ON Semiconductor

Design Note – DN05011/D
High Efficiency 3A Buck Regulator w/ Light Load Efficiency

Device	Application	Input Voltage	Output Voltage	Output Current	Topology
NCP3170A	Consumer Electronic	5V & 12V	0.8V-5.0V	3.0A	Buck

Circuit Description

This circuit is proposed for a wide varying +12V input (4.5V-18V) where there is a need to step-down the voltage to various low voltage outputs from 1.0V to 5.0V. The requirement specified using two 22uF ceramic output capacitors. Target efficiency is >80% with a thermally acceptable board temperature.

The NCP3170A is a synchronous PWM switching buck regulator which utilizes current mode control for simple power supply design. The NCP3170A operates from 4.5 V to 18 V, producing up to 3 A, and is capable of producing output voltages as low as 0.8 V. To reduce the number of external components, a number of features are internally set including soft start, power good detection, and switching frequency. The NCP3170A is currently available in an SOIC−8 package.

Key Features

- High Efficiency (90mΩ/25mΩ MOSFETs)
- 4.5 V to 18 V Operating Input Voltage Range
- FMEA Fault Tolerant During Pin Short Test
- Fixed 500 kHz and 1 MHz PWM Operation
- Cycle−by−Cycle Current Monitoring
- PowerGood Pin for Power Sequencing
- Dedicated ENABLE pin
- Turn on Into Pre−bias
- Short Circuit Protection
- Fixed Switching Frequency
- Enhanced Light Load Efficiency

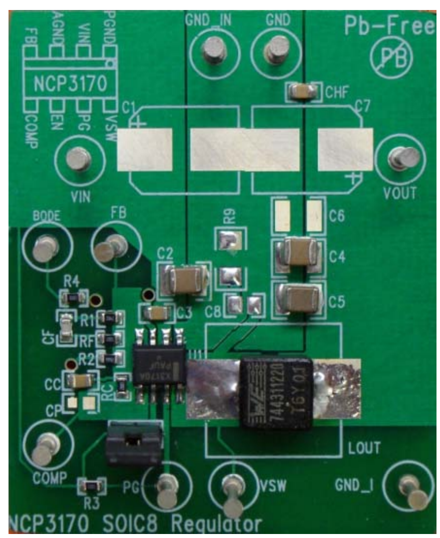

Figure 1: NCP3170A Demonstration PCB

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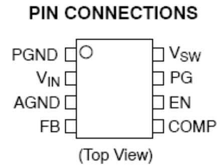

Figure 2: NCP3170A Pinout

Table 1: Pin Description

PIN	PIN NAME	DESCRIPTION
1	PGND	The power ground pin is the high current path for the device. The pin should be soldered to a large copper area to reduce thermal resistance. PGND needs to be electrically connected to AGND.
2	VIN	The input voltage pin powers the internal control circuitry and is monitored by multiple voltage comparators. The VIN pin is also connected to the internal power PMOS switch and linear regulator output. The VIN pin has high di/dt edges and must be decoupled to ground close to the pin of the device.
3	AGND	The analog ground pin serves as small-signal ground. All small-signal ground paths should connect to the AGND pin and should also be electrically connected to power ground at a single point, avoiding any high current ground returns.
4	FB	Inverting input to the OTA error amplifier. The FB pin in conjunction with the external compensation serves to stabilize and achieve the desired output voltage with current mode compensation.
5	COMP	The loop compensation pin is used to compensate the transconductance amplifier which stabilizes the operation of the converter stage. Place compensation components as close to the converter as possible. Connect a RC network between COMP and AGND to compensate the control loop.
6	EN	Enable pin. Pull EN to logic high to enable the device. Pull EN to logic low to disable the device. Do not leave it open.
7	PG	Power good is an open drain 500uA pull down indicating output voltage is within the power good window. If the power good function is not used, it can be connected to the VSW node to reduce thermal resistance. Do not connect PG to the VSW node if the application is turning on into pre-bias.
8	VSW	The VSW pin is the connection of the drains of the internal N and P MOSFETS. At switch off, the inductor will drive this pin below ground as the body diode and the NMOS conducts with a high dv/dt.

