ON Semiconductor

Design Note – DN06055/D

Power Supply PSU

Device	Application	Input Voltage	Output Voltage	Output Current	Topology
CS51221	**Cash Drawer**	**12 V**	**24V**	**4A**	**Boost**

Table 1: CS51221 Cash Drawer Power Supply

Characteristic	Min	Typ	Max	Unit
Output Voltage	23.56	24.72	26.04	V
Output Current	.5		20	A
Oscillator Frequency		140		kHz
Output Voltage Ripple	100	150	300	mVpk-pk
Load Regulation Iout = (0.1-8.3A) Vin= 12V		-1.33		mV/A
Size	Length 80	Width 59	Height 31	mm

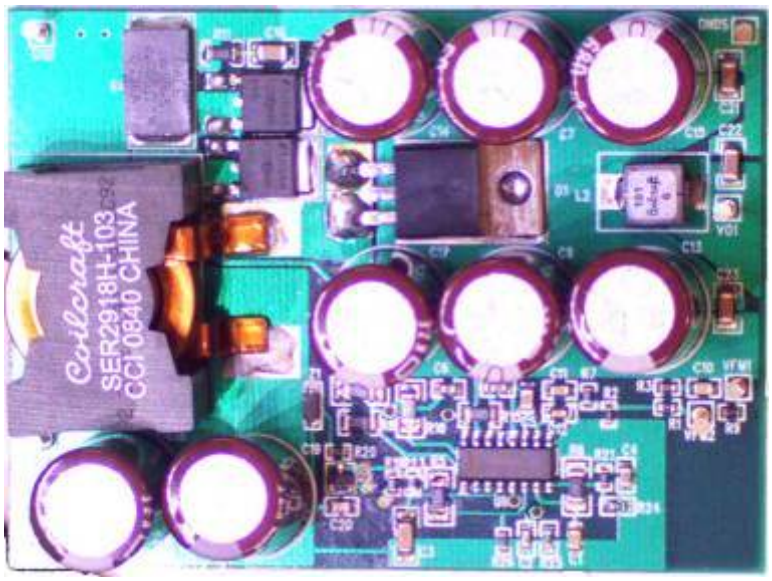


Figure 1: Demonstration Board Picture

Circuit Description

The design must minimize the use of through hole components, designed as small as possible on a 4 layer PCB, and only populated on one side. The power supply is required to maintain an 24.7V output while with an input of 12V.

Table 2: CS51221 Cash Drawer Power Supply Compliance Matrix

Item	Description	Minimum	Maximum	Measured	Pass/ Fail
1	Tolerance Line and Load Regulation (USB)	23.56 V	26.04 V	24.72 V	PASS
2	Tolerance Line and Load Regulation (Cash Drawer Interface)	21.08 V	26.04 V	24.72 V	PASS
3	Ripple Voltage Nominal Current (peak to peak)		100 mV	50 mV	PASS
4	Noise, HF ripple (peak to peak)		300 mV	149 mV	PASS
5	Transient Response 1.5A to 4.5A (10 A/us slew rate)	22.8 V	26.04 V	MIN = 24.24 V MAX = 24.95 V	PASS
6	Transient Response 1.5A to 7A (10 A/us slew rate)	22.8 V	26.04 V	MIN = 24.24 V MAX = 24.85 V	PASS
7	Transient Response 0A to 20A (10 A/us slew rate)	19.84 V	26.04 V	MIN = 21.23 V MAX = 25.65 V	PASS
8	Transient Response 2A to 16A (.014 A/us slew rate)	22.32 V	26.04 V	MIN = 23.97 V MAX = 25.21 V	PASS
9	Transient Response 0A to 16A (.014 A/us slew rate)	22.32 V	26.04 V	MIN = 23.8 V MAX = 24.95 V	PASS

The design has the following features:

- Adjustable cycle by cycle current limiting
- Over voltage Shutoff
- Under voltage shutoff
- Can be synchronized to a higher frequency
- Programmable soft start
- Voltage feed forward

Performance Information

The following figures show typical performance of the evaluation board.

