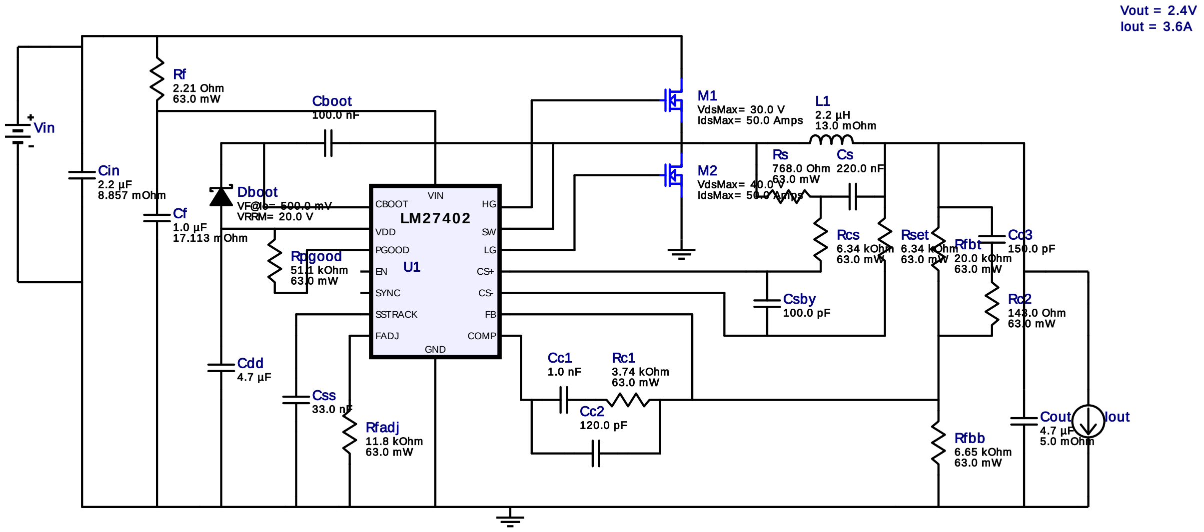
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 12.0V
VinMax = 18.0V
Vout = 2.4V
Iout = 3.6A

Device = LM27402SQ/NOPB
Topology = Buck
Created = 8/9/16 2:31:11 AM
BOM Cost = $2.31
BOM Count = 26
Total Pd = 1.38W

