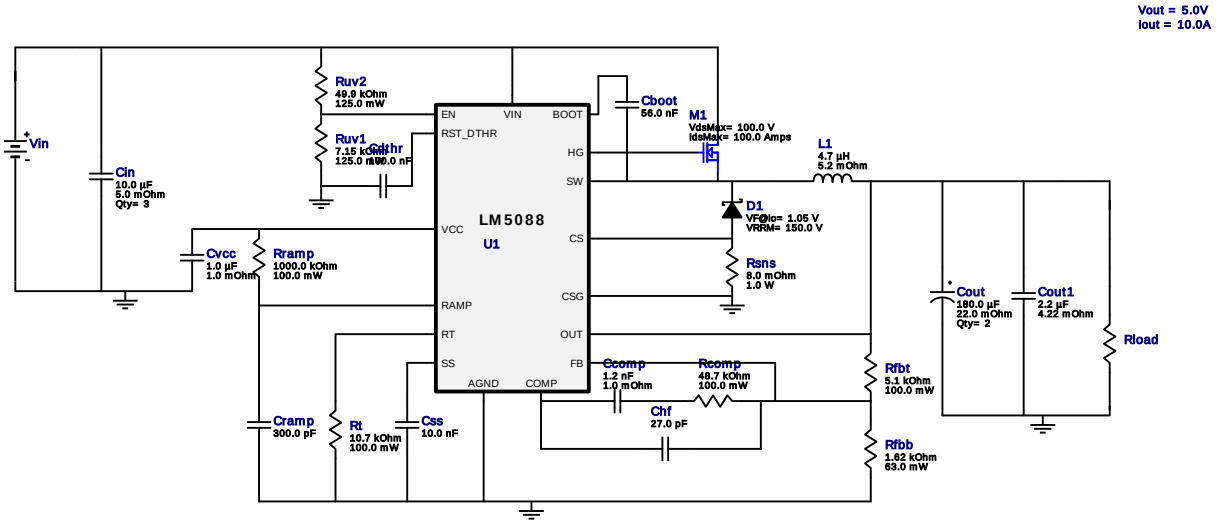
VinMin = 12.0V
VinMax = 70.0V
Vout = 5.0V
Iout = 10.0A

Device = LM5088MH-1/NOPB
Topology = Buck
Created = 2024-02-05 10:15:06.404
BOM Cost = $8.94
BOM Count = 26
Total Pd = 12.86W

WEBENCH® Design Report

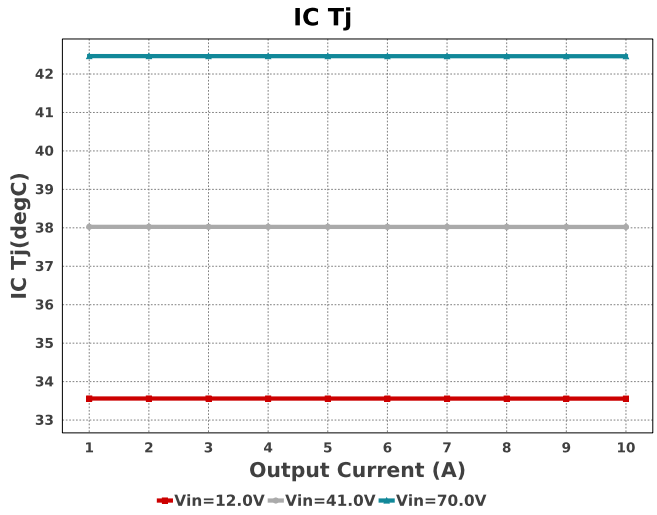
Design : 21 LM5088MH-1/NOPB
LM5088MH-1/NOPB 12V-70V to 5.00V @ 10A