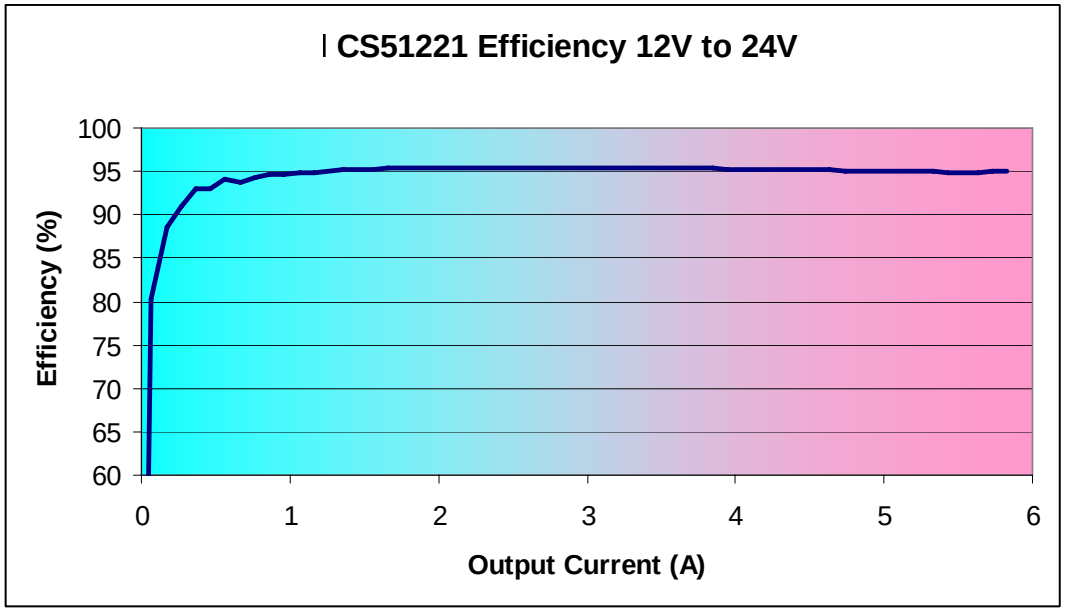


Figure 2: CS51221 Efficiency at 12V with a 24.7V Output Voltage

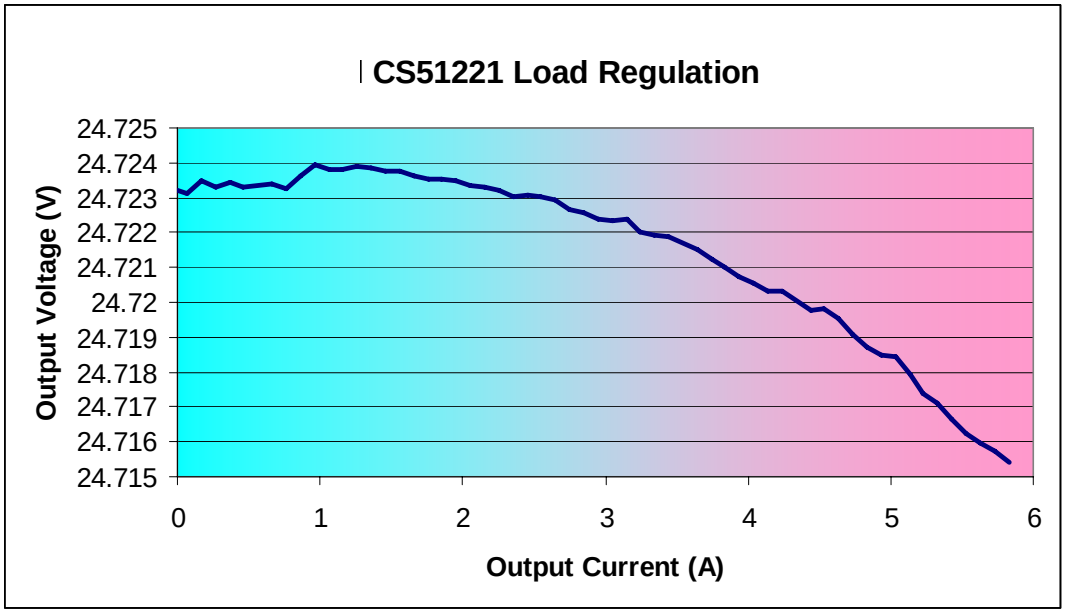


Figure 3: CS51221 Load Regulation

Schematic

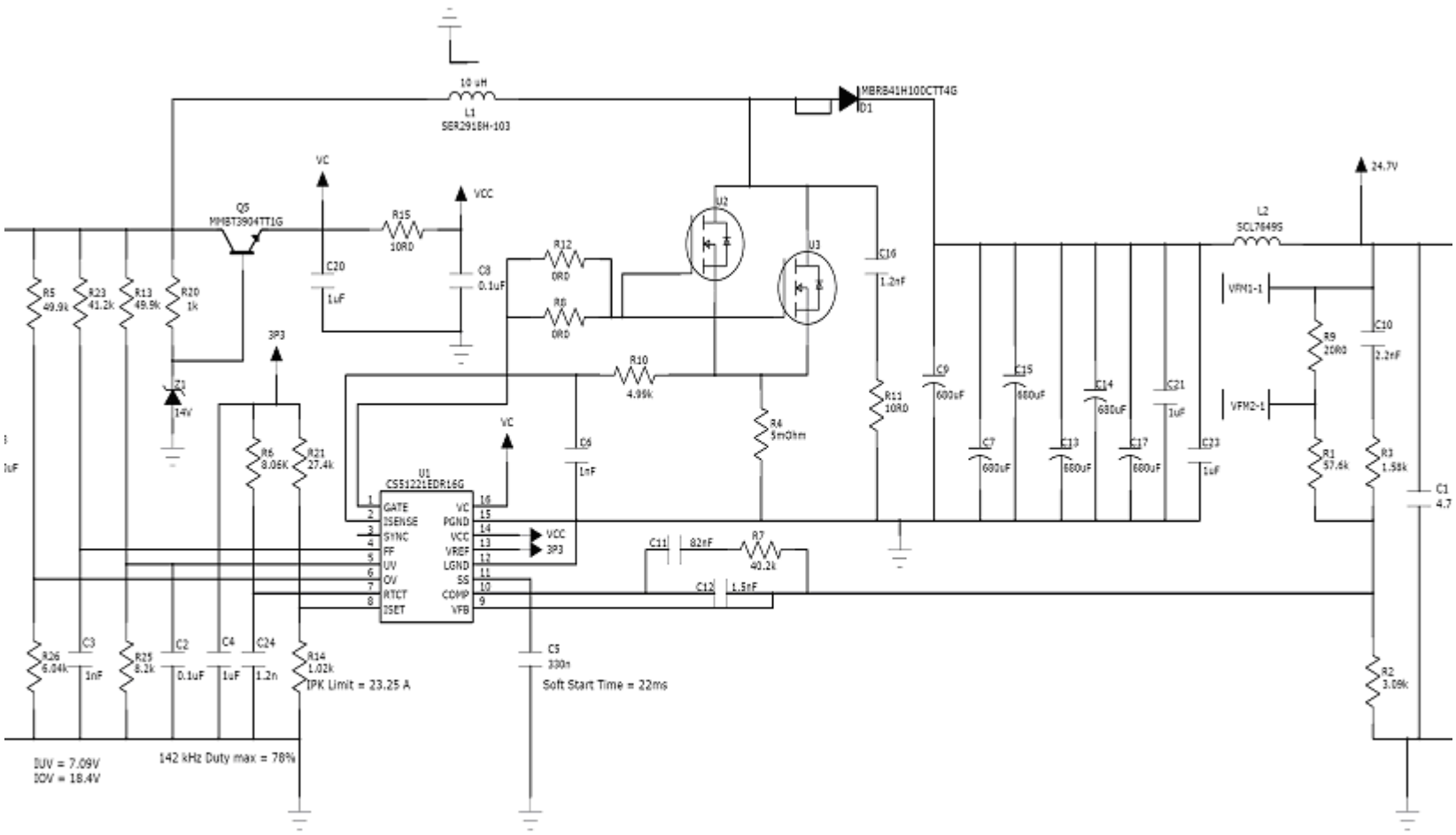


Figure 4: CS51221 Schematic

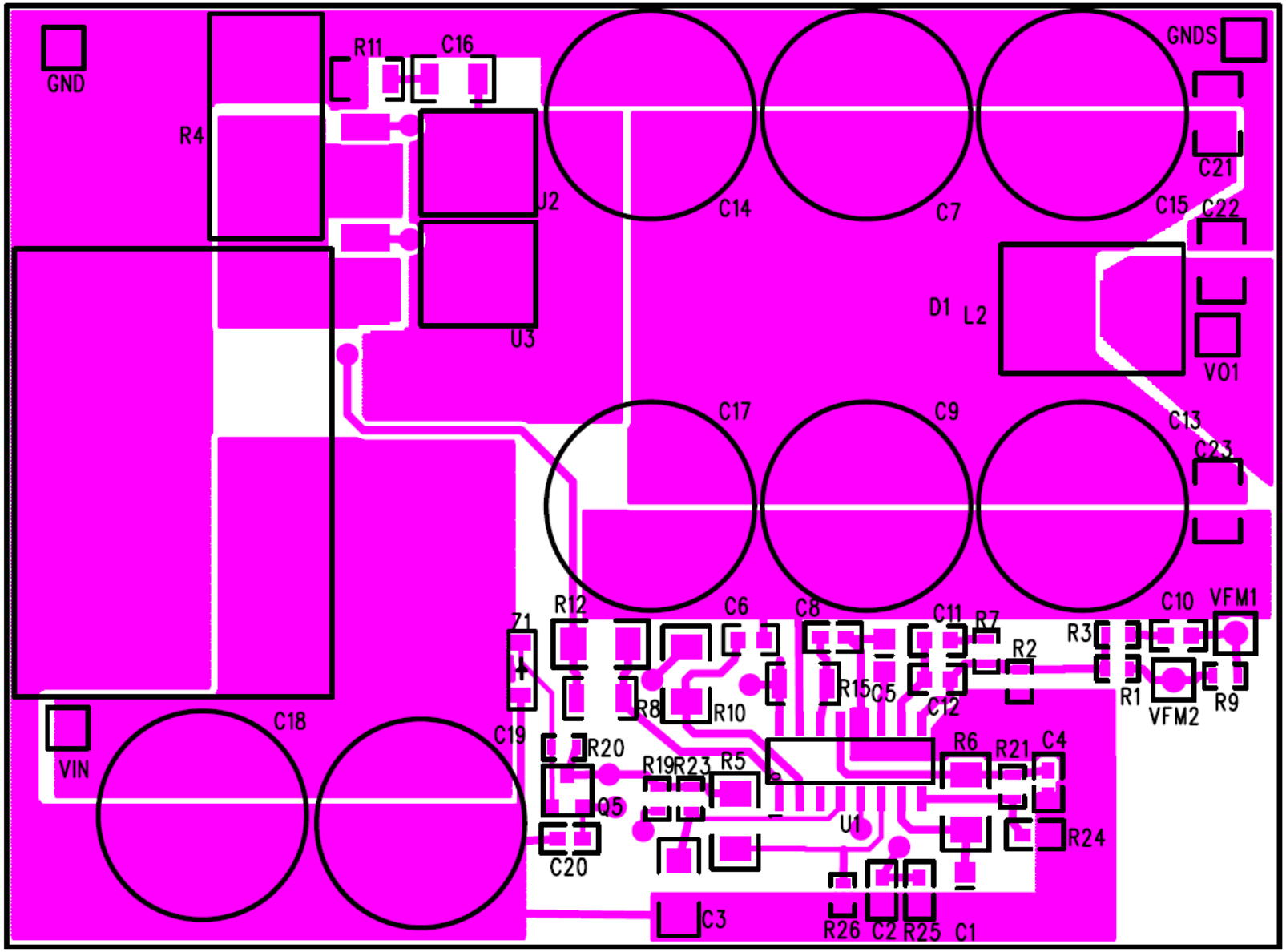


Figure 5: CS51221 Top Layout

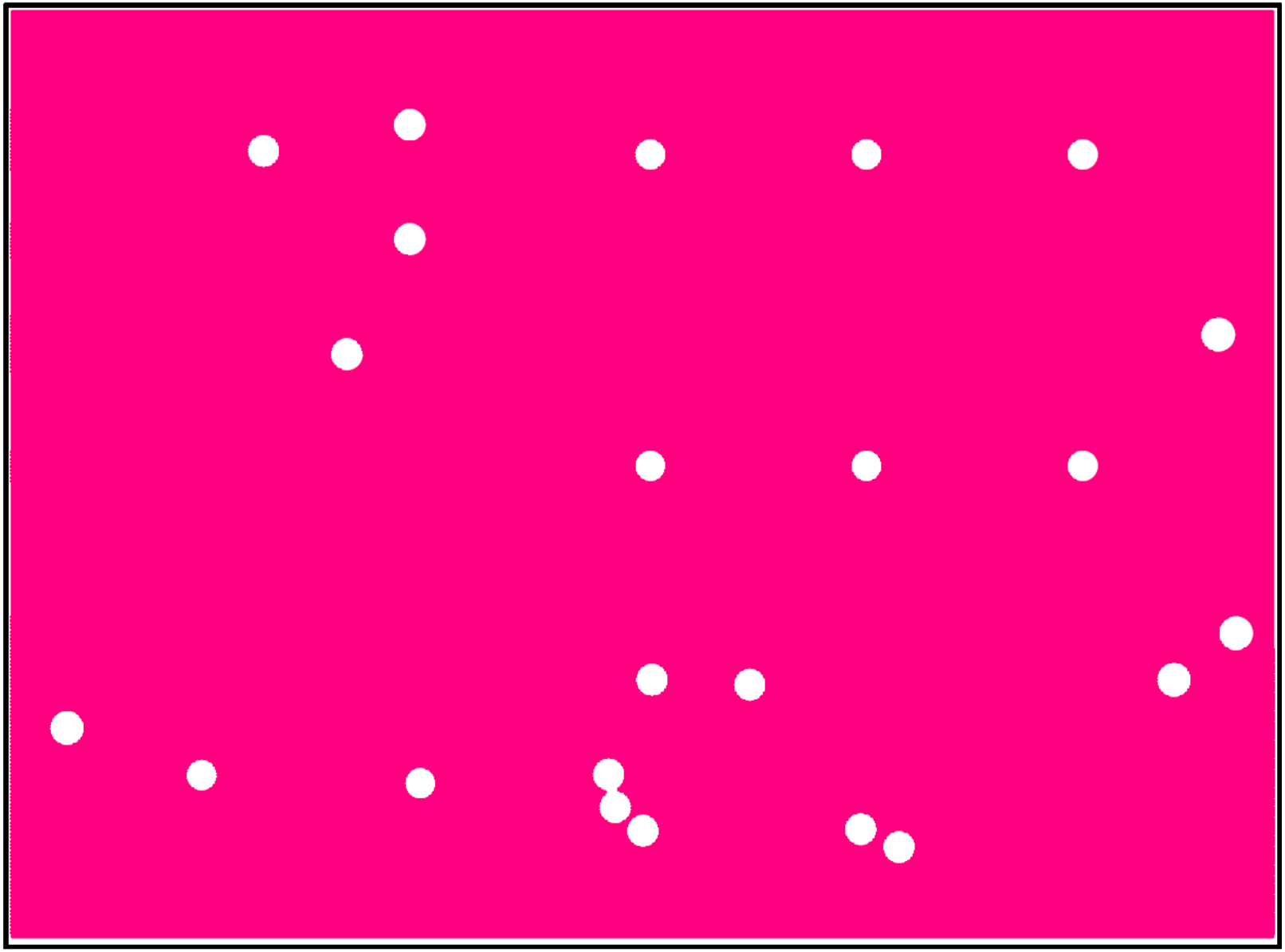


Figure 6: CS51221 Top Inner Layout

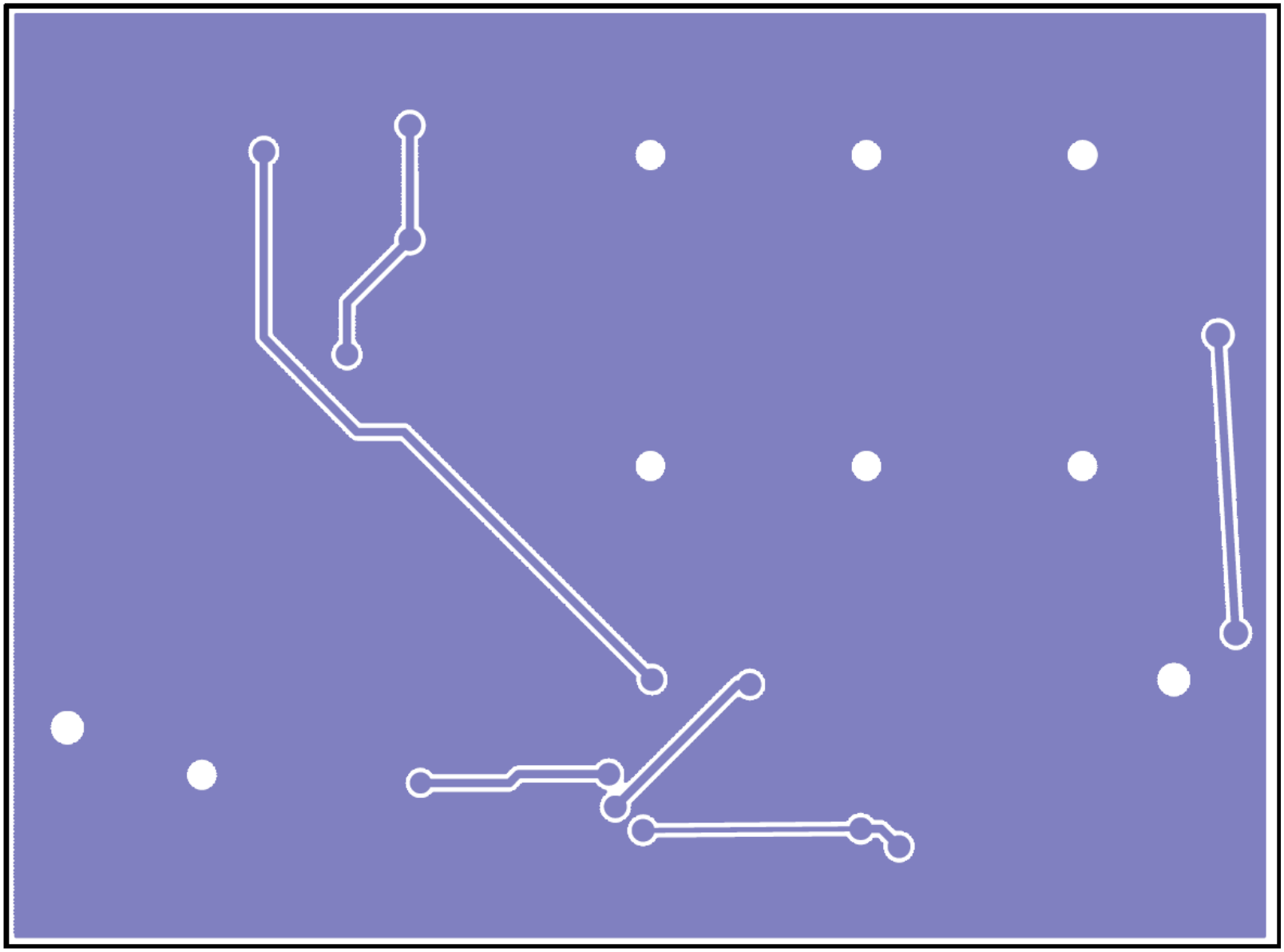


Figure 7: CS51221 Bottom Inner Layout

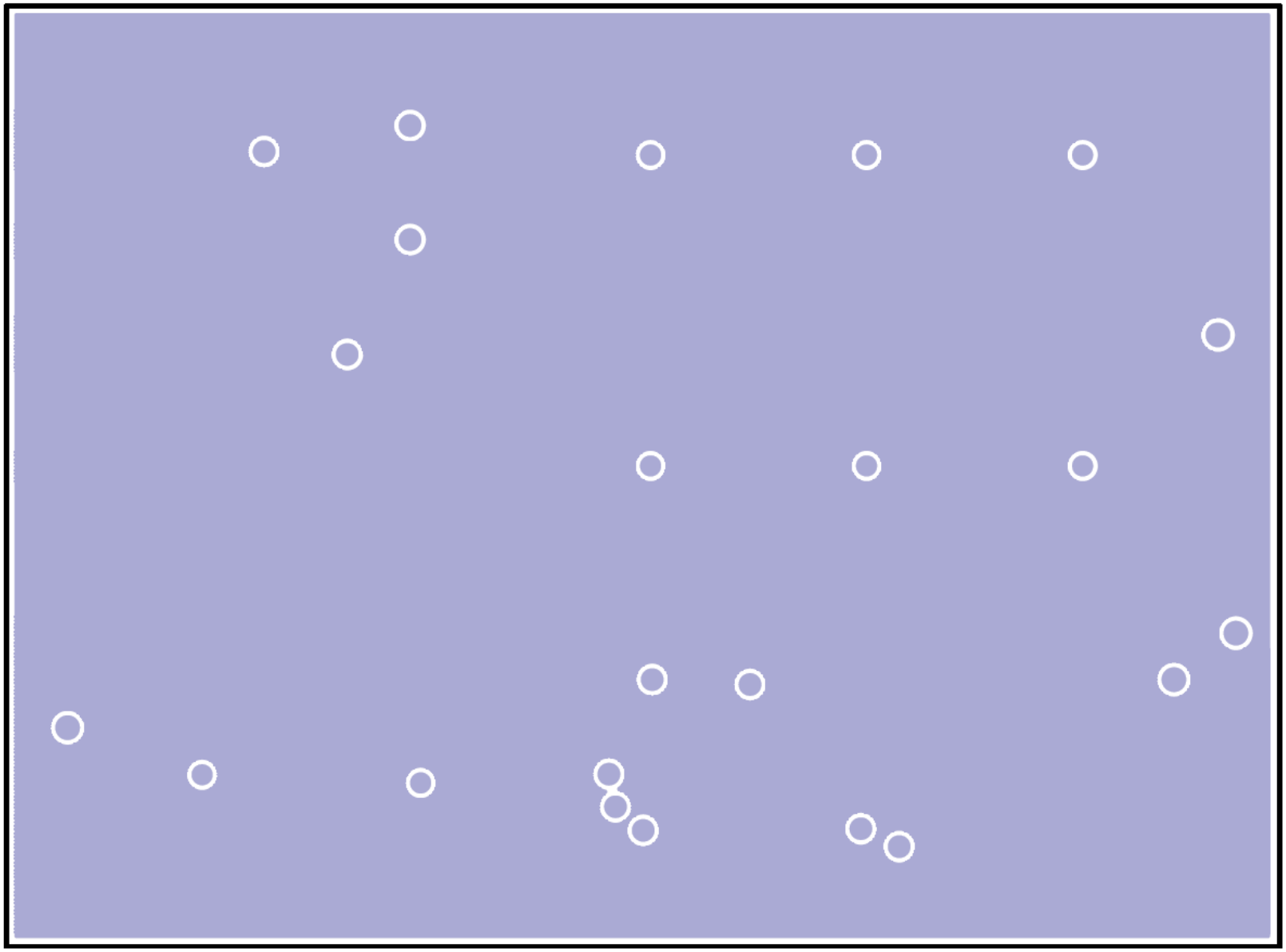


Figure 8: CS51221 Bottom Inner Layout

Table 3: CS51221 BOM

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number
C5	1	Ceramic Chip Capacitor 10V	330n	±20%	805	AVX Corporation	0805ZC334JAT2A
C8	1	Ceramic Chip Capacitor 25V	0.1uF	±20%	603	AVX Corporation	06033C104MAT2A
C2	1	Ceramic Chip Capacitor 25V	0.1uF	±20%	603	AVX Corporation	06033C104MAT2A
C12	1	Ceramic Chip Capacitor 10V	1.5nF	±10%	603	AVX Corporation	0603YC152KAT2A