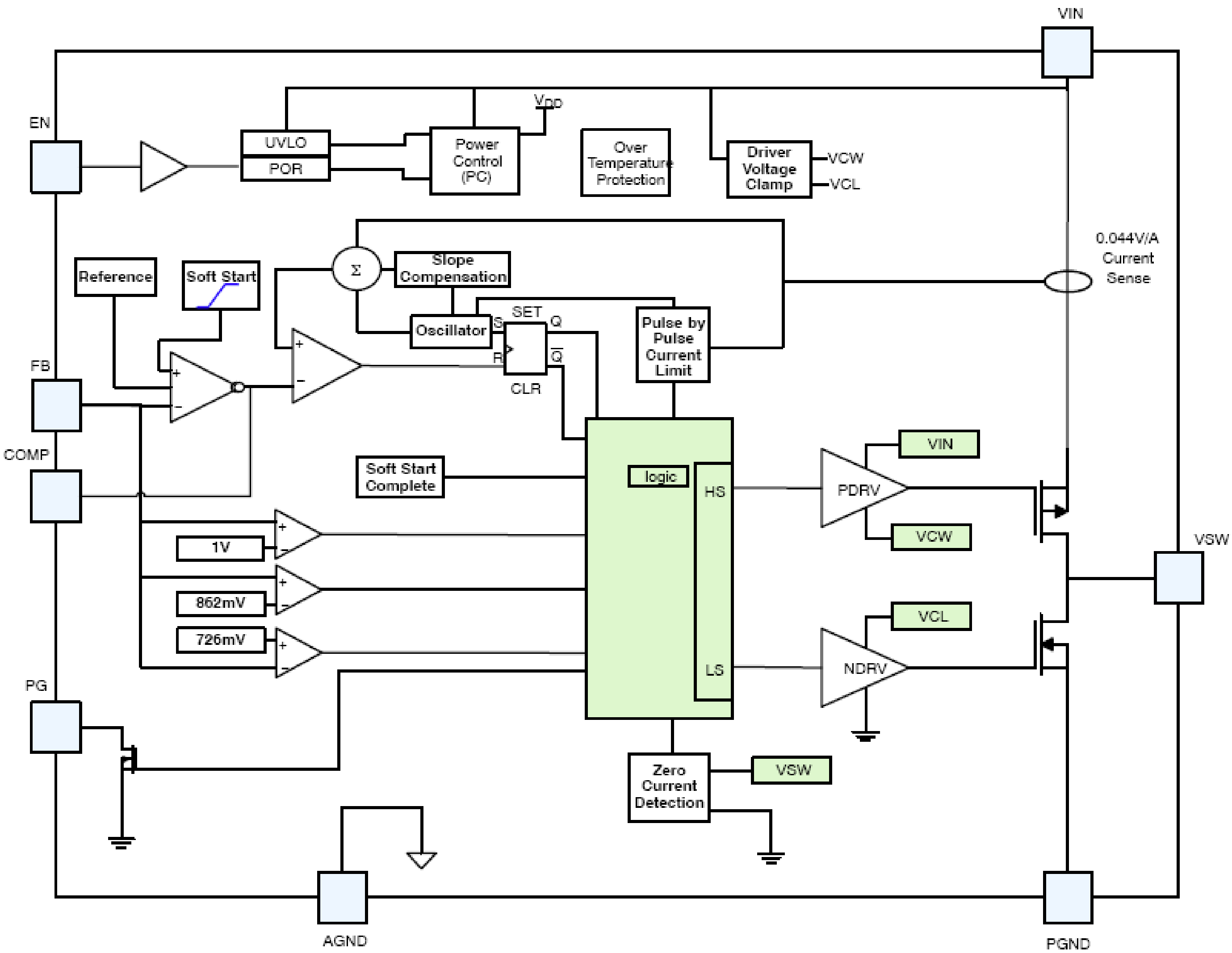

Figure 3: NCP3170A Block Diagram

Performance Information

The following figures show typical performance of the evaluation board.