Design : 4763576/6 LM27402SQ/NOPB
LM27402SQ/NOPB 12.0V-18.0V to 2.40V @ 3.6A

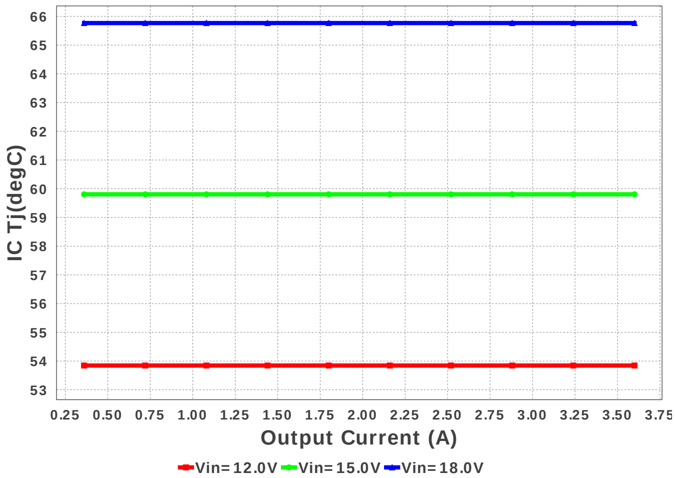


Electrical BOM

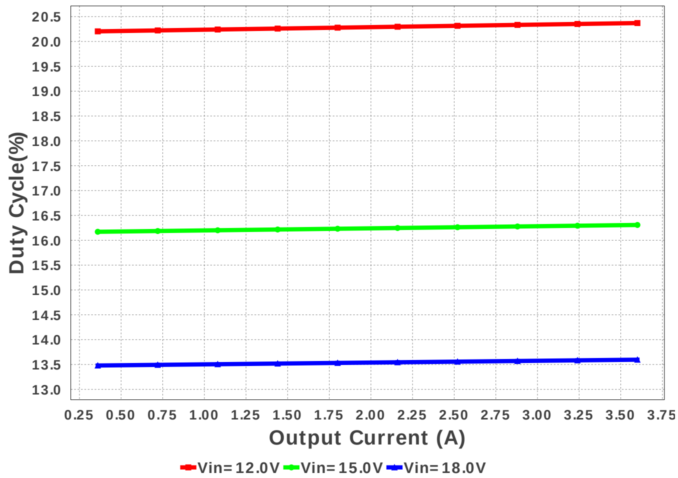
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Cboot	MuRata	GRM155R61C104KA88D Series= X5R	Cap= 100.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
2.	Cc1	Samsung Electro-Mechanics	CL21C102JBCNFNC Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
3.	Cc2	Samsung Electro-Mechanics	CL21C121JB61PNC Series= C0G/NP0	Cap= 120.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
4.	Cc3	TDK	C2012C0G1H151J Series= C0G/NP0	Cap= 150.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
5.	Cdd	Taiyo Yuden	LMK212BJ475KD-T Series= X5R	Cap= 4.7 uF VDC= 10.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm²
6.	Cf	MuRata	GRM188R61E105KA12D Series= X5R	Cap= 1.0 uF ESR= 17.113 mOhm VDC= 25.0 V IRMS= 979.39 mA	1	$0.01	0603 5 mm²
7.	Cin	MuRata	GRM21BR61E225KA12L Series= X5R	Cap= 2.2 uF ESR= 8.857 mOhm VDC= 25.0 V IRMS= 1.3111 A	1	$0.04	0805 7 mm²
8.	Cout	MuRata	GRM188R60J475KE19D Series= X5R	Cap= 4.7 uF ESR= 5.0 mOhm VDC= 6.3 V IRMS= 2.0 A	1	$0.01	0603 5 mm²
9.	Cs	MuRata	GRM155R71C224KA12D Series= X7R	Cap= 220.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²

#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
10.	Csby	MuRata	GRM0335C1E101JA01D Series= C0G/NP0	Cap= 100.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
11.	Css	MuRata	GRM033R60J333KE01D Series= X5R	Cap= 33.0 nF VDC= 6.3 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
12.	Dboot	Diodes Inc.	B220-13-F	VF@Io= 500.0 mV VRRM= 20.0 V	1	$0.08	SMB 44 mm^2
13.	L1	Bourns	SRN8040-2R2Y	L= 2.2 µH DCR= 13.0 mOhm	1	$0.22	SRN8040 100 mm^2
14.	M1	Texas Instruments	CSD17308Q3	VdsMax= 30.0 V IdsMax= 50.0 Amps	1	$0.28	TRANS_NexFET_Q3 18 mm^2
15.	M2	Texas Instruments	CSD18504Q5A	VdsMax= 40.0 V IdsMax= 50.0 Amps	1	$0.37	TRANS_NexFET_Q5A 55 mm^2
16.	Rc1	Vishay-Dale	CRCW04023K74FKED Series= CRCW..e3	Res= 3.74 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
17.	Rc2	Vishay-Dale	CRCW0402143RFKED Series= CRCW..e3	Res= 143.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
18.	Rcs	Vishay-Dale	CRCW04026K34FKED Series= CRCW..e3	Res= 6.34 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
19.	Rf	Vishay-Dale	CRCW04022R21FKED Series= CRCW..e3	Res= 2.21 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
20.	Rfadj	Vishay-Dale	CRCW040211K8FKED Series= CRCW..e3	Res= 11.8 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
21.	Rfbb	Vishay-Dale	CRCW04026K65FKED Series= CRCW..e3	Res= 6.65 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
22.	Rfbt	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
23.	Rpgood	Vishay-Dale	CRCW040251K1FKED Series= CRCW..e3	Res= 51.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
24.	Rs	Vishay-Dale	CRCW0402768RFKED Series= CRCW..e3	Res= 768.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
25.	Rset	Vishay-Dale	CRCW04026K34FKED Series= CRCW..e3	Res= 6.34 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
26.	U1	Texas Instruments	LM27402SQ/NOPB	Switcher	1	$1.10	SQB16A 25 mm^2