C6	1	Ceramic Chip Capacitor 10V	1nF	±10%	603	AVX Corporation	0603ZC102KA72A
C4	1	Ceramic Chip Capacitor 6.3V	1uF	±10%	603	AVX Corporation	06036D105KAT2A
C20	1	Ceramic Chip Capacitor 25V	1uF	±20%	603	AVX Corporation	06033D105MAT2A
C10	1	Ceramic Chip Capacitor 50V	2.2nF	±5%	603	AVX Corporation	06035C222JAT2A
C11	1	Ceramic Chip Capacitor 16V	82nF	±10%	603	AVX Corporation	0603YC823KAT2A
C24	1	Ceramic Chip Capacitor 6.3V	1.2n	±5%	805	AVX Corporation	08056A122JAT2A
C16	1	Ceramic Chip Capacitor 100V	1.2nF	±10%	1206	AVX Corporation	12061A122KAT2A
C3	1	Ceramic Chip Capacitor 100V	1nF	±10%	1206	AVX Corporation	12061C102KAT2A
C21 C23	2	Ceramic Chip Capacitor 50V	1uF	±10%	1206	AVX Corporation	12065C105KAT2A
C1	1	Ceramic Chip Capacitor 50V	4.7uF	±20%	1812	TDK Corporation	C4532X7R1H475M
U1	1	Mode PWM Controller	3V Ref	NA	SOIC 16	ON Semiconductor	CS51221EDR16G
C7 C9 C13-15 C17-19	8	Electrolytic Capacitor	680uF	±20%	12.5X25	United Chemicon	EKZE500ELL681MK30S