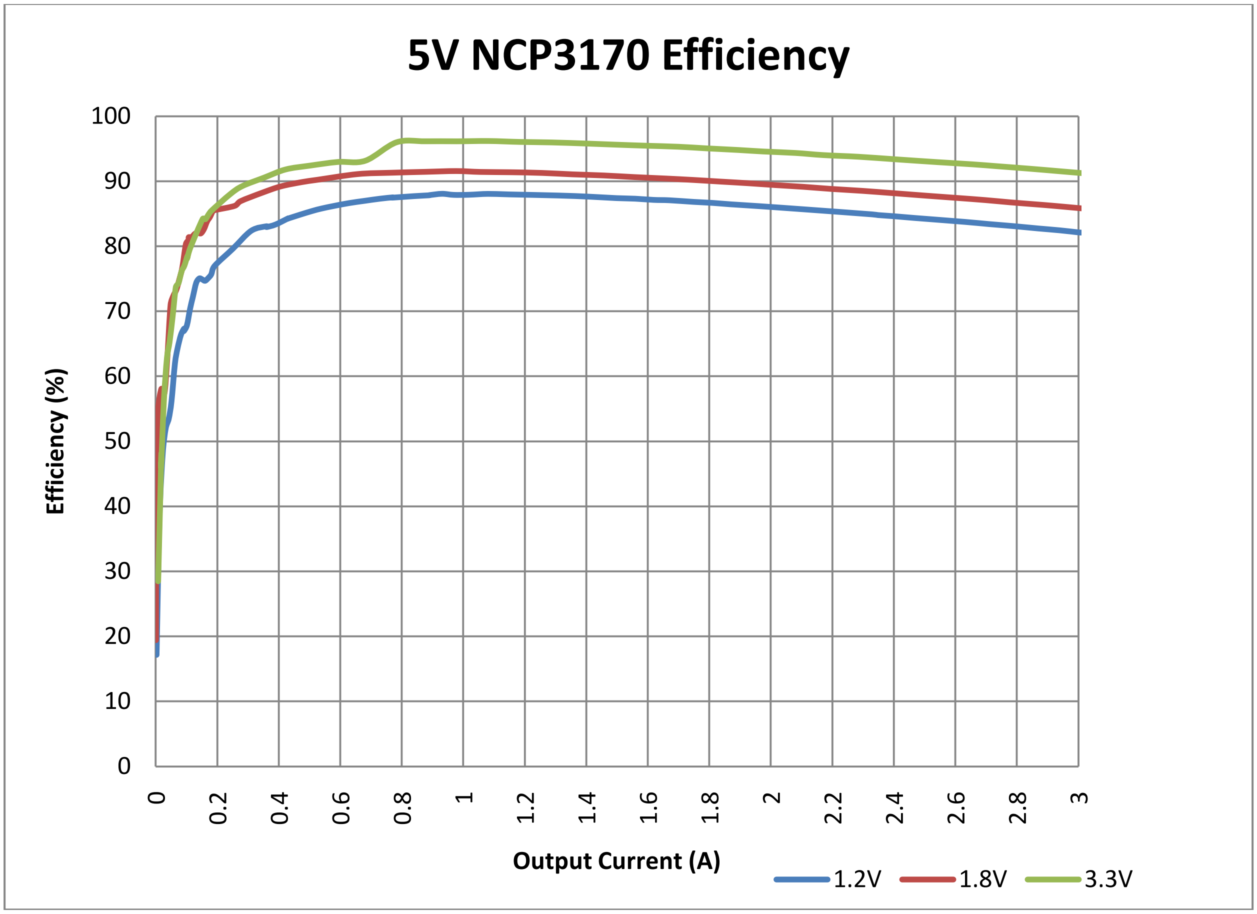

Figure 4: NCP3170 5V Efficiency

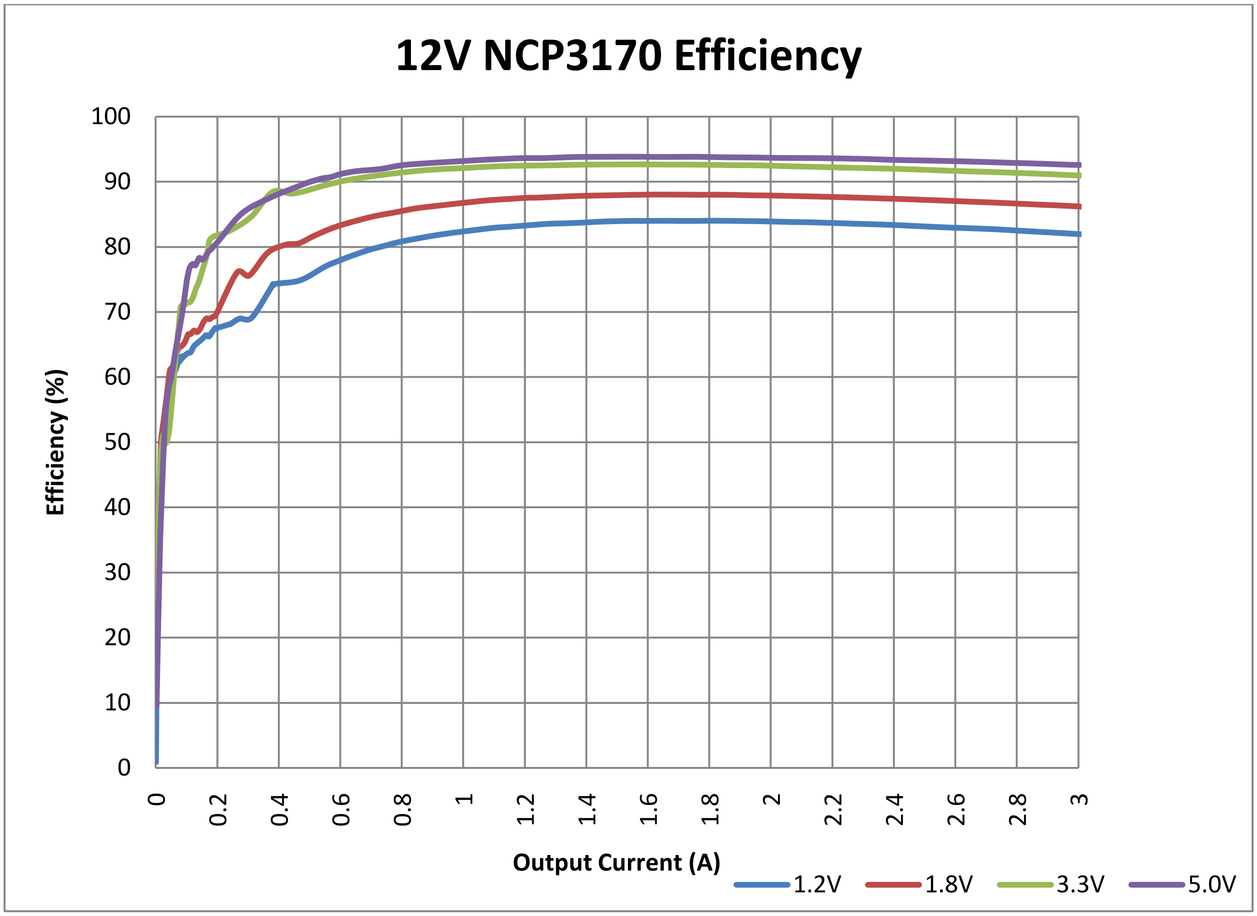

Figure 5: NCP3170 12V Efficiency Schematic

DN05011/D
Schematic

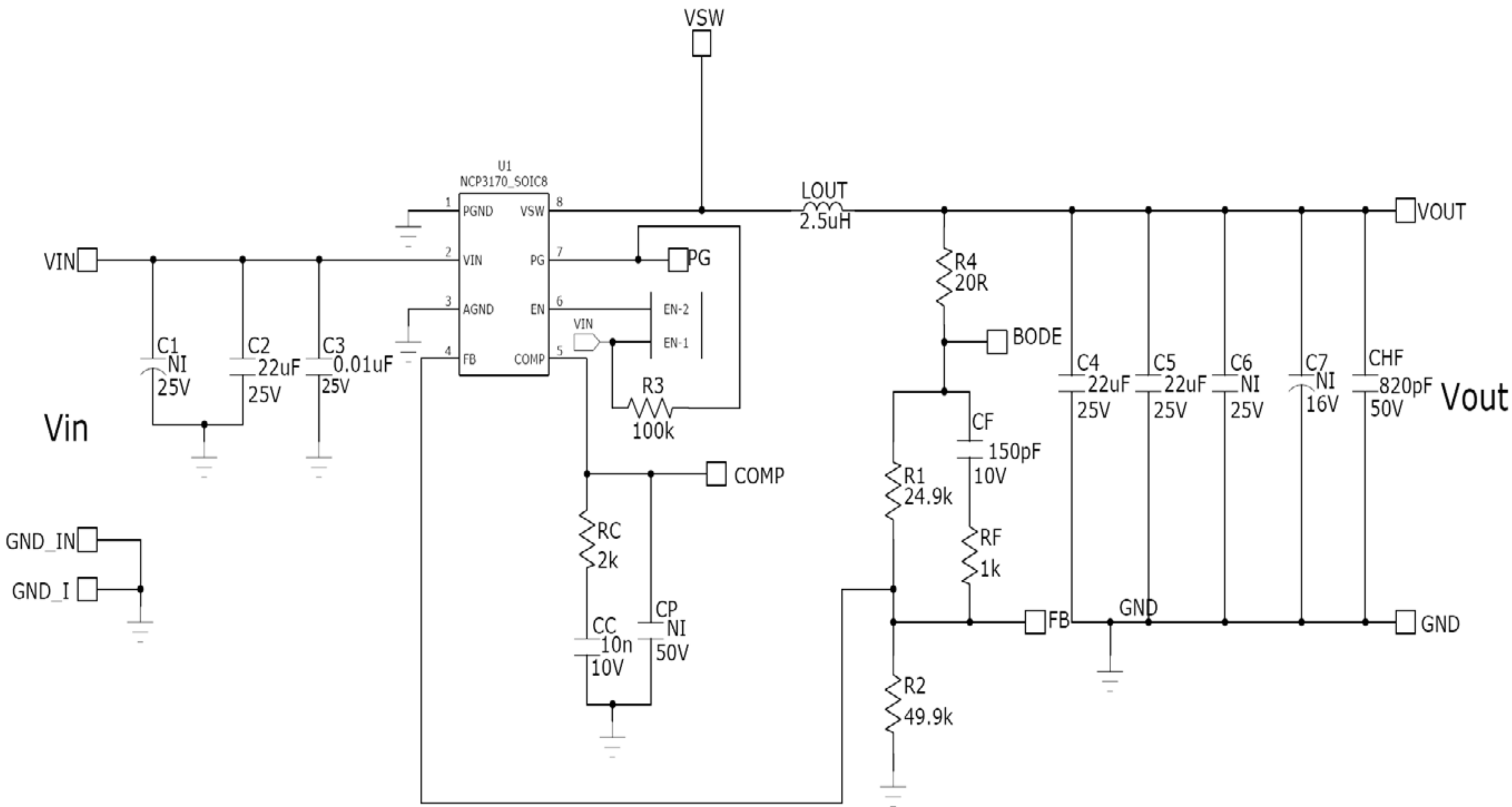

Figure 6: NCP3170 1.2V Schematic

Table 2: BOM for the NCP3170 1.2V Design

Reference	Qty	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number
C3	1	SMT Ceramic Capacitor	0.01uF	±5%	603	TDK	C1608C0G1E103J
CF	1	SMT Ceramic Capacitor	150pF	±5%	603	Murata	GRM1885C1H151JA01D
CC	1	SMT Ceramic Capacitor	10nF	±5%	603	TDK	C1608C0G1E103J
CHF	1	SMT Ceramic Capacitor	820pF	±5%	603	AVX	06035A821JAT2A
CP	1	SMT Ceramic Capacitor	NI	±5%	603		