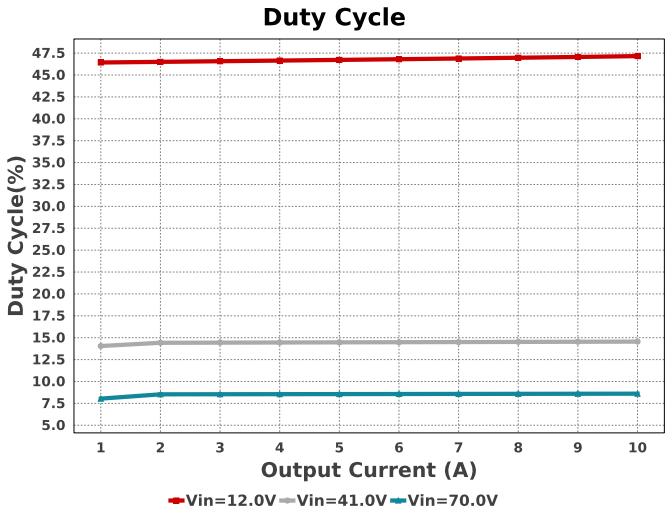


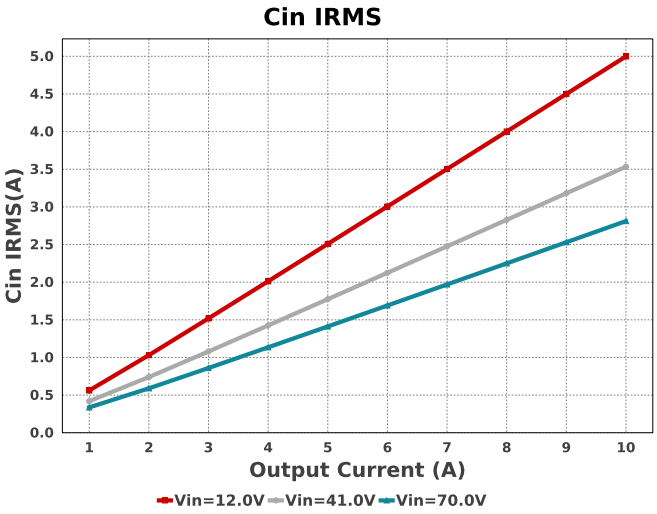
Electrical BOM

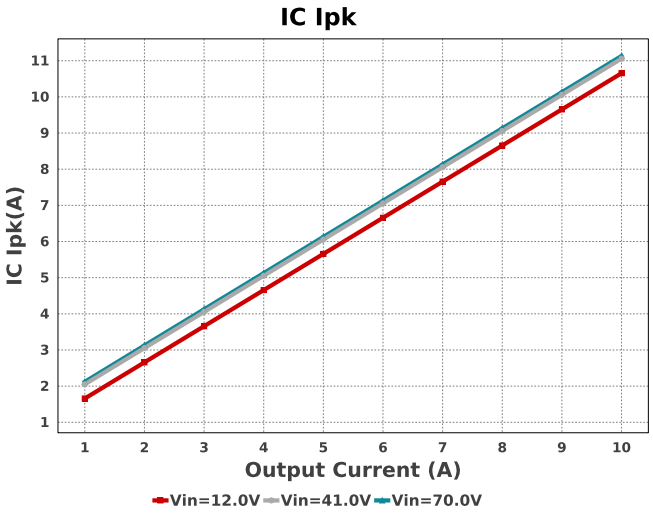
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Kemet	C1812C563J5GACTU Series= C0G/NP0	Cap= 56.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.80	1812 23 mm²
Ccomp	MuRata	GRM188R71E122KA01D Series= X7R	Cap= 1.2 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cdthr	AVX	08053C104JAZ2A Series= X7R	Cap= 100.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.07	0805 7 mm²
Chf	Samsung Electro-Mechanics	CL10C270JB81PNC Series= C0G/NP0	Cap= 27.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cin	TDK	C5750X7S2A106M230KB Series= X7S	Cap= 10.0 uF ESR= 5.0 mOhm VDC= 100.0 V IRMS= 6.45 A	3	$0.76	2220 54 mm²
Cout	Panasonic	16SVPF180M Series= SVPF	Cap= 180.0 uF ESR= 22.0 mOhm VDC= 16.0 V IRMS= 3.3 A	2	$0.57	CAPSMT_62_F61 74 mm²
Cout1	MuRata	GRM21BR71A225KA01L Series= X7R	Cap= 2.2 uF ESR= 4.22 mOhm VDC= 10.0 V IRMS= 2.08454 A	1	$0.03	0805 7 mm²
Cramp	Samsung Electro-Mechanics	CL10C301JB8NNNC Series= C0G/NP0	Cap= 300.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Css	Samsung Electro-Mechanics	CL10C103JA8NNNC Series= C0G/NP0	Cap= 10.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.04	0603 5 mm²

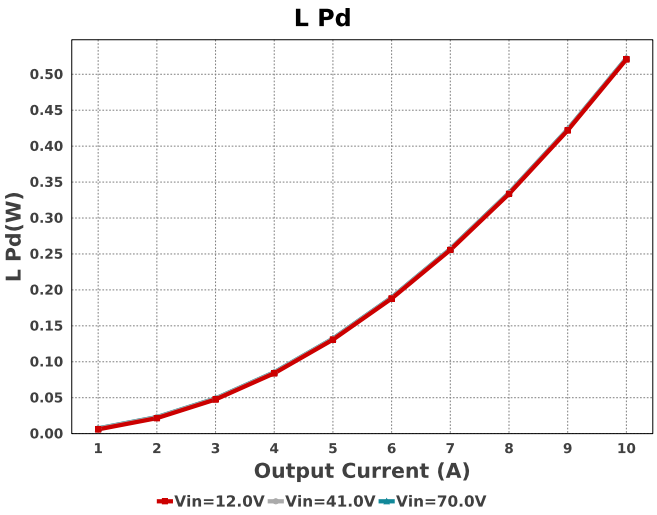
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cvcc	Kemet	C0603C105Z8VACTU Series= Y5V	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	 0603 5 mm²
D1	SMC Diode Solutions	SB20150TR	VF@Io= 1.05 V VRRM= 150.0 V	1	$0.32	 DO-201AD 166 mm²
L1	Coilcraft	XAL1010-472MEB	L= 4.7 µH 5.2 mOhm	1	$1.71	 XAL1010 160 mm²
M1	Texas Instruments	CSD19531Q5A	VdsMax= 100.0 V IdsMax= 100.0 Amps	1	$0.52	 TRANS_NexFET_Q5A 55 mm²
Rcomp	Vishay-Dale	CRCW060348K7FKEA Series= CRCW..e3	Res= 48.7 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	 0603 5 mm²
Rfbb	Vishay-Dale	CRCW04021K62FKED Series= CRCW..e3	Res= 1.62 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
Rfbt	Yageo	RC0603FR-075K1L Series= ?	Res= 5.1 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	 0603 5 mm²
Rramp	Vishay-Dale	CRCW06031M00FKEA Series= CRCW..e3	Res= 1000.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	 0603 5 mm²
Rsns	Susumu Co Ltd	PRL1632-R008-F-T1 Series= PRL1632	Res= 8.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.20	 0612 11 mm²
Rt	Vishay-Dale	CRCW060310K7FKEA Series= CRCW..e3	Res= 10.7 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	 0603 5 mm²
Rt	Vishay-Dale	CRCW060310K7FKEA Series= CRCW..e3	Res= 10.7 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	 0603 5 mm²
Ruv1	Panasonic	ERJ-6ENF7151V Series= ERJ-6E	Res= 7.15 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	 0805 7 mm²
Ruv2	Vishay-Dale	CRCW080549K9FKEA Series= CRCW..e3	Res= 49.9 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	 0805 7 mm²
U1	Texas Instruments	LM5088MH-1/NOPB	Switcher	1	$1.71	 MXA16A 59 mm²