D1	1	Schottky Power Rectifier	40A 100V	NA	D2PAK 3 LEAD	ON Semiconductor	MBRB41H100CTT4G
Q5	1	NPN Transistor	40V 200mA	NA	SOT-23	ON Semiconductor	MMBT3904TT1G
Z1	1	Zener Diode	14V	±5%	SOD-123	ON Semiconductor	MMSZ5244BT1G
U2-3	2	N MOSFET 8.1mOhm	60V 50A	NA	DPAK	Infineon	IPB081N06L3G
R5	1	SMT Resistor	49.9k	±1.0%	1206	Vishay	CRCW120649K9FKEA
R14	1	SMD Resistor	1.02k	±1.0%	603	Vishay / Dale	CRCW06031K02FKEA
R3	1	SMD Resistor	1.58k	±1.0%	603	Vishay / Dale	CRCW06031K58FKEA
R20	1	SMD Resistor	1k	±5.0%	603	Vishay / Dale	CRCW06031K00JNEA
R9	1	SMD Resistor	20R0	±1.0%	603	Vishay / Dale	CRCW060320R0FKEA
R21	1	SMD Resistor	27.4k	±1.0%	603	Vishay / Dale	CRCW060327K4FKEA
R2	1	SMD Resistor	3.09k	±1.0%	603	Vishay / Dale	CRCW06033K09FKEA
R7	1	SMD Resistor	40.2k	±1.0%	603	Vishay / Dale	CRCW060340K2FKEA
R23	1	SMD Resistor	41.2k	±1.0%	603	Vishay / Dale	CRCW060341K2FKEA
R13	1	SMD Resistor	49.9k	±1.0%	603	Vishay / Dale	CRCW060349K9FKEA
R1	1	SMD Resistor	57.6k	±1.0%	603	Vishay / Dale	CRCW060357K6FKEA