C2 C4-5	3	SMT Ceramic Capacitor	22uF	±20%	1210	AVX	12103D226MAT2A
C6	1	SMT Ceramic Capacitor	NI	±10%	1210		
C1	1	Surface Mount E-Cap	NI	±20%	(8mm x 6.2)mm		
C7	1	Surface Mount E-Cap	NI	±20%	(8.3 x 8.3)mm		
LOUT	1	SMT Inductor	2.5uH	20%	(10.2x 10.2 x 6.4)mm	Wurth	7447798250
U1	1	Switching PWM Regulator	500kHz	NA	SOIC8	ON Semiconductor	NCP3170
R2	1	SMT Resistor	49.9k	±1.0%	603	Vishay / Dale	CRCW060349K9FKEA
R3	1	SMT Resistor	100k	±1.0%	603	Vishay / Dale	CRCW0603100KFKEA
R4	1	SMT Resistor	20R	±1.0%	603	Vishay / Dale	CRCW060320R0FKEA
RC	1	SMT Resistor	2k	±1.0%	603	Vishay / Dale	CRCW06032K00FKEA
R1	1	SMT Resistor	24.9k	±1.0%	603	Vishay / Dale	CRCW060324K9FKEA
RF	1	SMT Resistor	1k	±1.0%	603	Vishay / Dale	CRCW06031K00FKEA