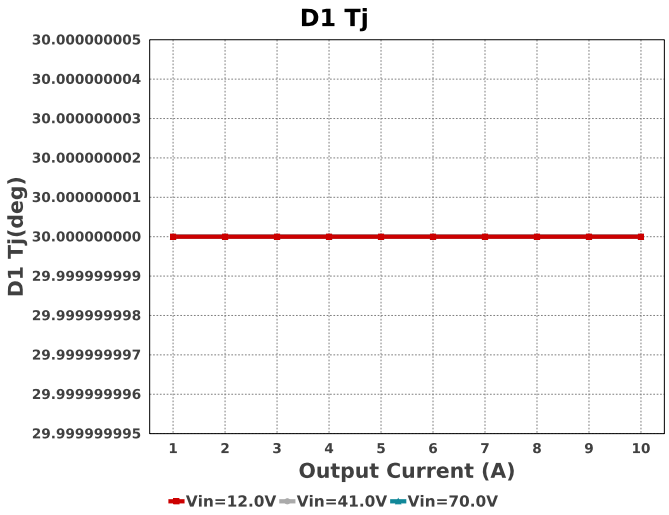


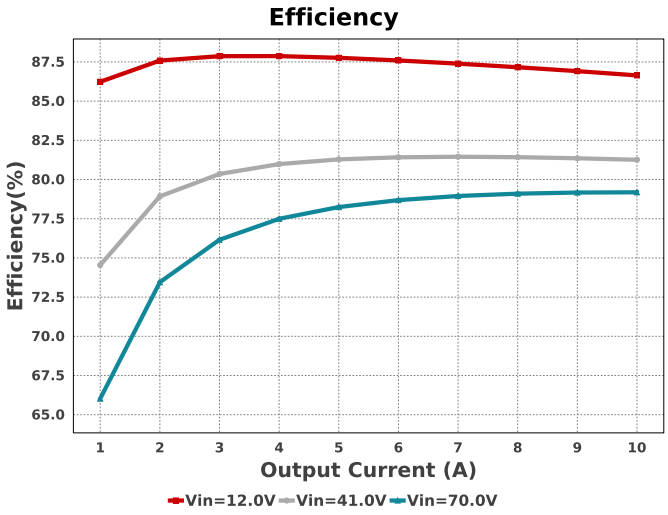


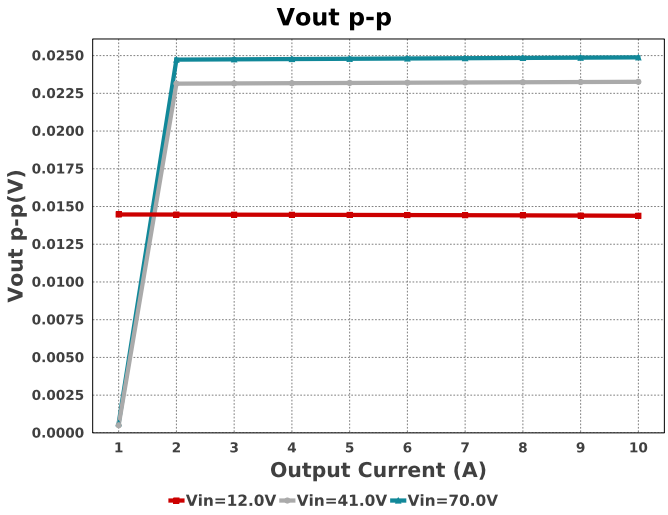


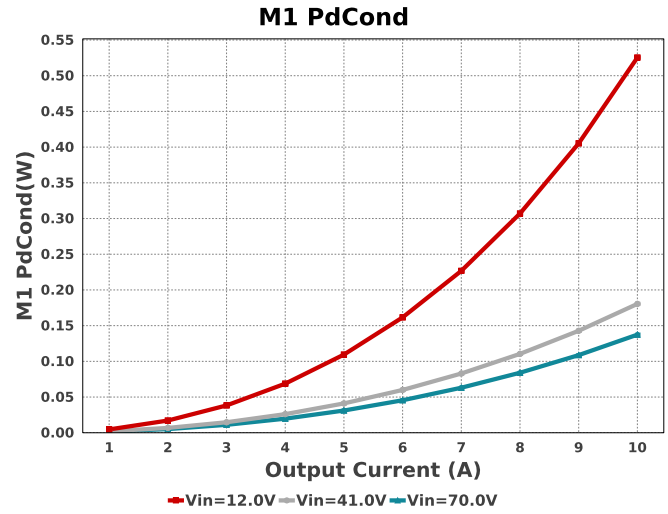


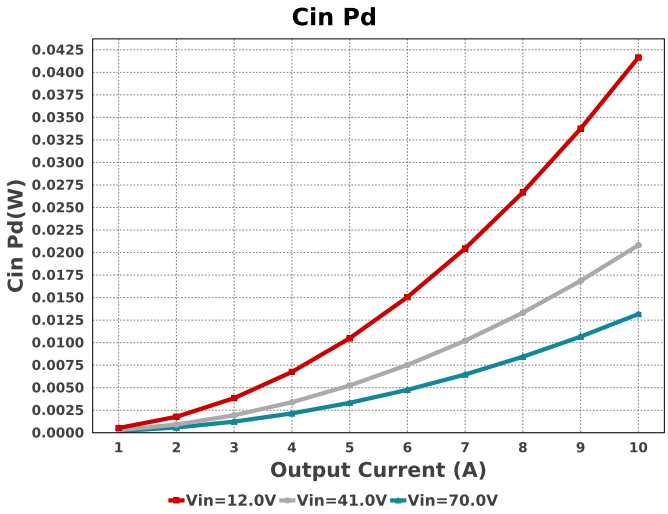


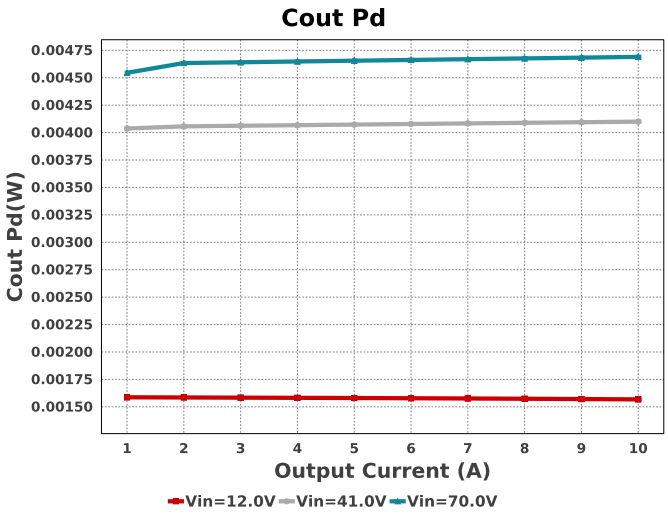


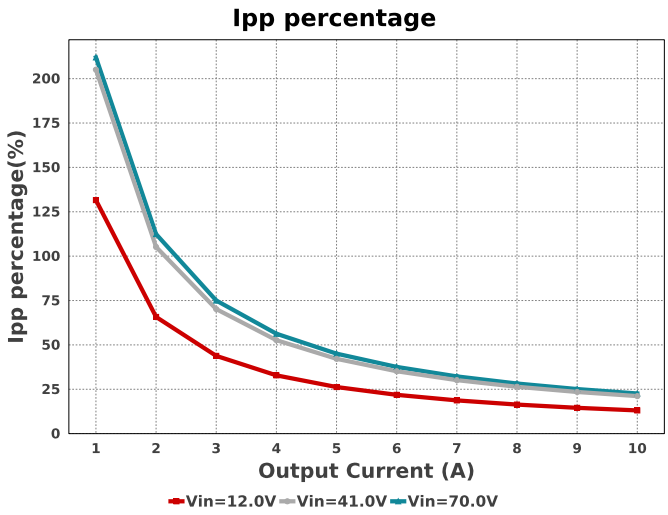

Efficiency
Efficiency(%)
87.5
85.0
82.5
80.0
77.5
75.0
72.5
70.0
67.5
65.0
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=41.0V Vin=70.0V