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number
R26	1	SMD Resistor	6.04k	±1.0%	603	Vishay / Dale	CRCW06036K04FKEA
R25	1	SMD Resistor	8.2k	±1.0%	603	Vishay / Dale	CRCW06038K20FKEA
R8 R12	2	SMD Resistor	0R0	±5.0%	1206	Vishay / Dale	CRCW12060000Z0EA
R11 R15	2	SMD Resistor	10R0	±5.0%	1206	Vishay / Dale	CRCW120610R0FKEA
R10	1	SMD Resistor	4.99k	±1.0%	1206	Vishay / Dale	CRCW12064K99FKEA
R6	1	SMD Resistor	8.06K	±1.0%	1206	Vishay / Dale	CRCW12068K06FKEA
R4	1	SMD Resistor	5mOhm	±1.0%	4527	Vishay / Dale	WSR55L00F
L2	1	SMT Inductor 0.17 mOhm	.1 uH	±10%	7.5mmX7.6mm	Coilcraft	SLC7649S-101KL
L1	1	SMT Inductor 1.8 mOhm	10 uH	±10%	27.94mmX27.9mm	Coilcraft	SER2918H-103

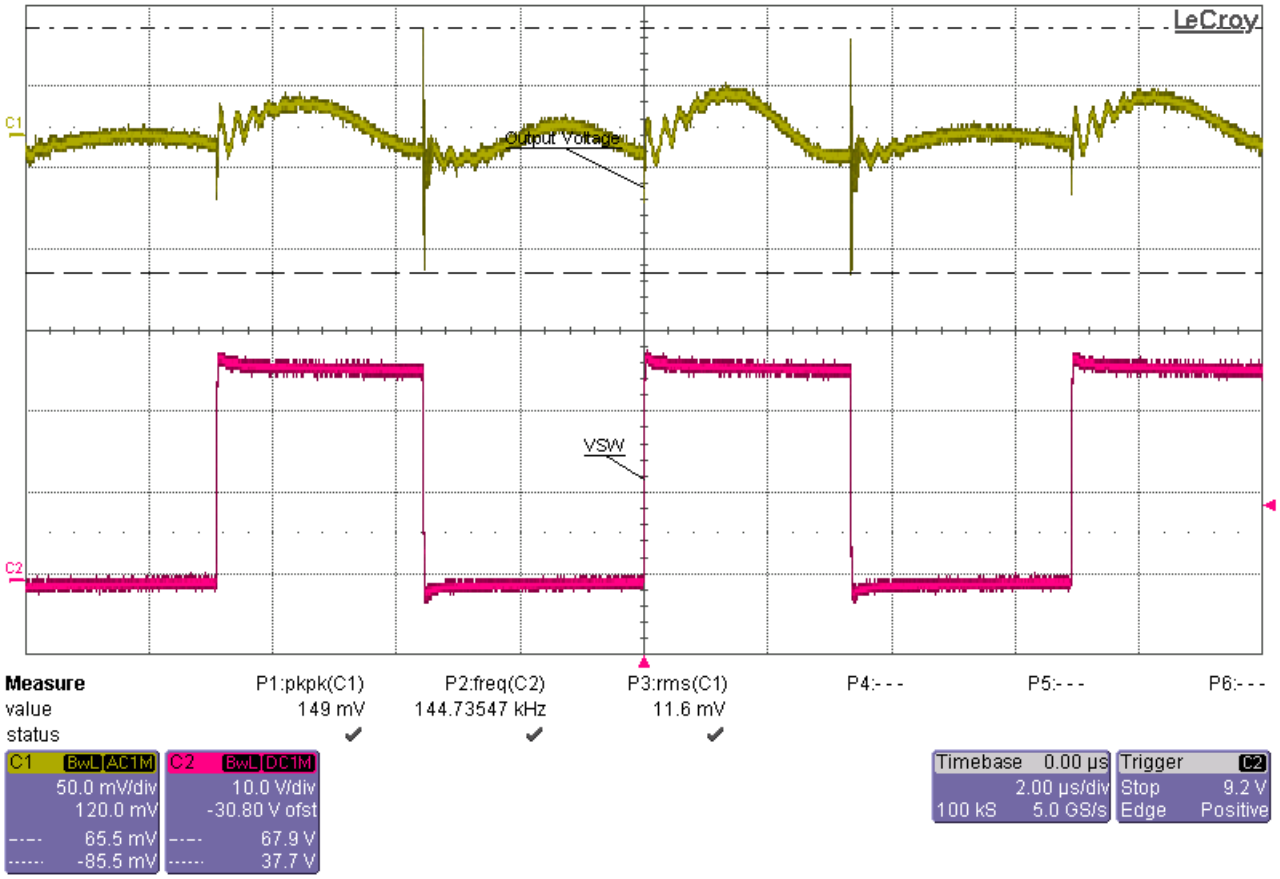


Figure 9: Vin = 12V Vout =24V Iout = 4A 149 mVpp High Frequency 50mV Fundamental

The PSU has to cover the following peak load conditions:

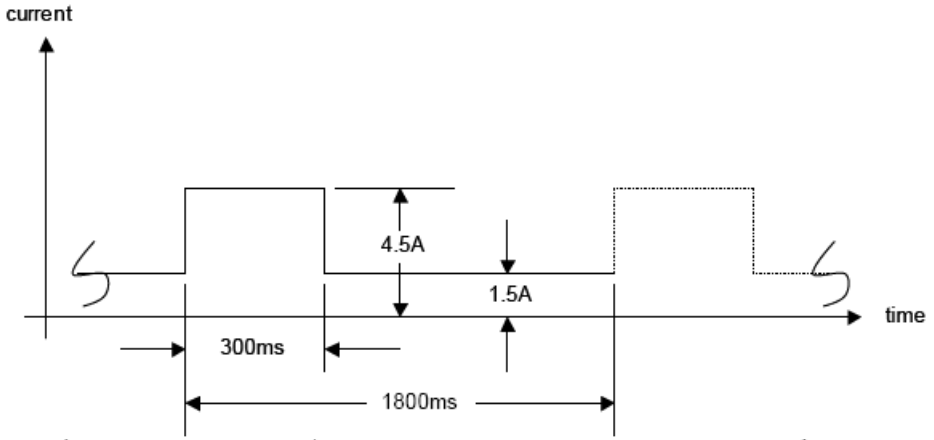


Diagram1: I_{peak}: 4.5A/300ms + I_{basic}: 1.5A, T=1.8s; P24V8 tolerance: +22.8V / -8%