Table 3: BOM changes to achieve desired output

VIN (V)	V_{out} (V)	L_{out} (µF)	R1 (kΩ)	R2 (kΩ)	Rf (kΩ)	Cf (pF)	Cc (nF)	Rc (kΩ)	Cp (nF)
12	0.8	1.8	24.9	NI	NI	NI	NI	NI	15
12	1.0	2.5	24.9	100	1	150	15	.825	NI
12	1.1	2.5	24.9	66.5	1	150	10	2	NI
12	1.2	2.5	24.9	49.9	1	150	10	2	NI
12	1.5	3.6	24.9	28.7	1	150	10	2.49	NI
12	1.8	3.6	24.9	20	1	150	10	2.49	NI
12	2.5	4.7	24.9	11.8	1	150	8.2	3.74	NI
12	3.3	4.7	24.9	7.87	1	150	6.8	4.99	NI
12	5.0	7.2	24.9	4.75	1	150	3.9	10	NI
12	10.68	7.2	24.9	2.05	1	150	3.9	10	NI
18	14.8	7.2	24.9	1.43	1	150	6.8	6.98	NI
5	0.8	1.8	24.9	NI	NI	NI	NI	NI	15
5	1.0	2.5	24.9	100	1	150	15	.825	NI
5	1.1	2.5	24.9	66.5	1	150	10	2	NI
5	1.2	2.5	24.9	49.9	1	150	10	2	NI
5	1.5	3.6	24.9	28.7	1	150	10	2.49	NI
5	1.8	3.6	24.9	20	1	150	10	2.49	NI
5	2.5	3.6	24.9	11.8	1	150	6.8	4.99	NI
5	3.3	3.6	24.9	7.87	1	150	6.8	4.99	NI

