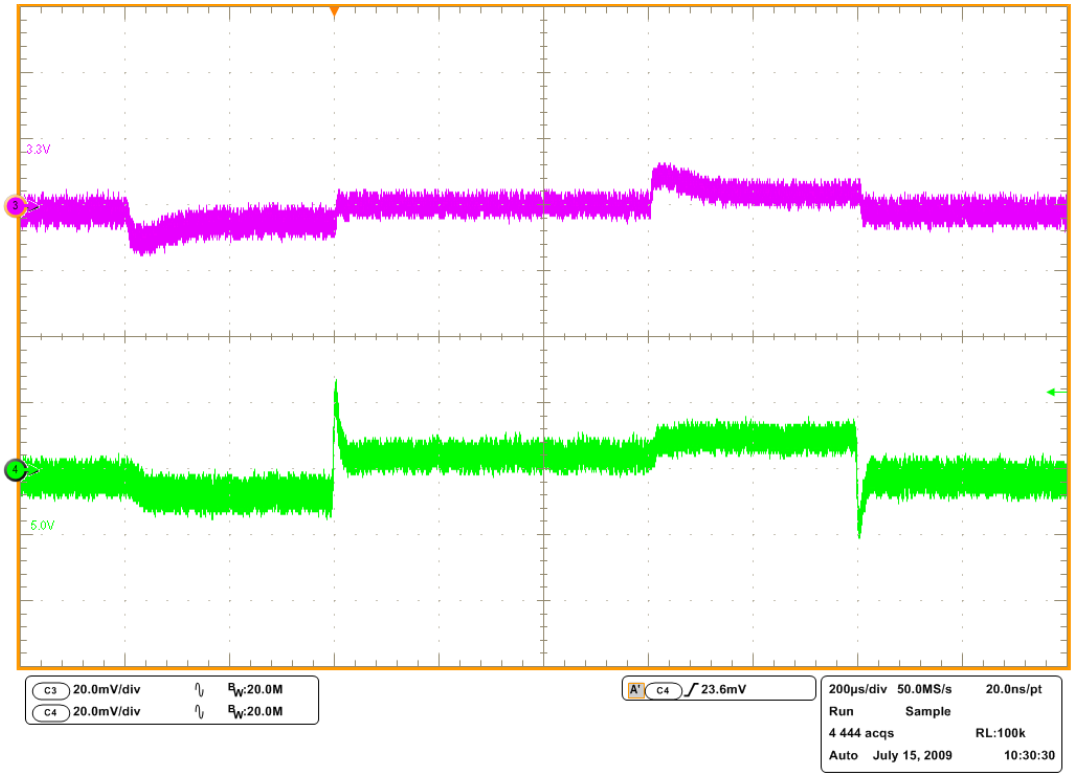
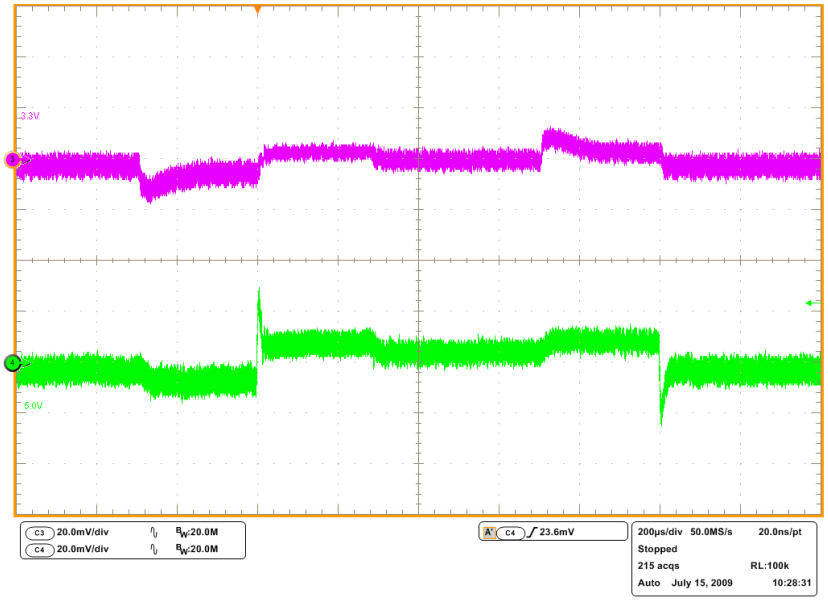


Figure 12. Vout3 and Vout4 Transient Response (50% step), Vin=12.0V



Note: At higher input voltages, depending on the load, the two channels of the 3.3V and 5V outputs may have duty cycles that would require both outputs to switch simultaneously. The ADP1877 delays one of the outputs so that it can measure the current in the low side fet during a quiet period. This causes some additional transient response that resembles a beat frequency on the ripple. It is not instability and is well-bounded. It resembles voltage drop in the ground plane due to the load change. Here is an example (50% step, Vin=13.2V). Note the extra transition in the center, not due to the load transient.



PERFORMANCE DATA

Table 3. Vout1/2 Temperature Rise over Ambient

Component	*Vinnom*	*Units*
U1	21.4	degC
L1	29.3	degC
QH1	19.4	degC
QL1	25.2	degC
L2	28.5	degC
QH2	18.5	degC
QL2	20.2	degC

Table 4. Vout3/4 Temperature Rise over Ambient

Component	*Vinnom*	*Units*
U1	25.5	degC
L1	19.8	degC
QH1	28.3	degC
QL1	37.7	degC
L2	17.1	degC
QH2	25.7	degC
QL2	35.4	degC