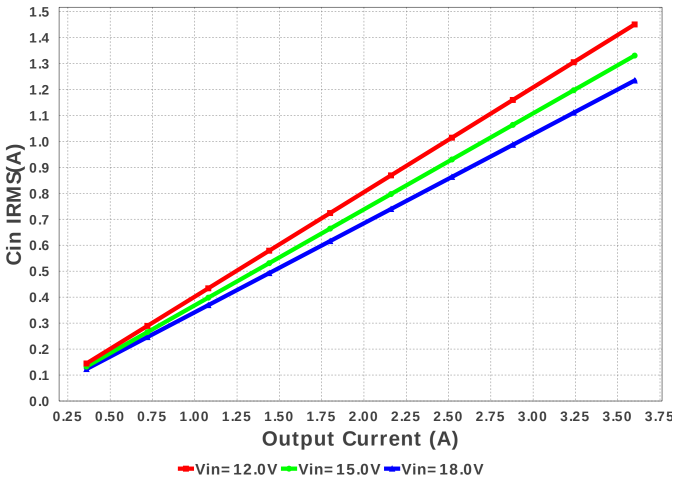
IC Tj



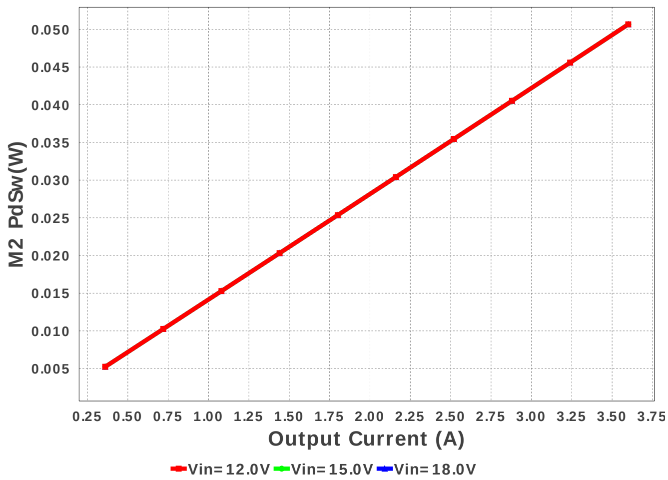
Duty Cycle



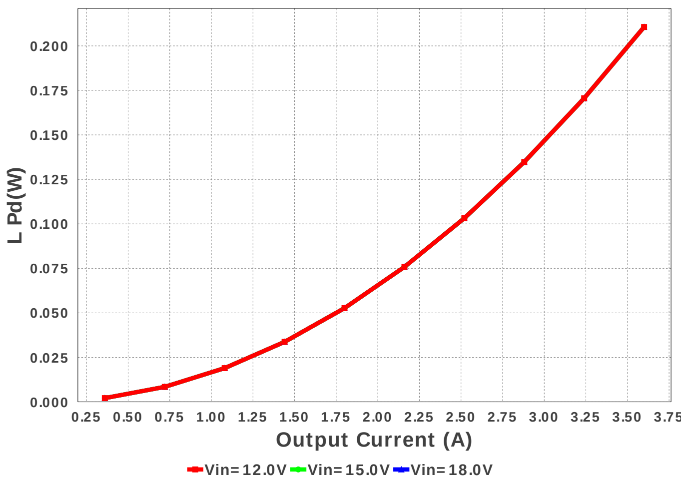
Cin IRMS



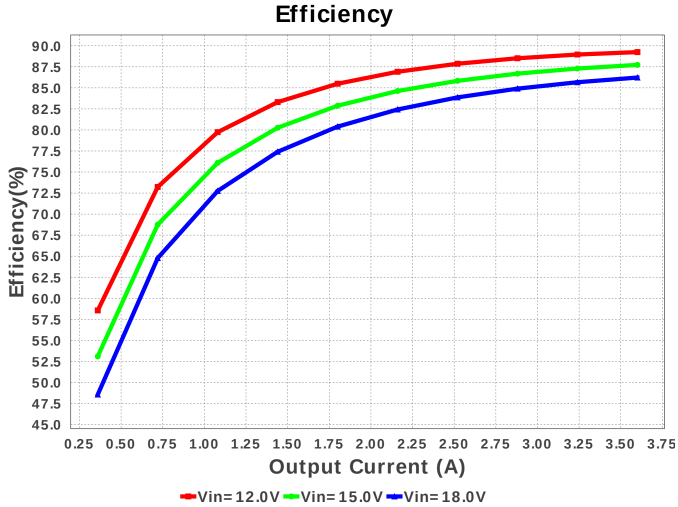
M2 PdSw

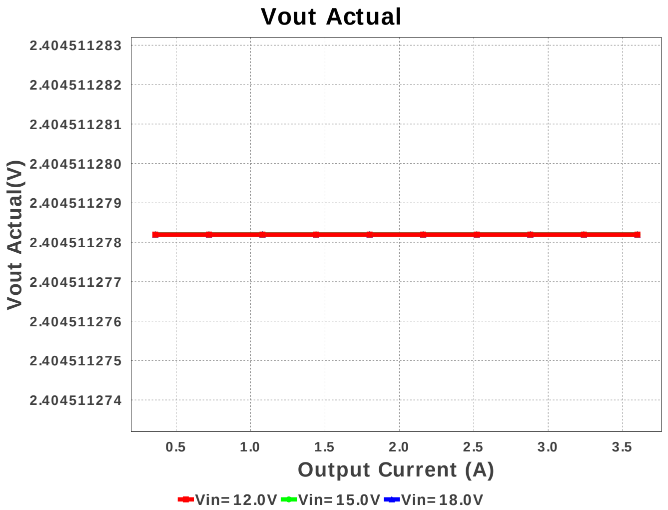