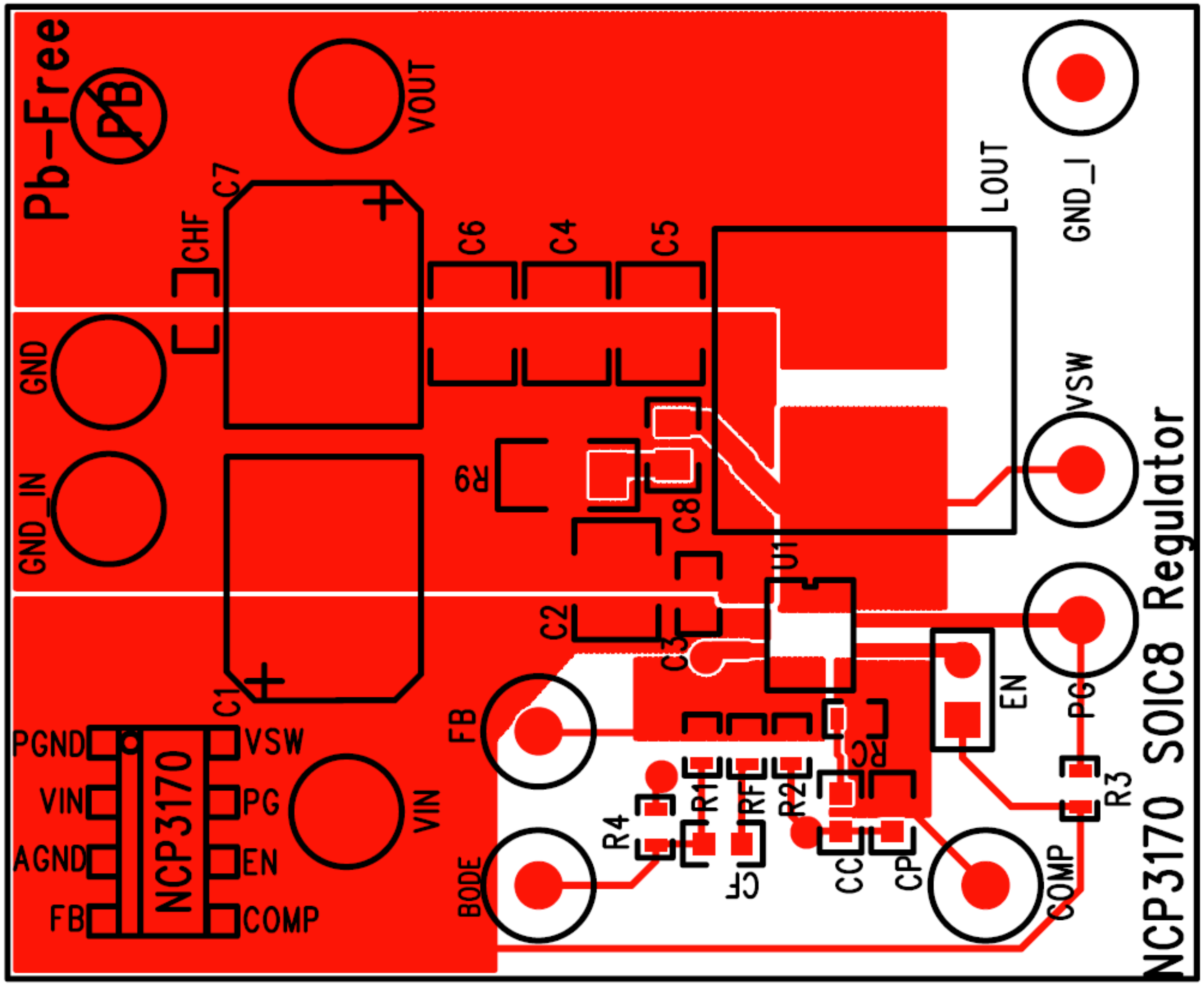

Figure 7: Layout Top
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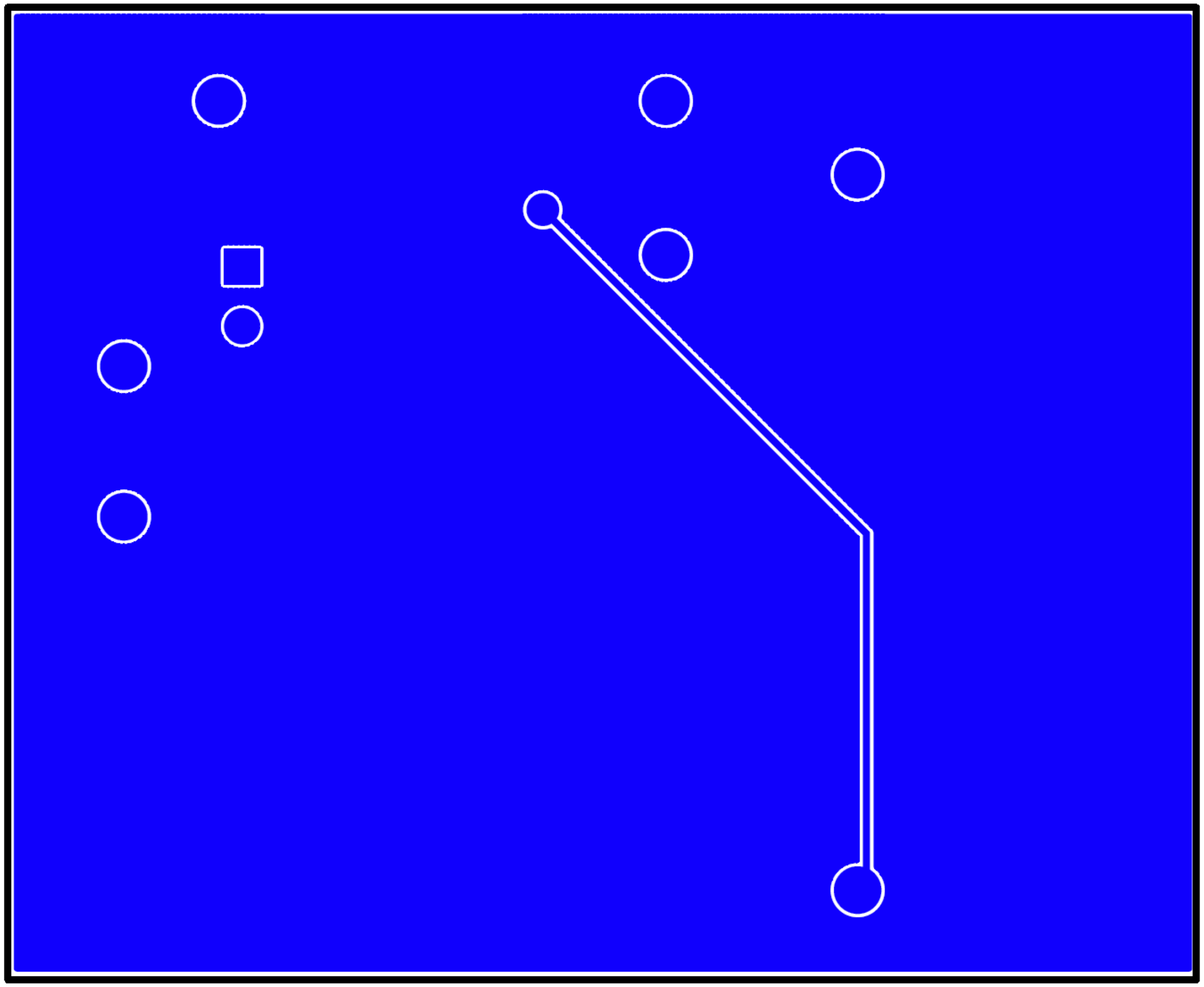