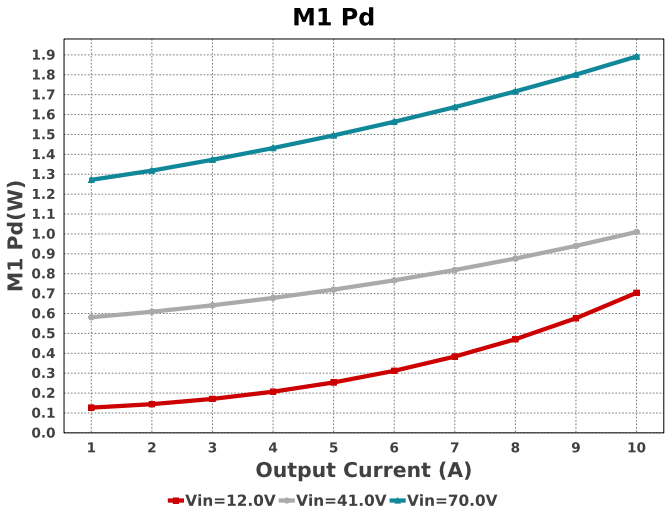

Vout p-p
Vout p-p(V)
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=41.0V Vin=70.0V

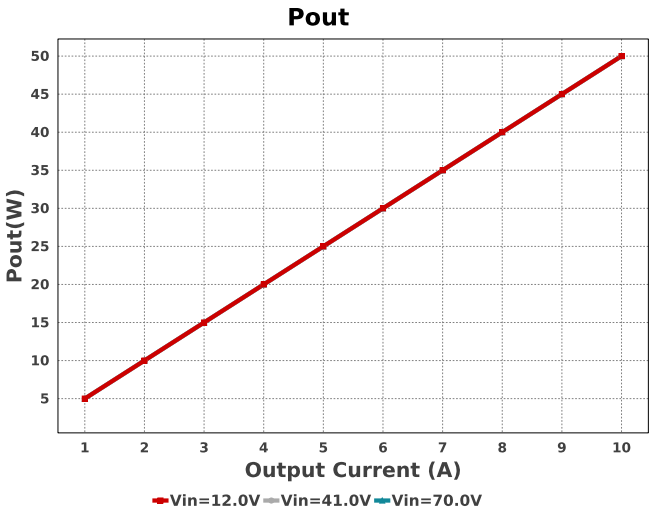

M1 PdCond
M1 PdCond(W)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=41.0V Vin=70.0V

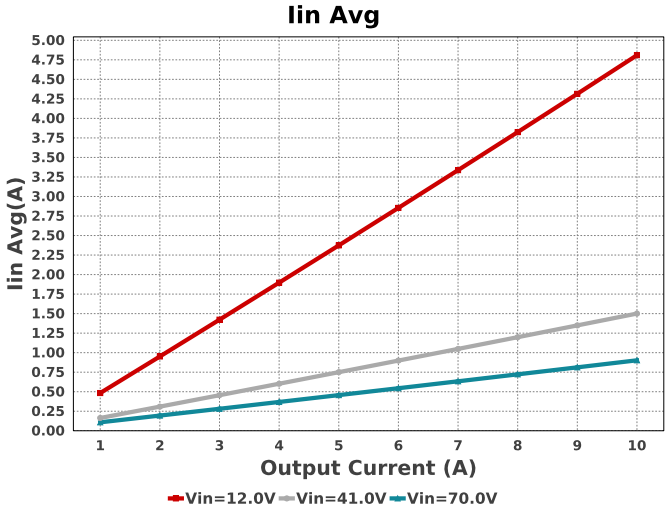

Cin Pd
Cin Pd(W)
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=41.0V Vin=70.0V

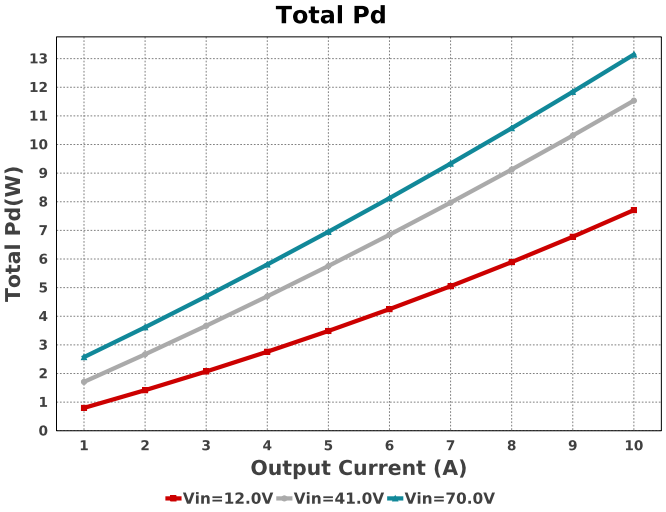

Cout Pd
Cout Pd(W)
0.00475
0.00450
0.00425
0.00400
0.00375
0.00350
0.00325
0.00300
0.00275
0.00250
0.00225
0.00200
0.00175
0.00150
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=41.0V Vin=70.0V

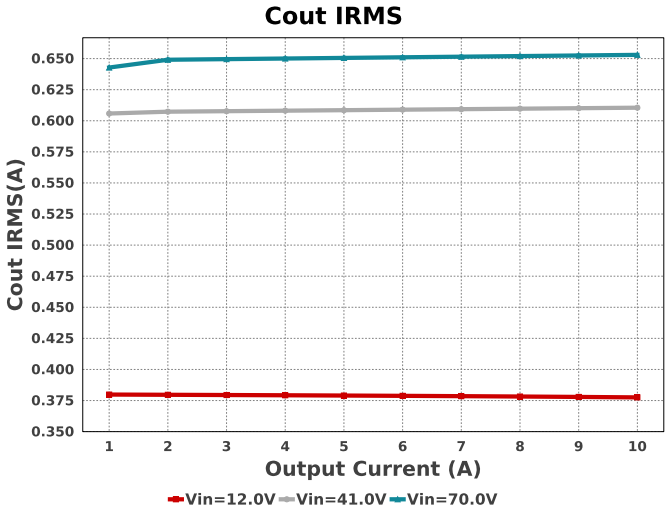

Ipp percentage
Ipp percentage(%)
200
175
150
125
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=41.0V Vin=70.0V