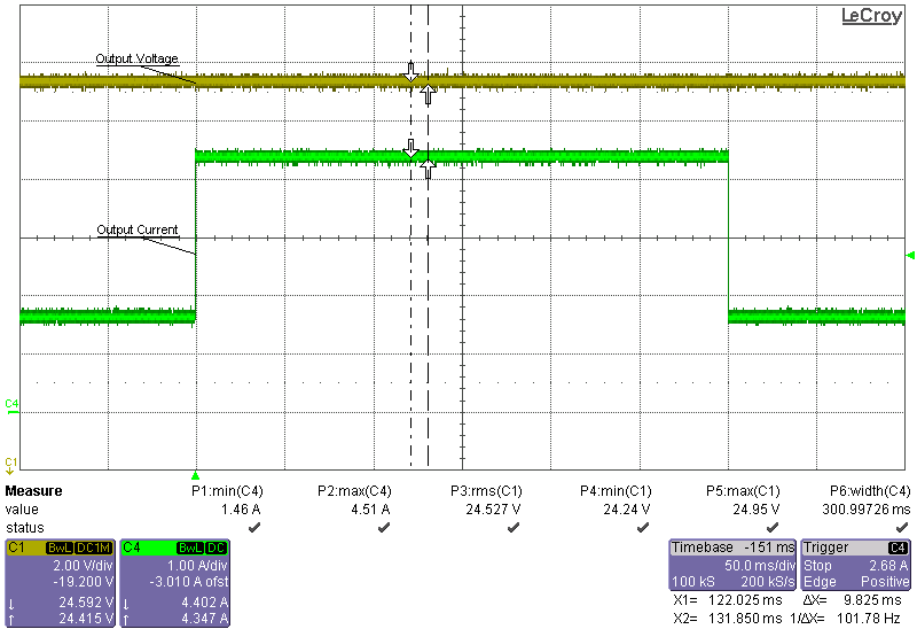


Figure 10: Transient Response 1.5A to 4.5A with a Slew Rate of 10A/us for a Duration of 300ms and a Period of 1800ms

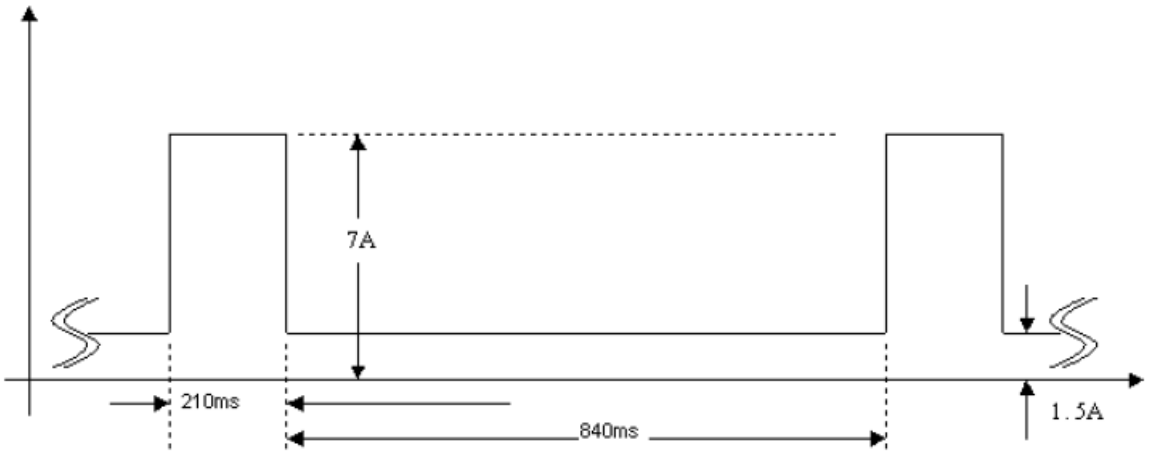


Diagram2: I_{peak}: 7A/210ms, T=1050ms; P24V8 tolerance: +22.8V / -8%

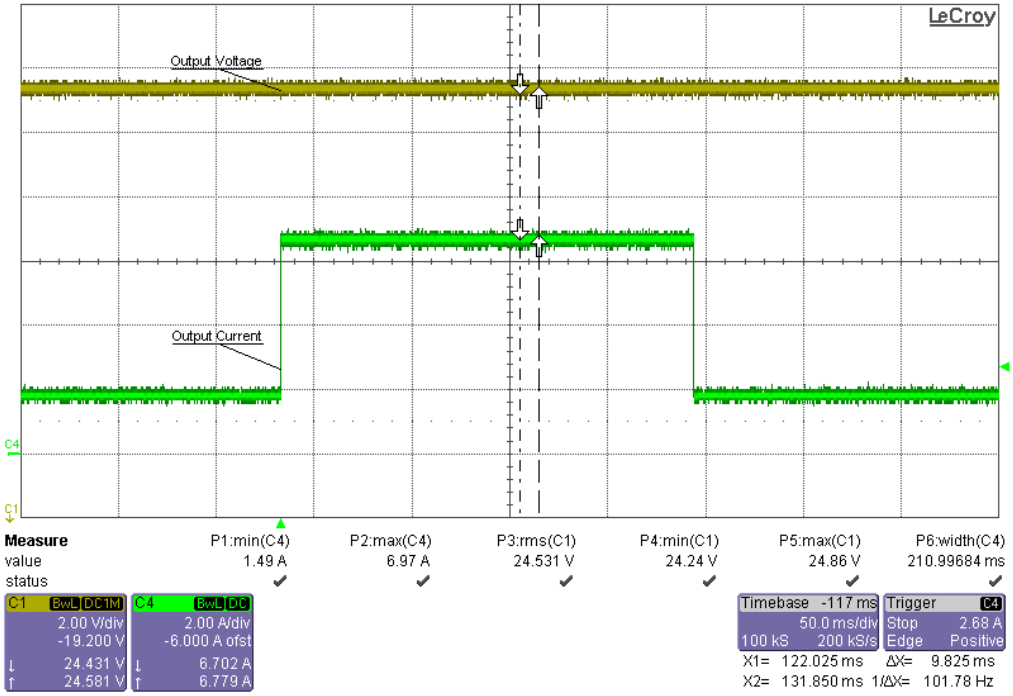


Figure 11: Transient Response 1.5A to 7A with a Slew Rate of 10A/us for a Duration of 210ms and a Period of 1050ms