Figure 8: Layout Bottom

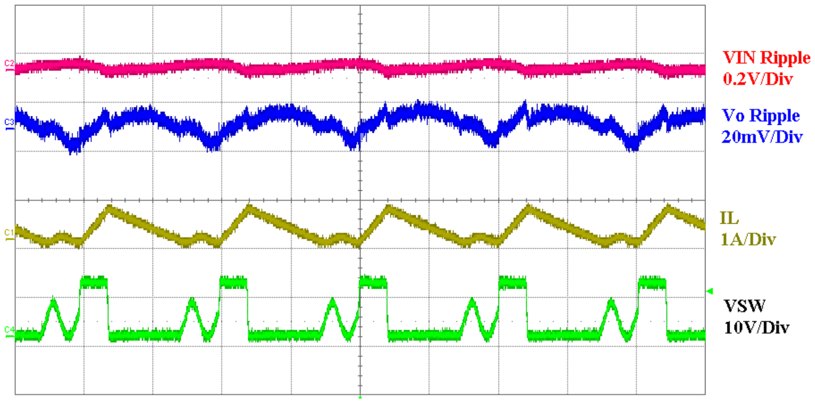

Figure9: Output Ripple Voltage 12 V to 3.3 V with 0.3 A Load

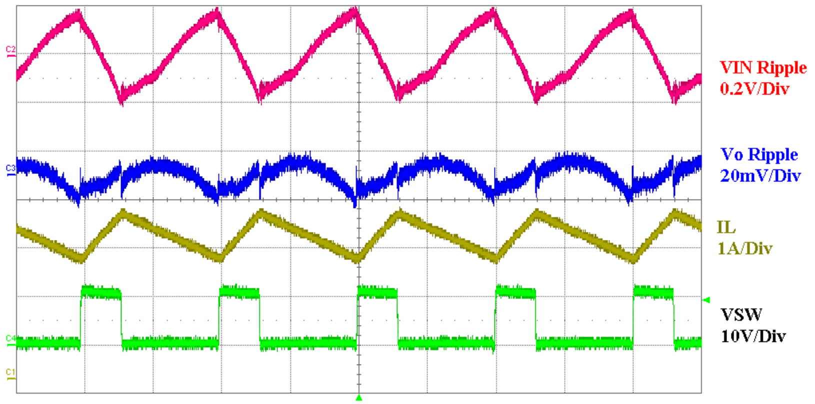

Figure10: Output Ripple Voltage 12 V to 3.3 V with 3.0 A Load

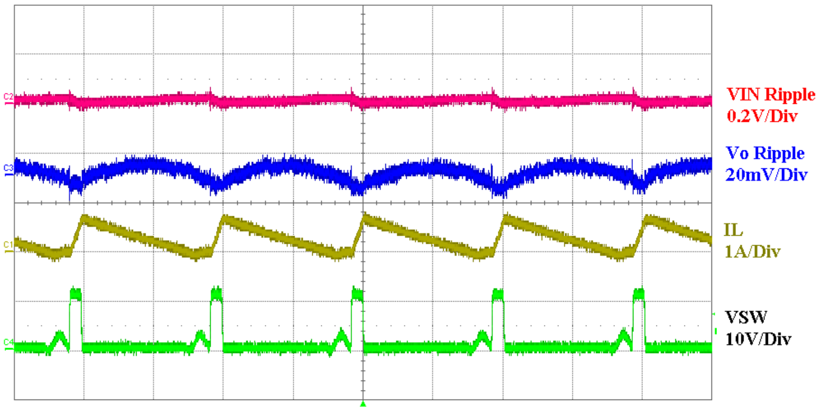

Figure11: Output Ripple Voltage 12 V to 1.2 V with 0.3 A Load

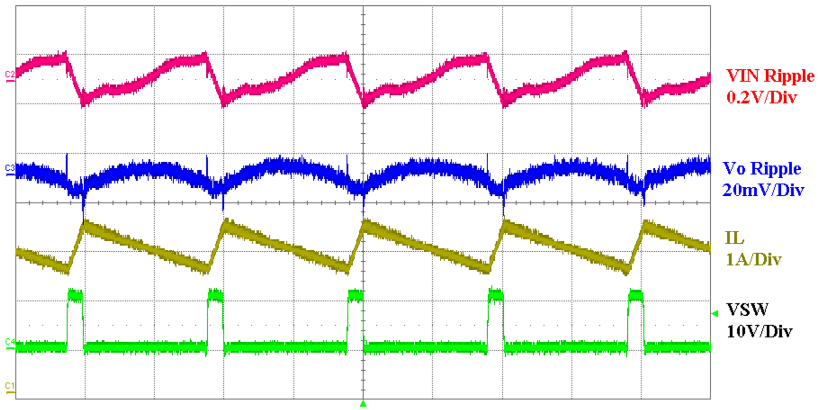

Figure12: Output Ripple Voltage 12 V to 1.2 V with 3.0 A Load

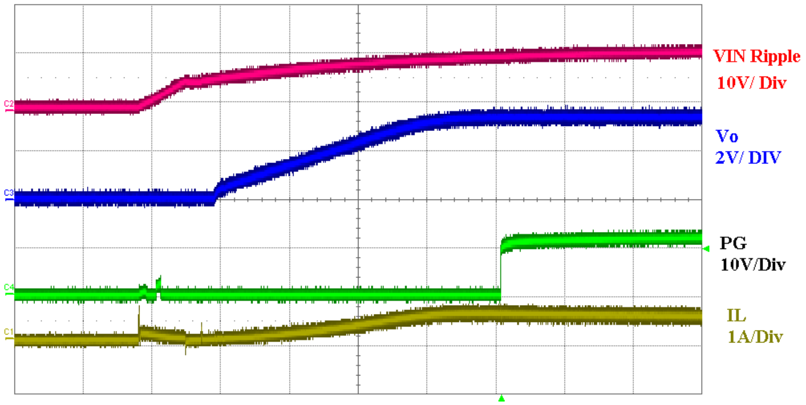

Figure13: 12 V to 3.3 V with Soft start