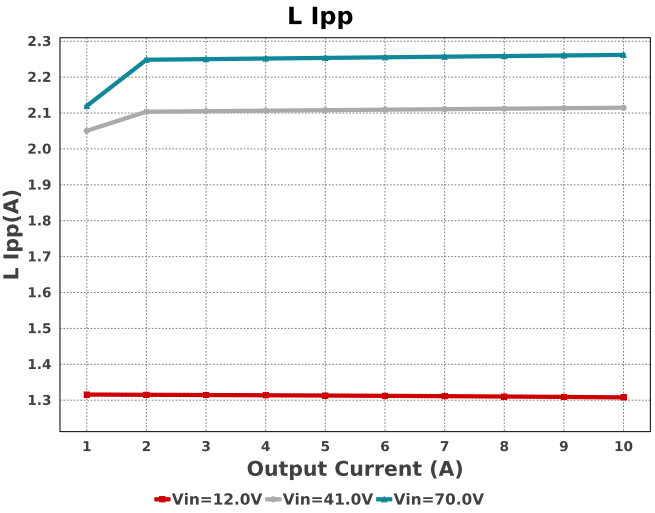


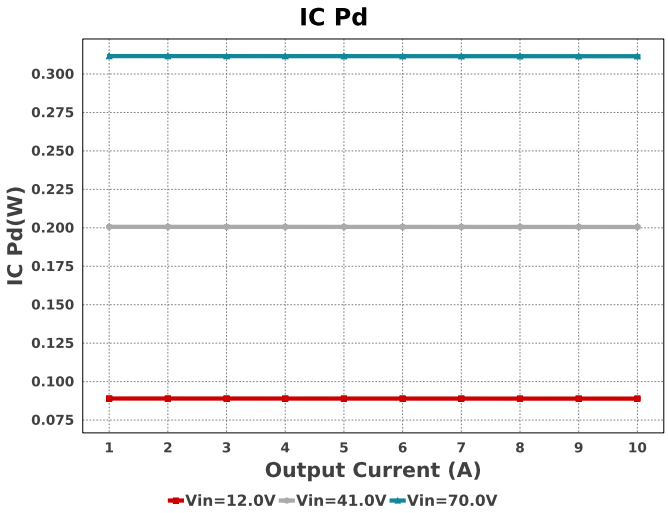


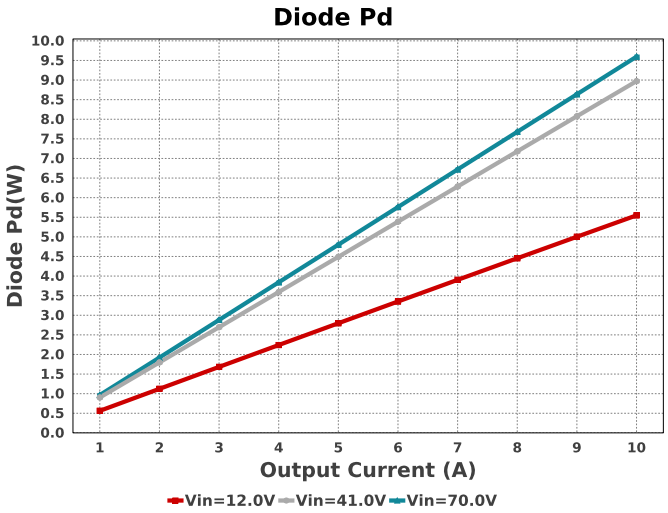


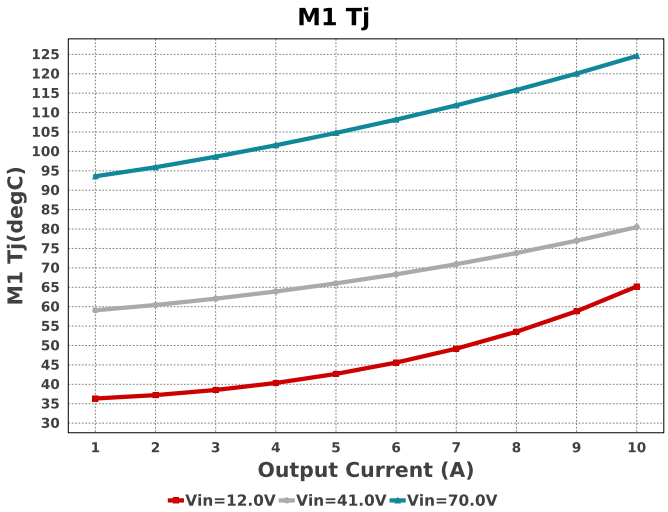


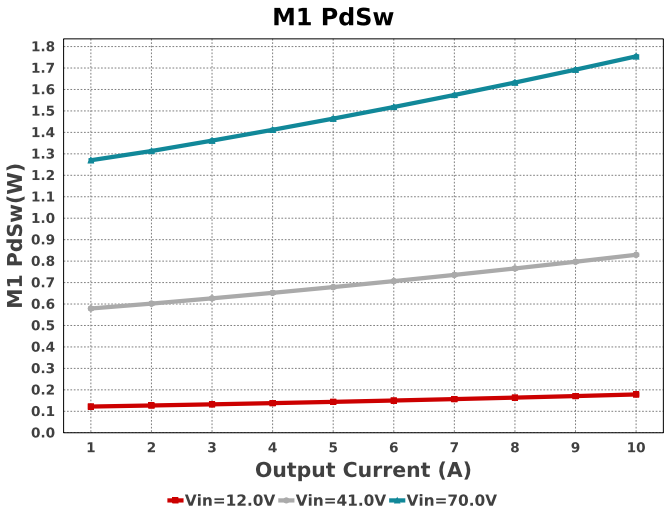












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	2.811 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	13.171 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	652.997 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	4.69 mW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	30.0 deg	Diode	D1 junction temperature
6.	Diode Pd	9.596 W	Diode	Diode power dissipation
7.	IC Ipk	11.131 A	IC	Peak switch current in IC
8.	IC Pd	311.57 mW	IC	IC power dissipation
9.	IC Tj	42.463 degC	IC	IC junction temperature
10.	IC Tolerance	18.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	40.0 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	897.94 mA	IC	Average input current
13.	Ipp percentage	22.62 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	2.262 A	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	522.22 mW	Inductor	Inductor power dissipation
16.	M1 Pd	1.739 W	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	132.07 mW	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	1.607 W	Mosfet	M1 MOSFET switching losses
19.	M1 Tj	116.94 degC	Mosfet	M1 MOSFET junction temperature
20.	Cin Pd	13.171 mW	Power	Input capacitor power dissipation
21.	Cout Pd	4.69 mW	Power	Output capacitor power dissipation
22.	Diode Pd	9.596 W	Power	Diode power dissipation
23.	IC Pd	311.57 mW	Power	IC power dissipation
24.	L Pd	522.22 mW	Power	Inductor power dissipation
25.	M1 Pd	1.739 W	Power	M1 MOSFET total power dissipation
26.	M1 PdCond	132.07 mW	Power	M1 MOSFET conduction losses
27.	M1 PdSw	1.607 W	Power	M1 MOSFET switching losses
28.	Total Pd	12.856 W	Power	Total Power Dissipation
29.	BOM Count	26	System Information	Total Design BOM count