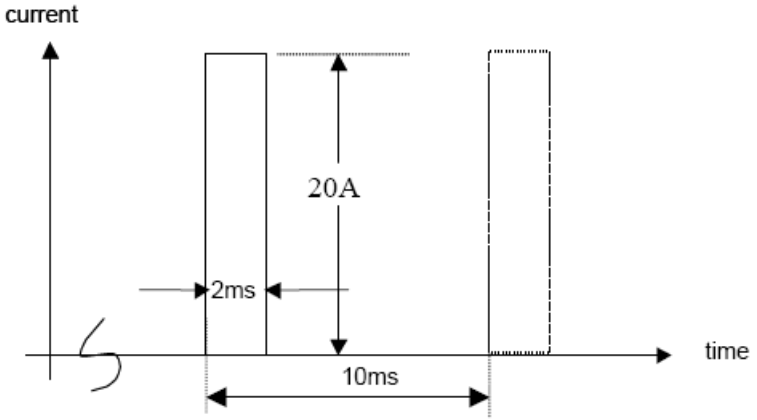


Diagram3: I_{peak} 20A/2ms; P24V8 tolerance: 19.84V / -20%

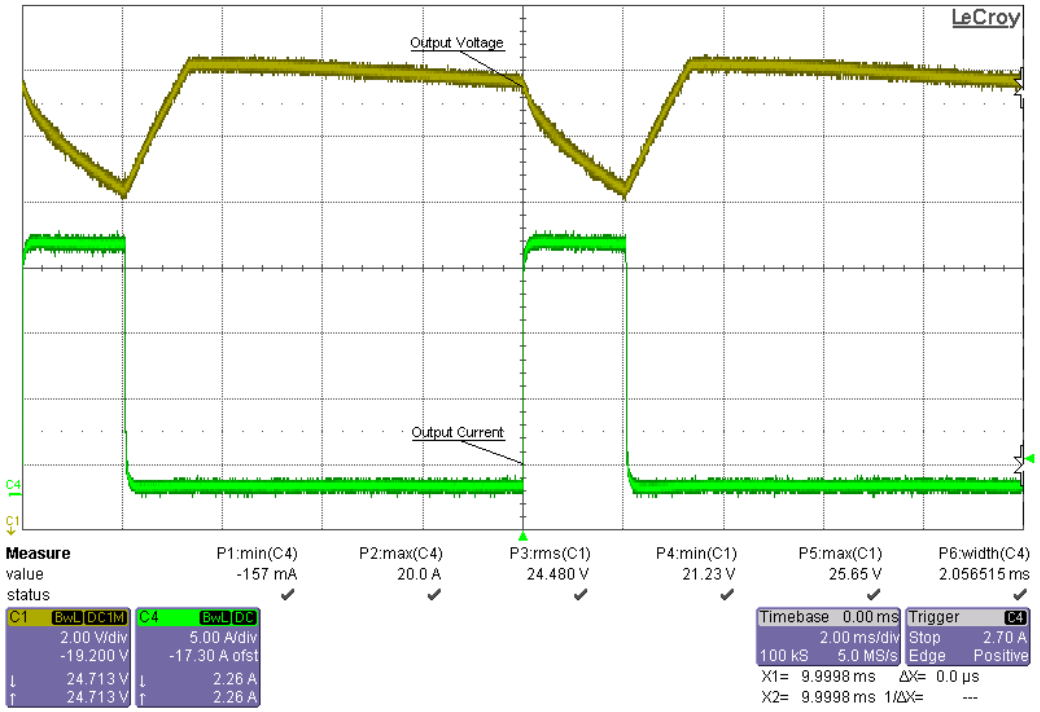
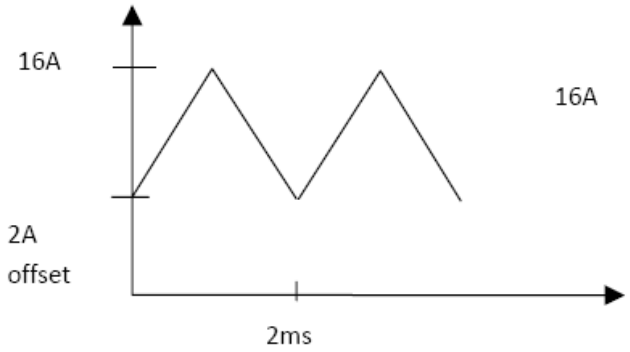


Figure 12: Transient Response 0A to 20A with a Slew Rate of 10A/us for a Duration of 2ms and a Period of 10ms



Load for a minimum of 8 cycles

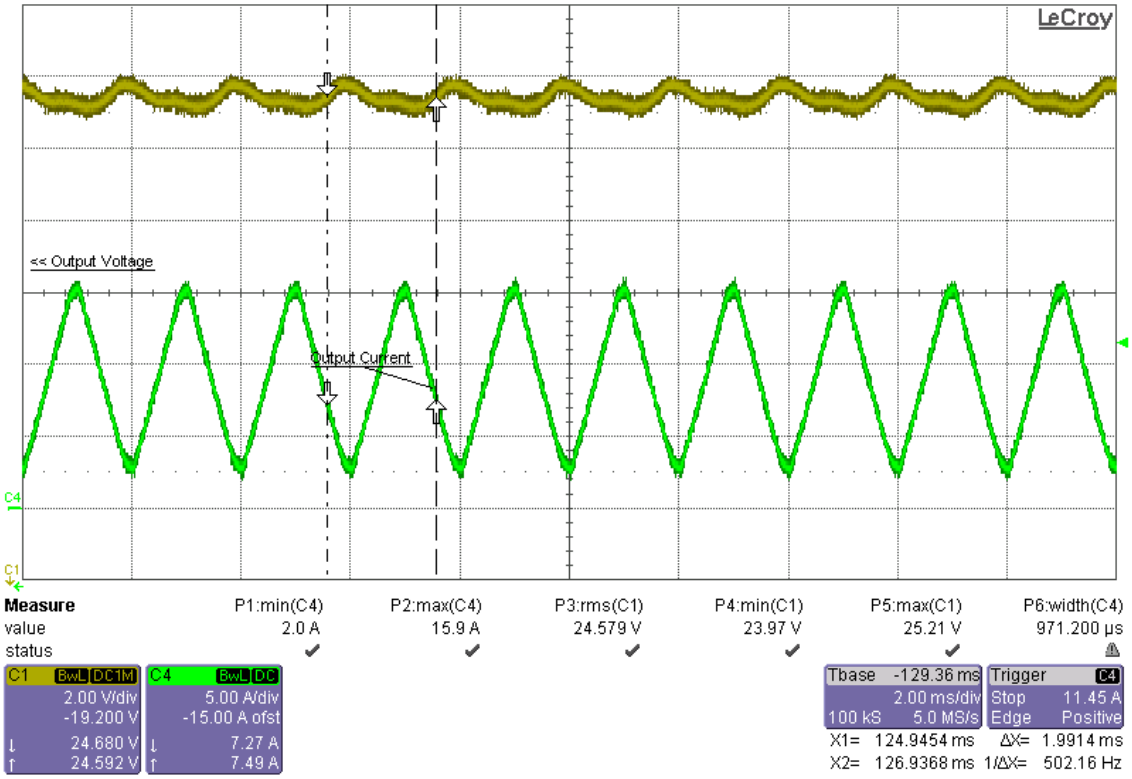


Figure 13: Transient Response 2A to 16A with a Slew Rate of 0.014A/us and a Period of 2ms