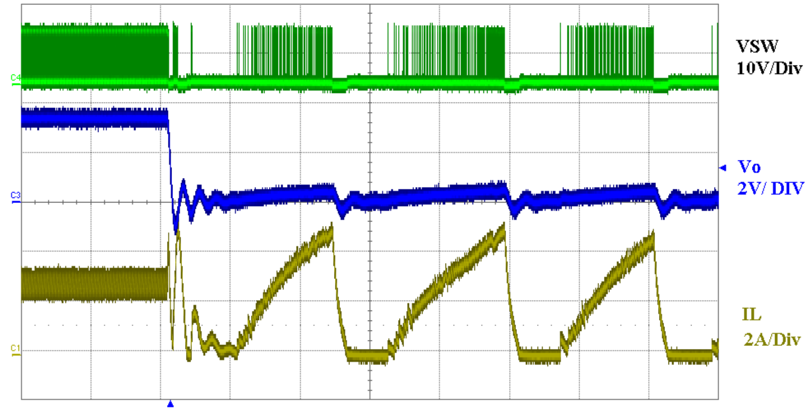

Figure14: 12 V to 3.3 V Short

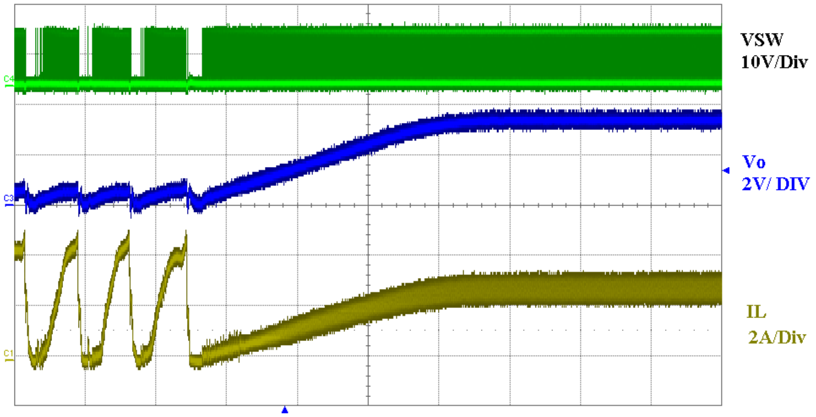

Figure15: 12 V to 3.3 V Release From Short

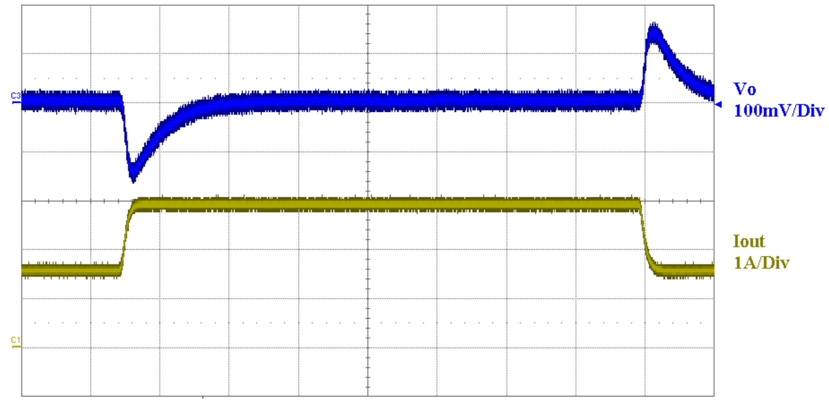

Figure16: 12 V to 3.3 V Transient Response 50% to 100%

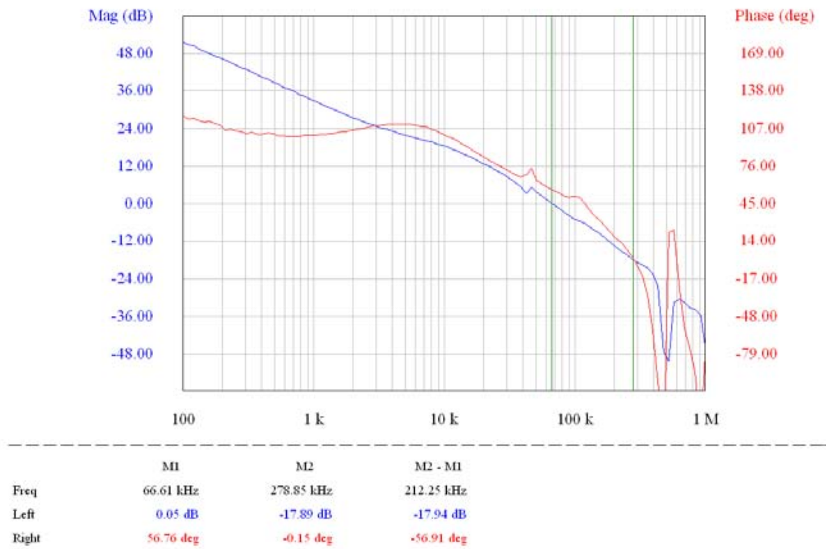

Figure17: 12 V to 3.3 V 3A Load Frequency Response

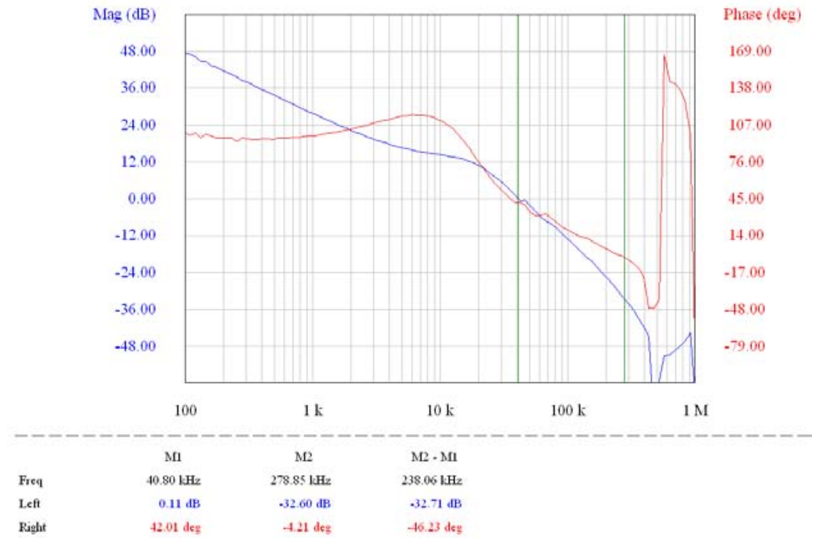

Figure18: 12 V to 1.2 V 3A Load Frequency Response

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