#	Name	Value	Category	Description
30.	Duty Cycle	8.607 %	System Information	Duty cycle
31.	Efficiency	79.547 %	System Information	Steady state efficiency
32.	FootPrint	859.0 mm^2	System Information	Total Foot Print Area of BOM components
33.	Frequency	524.549 kHz	System Information	Switching frequency
34.	Iout	10.0 A	System Information	Iout operating point
35.	Mode	CCM	System Information	Conduction Mode
36.	Pout	50.0 W	System Information	Total output power
37.	Total BOM	$8.94	System Information	Total BOM Cost
38.	Vin	70.0 V	System Information	Vin operating point
39.	Vout	5.0 V	System Information	Operational Output Voltage
40.	Vout Actual	4.999 V	System Information	Vout Actual calculated based on selected voltage divider resistors
41.	Vout Tolerance	3.05 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
42.	Vout p-p	24.883 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	10.0	Maximum Output Current
VinMax	70.0	Maximum input voltage
VinMin	12.0	Minimum input voltage
Vout	5.0	Output Voltage
base_pn	LM5088	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature

WEBENCH® Assembly

Component Testing

Some published data on components in datasheets such as Capacitor ESR and Inductor DC resistance is based on conservative values that will guarantee that the components always exceed the specification. For design purposes it is usually better to work with typical values. Since this data is not always available it is a good practice to measure the Capacitance and ESR values of Cin and Cout, and the inductance and DC resistance of L1 before assembly of the board. Any large discrepancies in values should be electrically simulated in WEBENCH to check for instabilities and thermally simulated in WebTHERM to make sure critical temperatures are not exceeded.

Soldering Component to Board

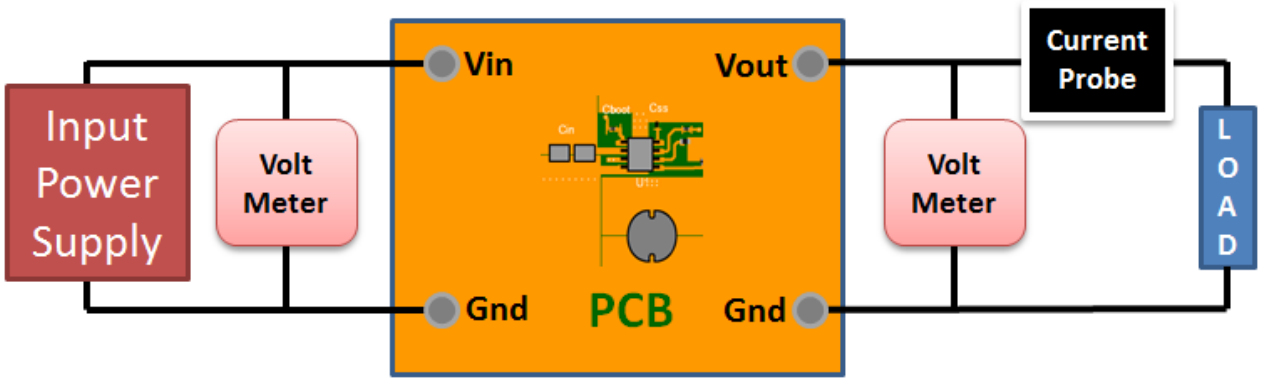
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab town to the board place the iron down on the board while resting against the tab, heating both surfaces simultaneously. Apply light pressure to the top of the plastic case until the solder flows around the part and the part is flush with the PCB. If the solder is not flowing around the board you may need a higher wattage iron (generally 25W to 30W is enough).

Initial Startup of Circuit

It is best to initially power up the board by setting the input supply voltage to the lowest operating input voltage 12.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

Load Testing

The setup is the same as the initial startup, except that an additional digital voltmeter is connected between Vin and GND, a load is connected between Vout and GND and a current meter is connected in series between Vout and the load. The load must be able to handle at least rated output power + 50% (7.5 watts for this design). Ideally the load is supplied in the form of a variable load test unit. It can also be done in the form of suitably large power resistors. When using an oscilloscope to measure waveforms on the prototype board, the ground leads of the oscilloscope probes should be as short as possible and the area of the loop formed by the ground lead should be kept to a minimum. This will help reduce ground lead inductance and eliminate EMI noise that is not actually present in the circuit.