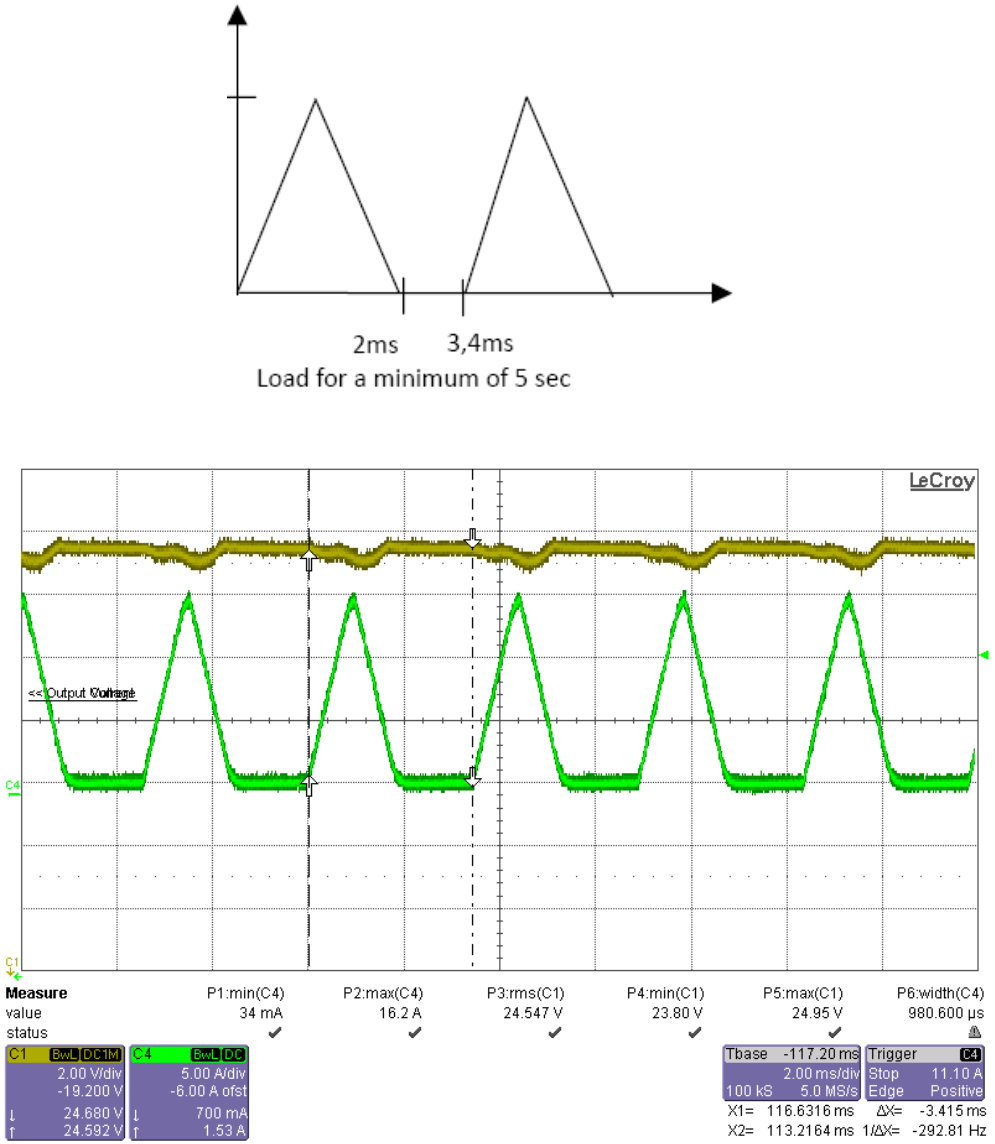


Figure 14: Transient Response 0A to 16A with a Slew Rate of 0.014A/us and a Period of 3.4 ms

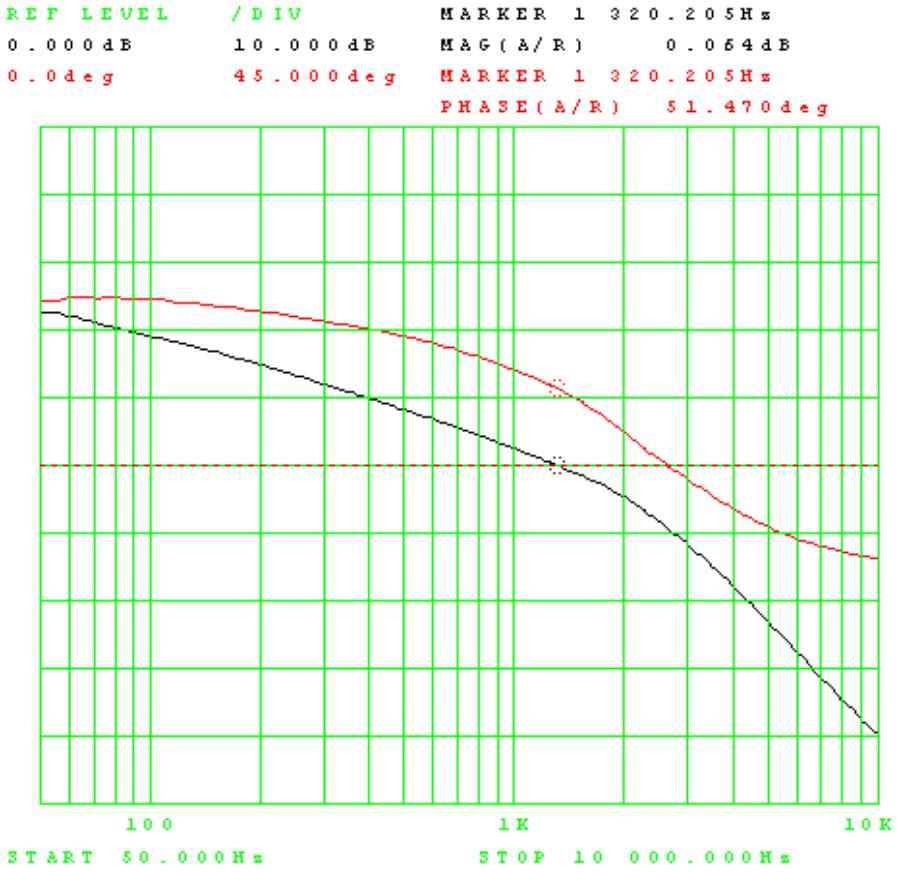


Figure 15: 12V Frequency Response 1.3 kHz at 51 Degrees of Phase Margin 4A Load

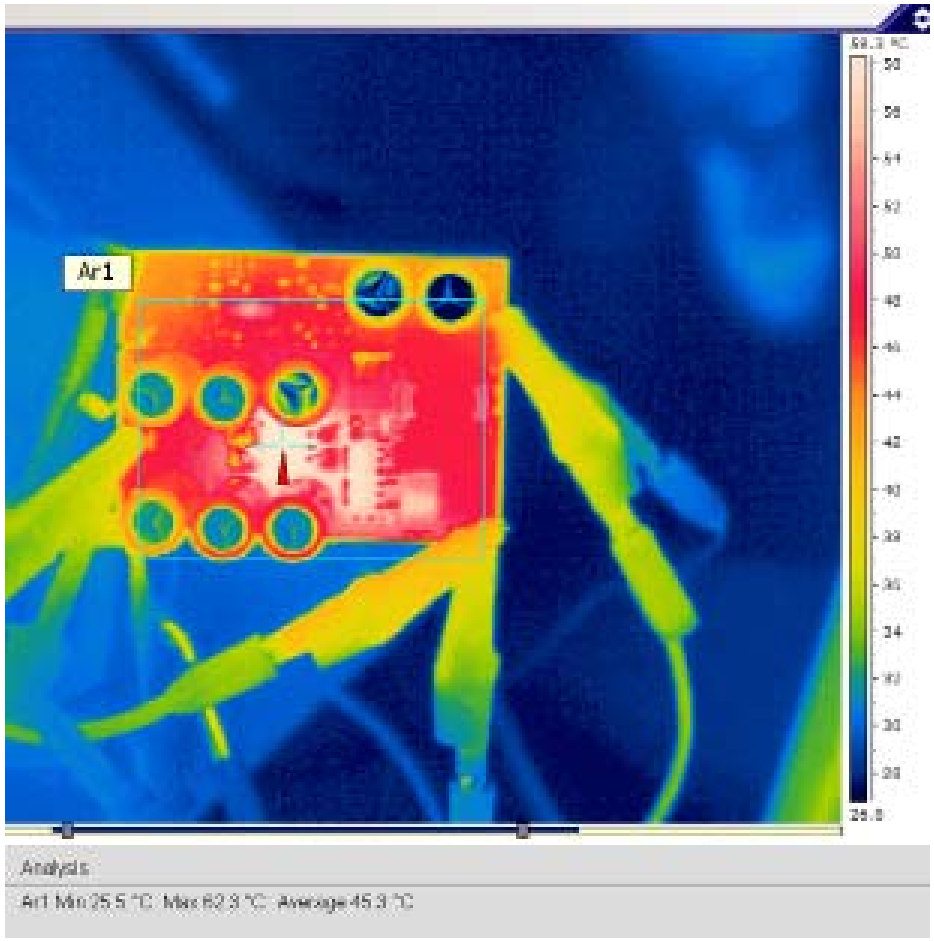


Figure 16: Thermal Image of PCB at 12V with a 4A Load and 25C Ambient

Design note created by Tim Kaske and Bryan McCoy, e-mail: Tim.Kaske@onsemi.com ; Bryan.McCoy@onsemi.com