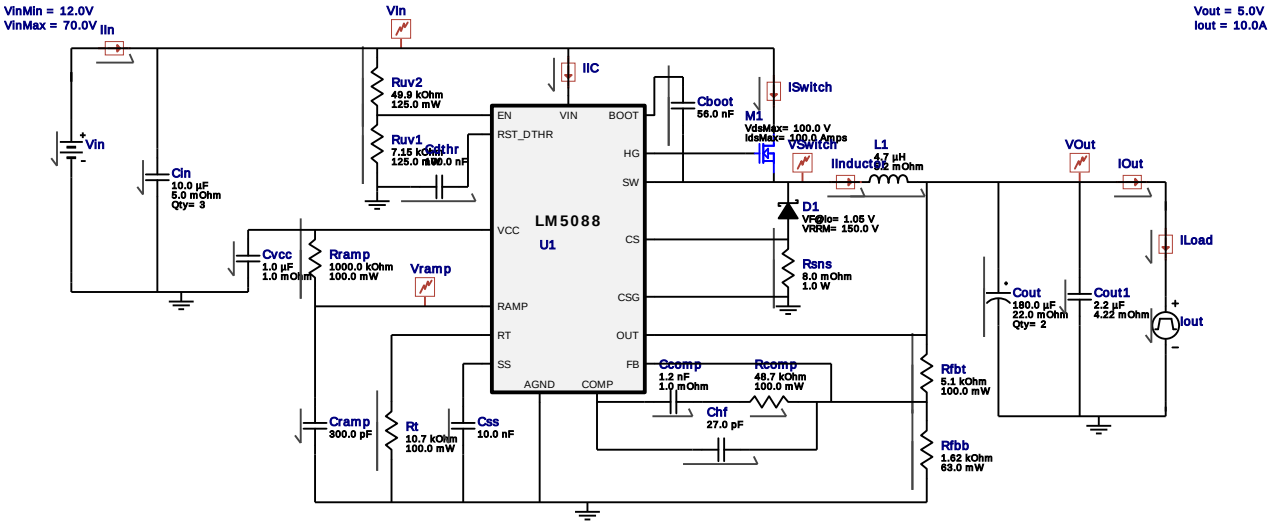


WEBENCH® Electrical Simulation Report

Design Id = 21

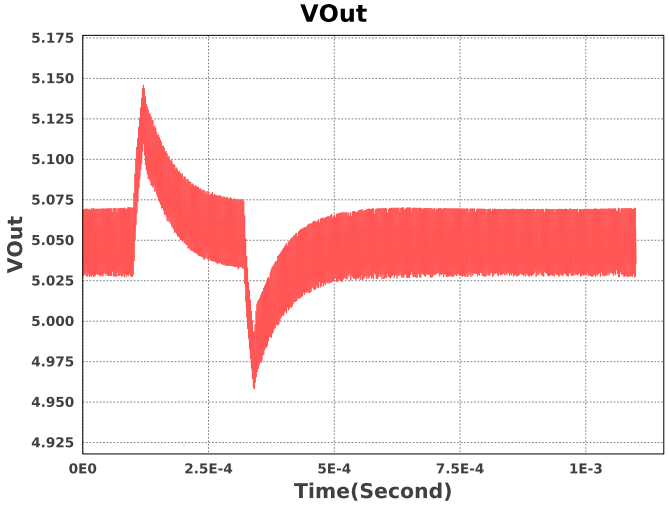
sim_id = 1

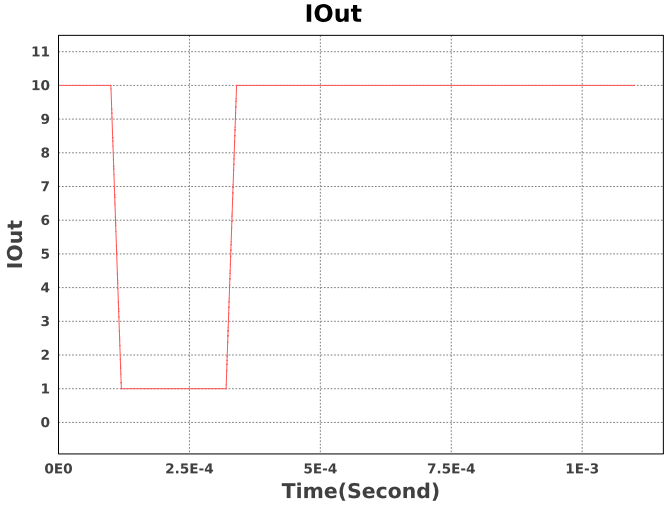
Simulation Type = Load Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	L1	IC	Initial Condition through the inductor	10.0 A
2.	Cvcc	IC	Initial Condition across the capacitor	7.7 V
3.	Cin	IC	Initial Condition Across Cin	41.0 V
4.	Rramp	R	Default Resistance	1000000.0 Ohm
5.	Cout	IC	Initial Condition	5
6.	Css	IC	Initial Condition across the capacitor	1.225 V
7.	Iout	signal type	Signal Type	PULSE
		signal_type	Signal Type	PULSE
		I1	Initial Load Current	10.0 A
		I2	Minimum Load Current	1.0 A
		Td	Initial Time Delay	100u S
		Tf	Fall Time	20u s
		Tr	Rise Time	20u s
		Pw	Pulse Width	200u s

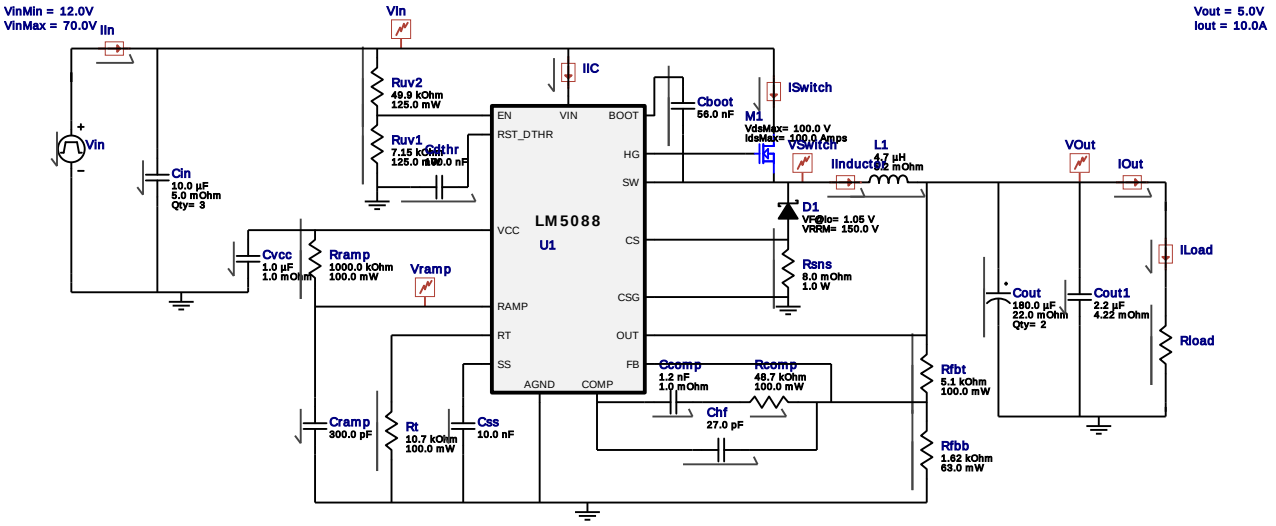




Design Id = 21

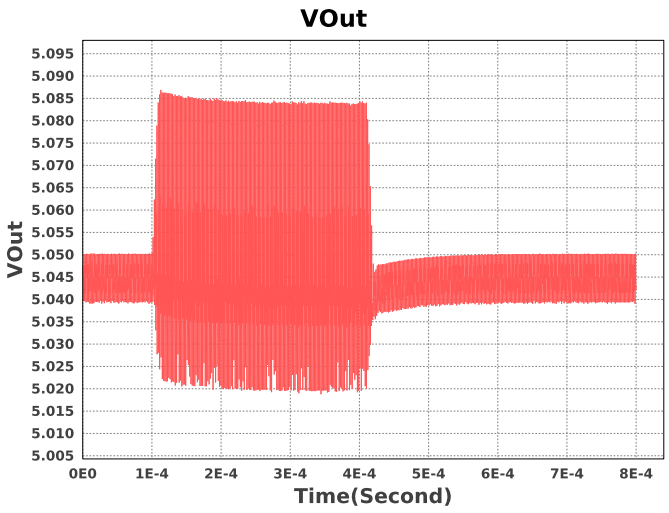
sim_id = 2

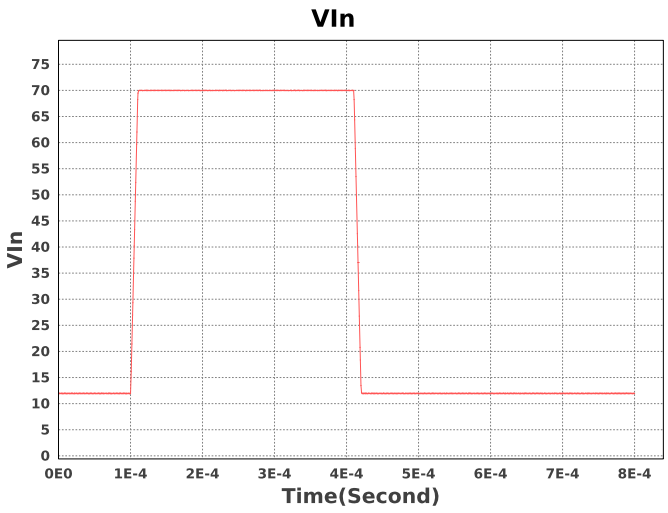
Simulation Type = Input Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	L1	IC	Initial Current	10.0 A
2.	Cvcc	IC	Initial Condition across the capacitor	7.7 V
3.	Cin	IC	Initial Condition Across Cin	12.0 V
4.	Rramp	R	Default Resistance	1.00E+10 Ohm
5.	Cout	IC	Initial Condition Across Cout	0 V
6.	Css	IC	Initial Condition across the capacitor	1.205 V
7.	Rload	R	Load Resistance	0.5 ohm

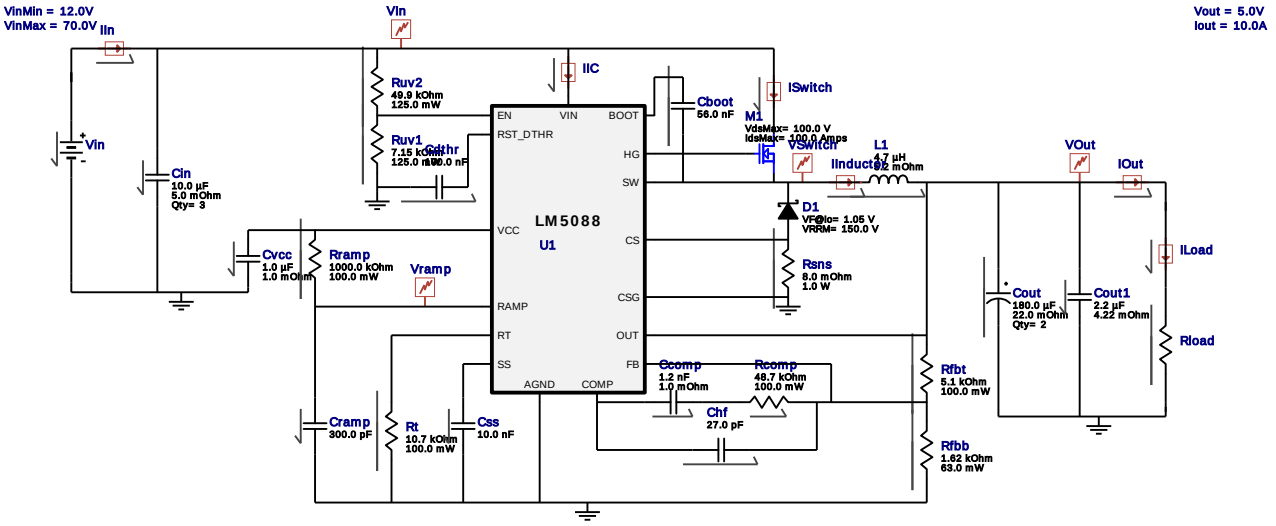




Design Id = 21

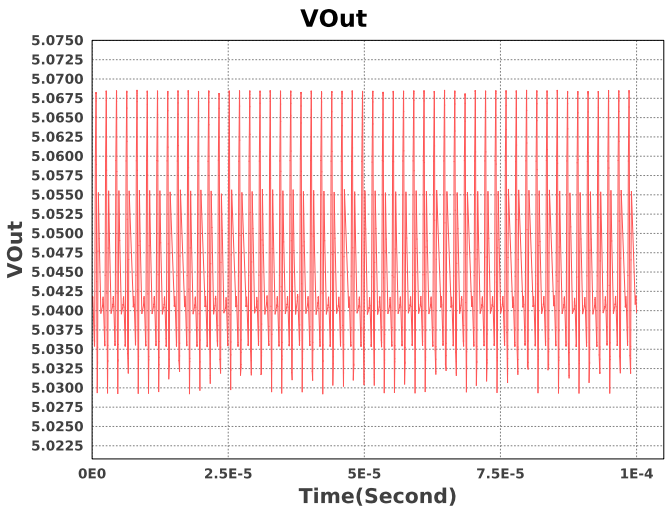
sim_id = 3

Simulation Type = Steady State



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	L1	IC	Initial Current	10.0 A
2.	Cvcc	IC	Initial Condition across the capacitor	7.7 V
3.	Cin	IC	Initial Condition Across Cin	41.0 V
4.	Rramp	R	Default Resistance	1.00E+10 Ohm
5.	Cout	IC	Initial Condition	0 V
6.	Css	IC	Initial Condition across the capacitor	1.205 V
7.	Rload	R	Load Resistance	0.5 ohm



Design Assistance

1. Master key : A269AB43473AAA080D5C89E8DA3313AD[v1]
2. **LM5088** Product Folder : http://www.ti.com/product/LM5088 : contains the data sheet and other resources.