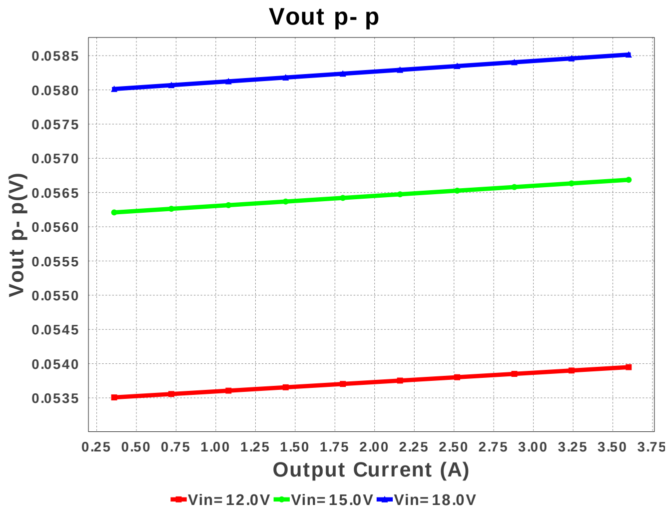
L Pd

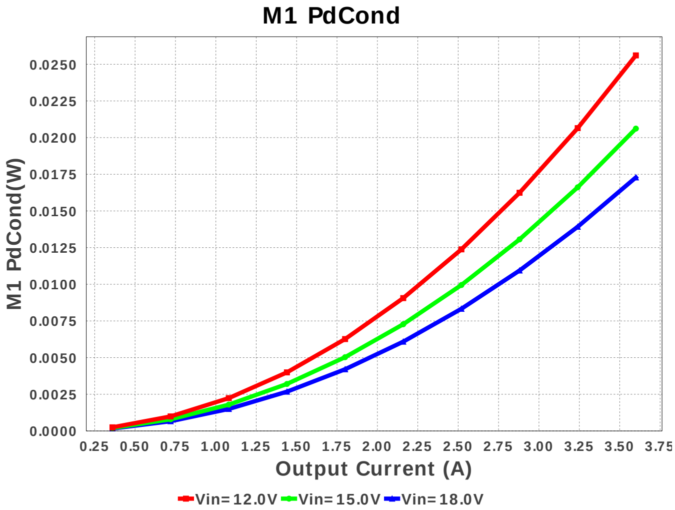


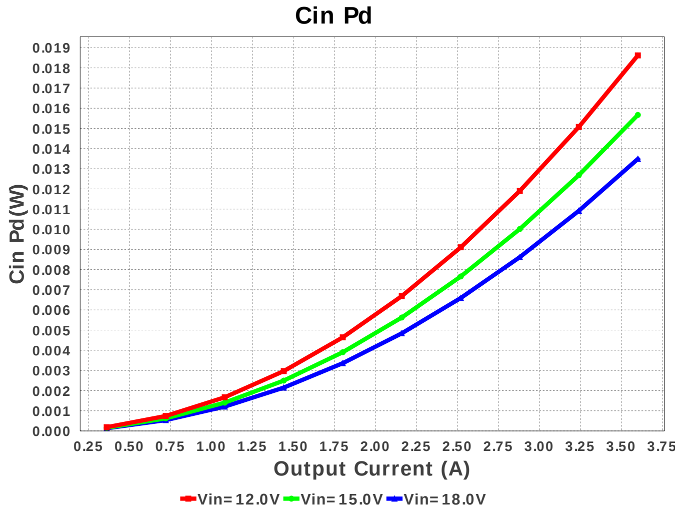
Efficiency

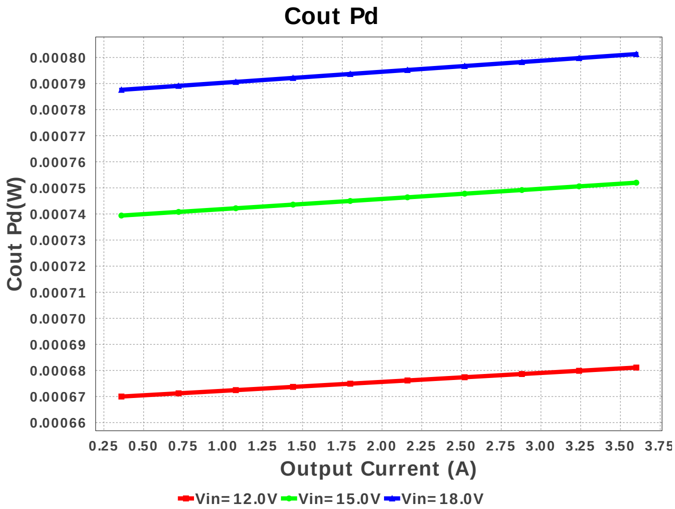


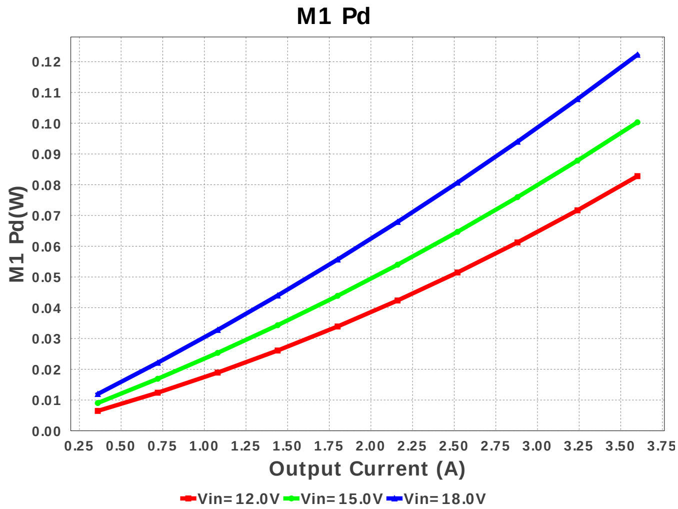

Vout Actual
Vout Actual(V)
2.404511283
2.404511282
2.404511281
2.404511280
2.404511279
2.404511278
2.404511277
2.404511276
2.404511275
2.404511274
0.5 1.0 1.5 2.0 2.5 3.0 3.5
Output Current (A)
Vin=12.0V Vin=15.0V Vin=18.0V

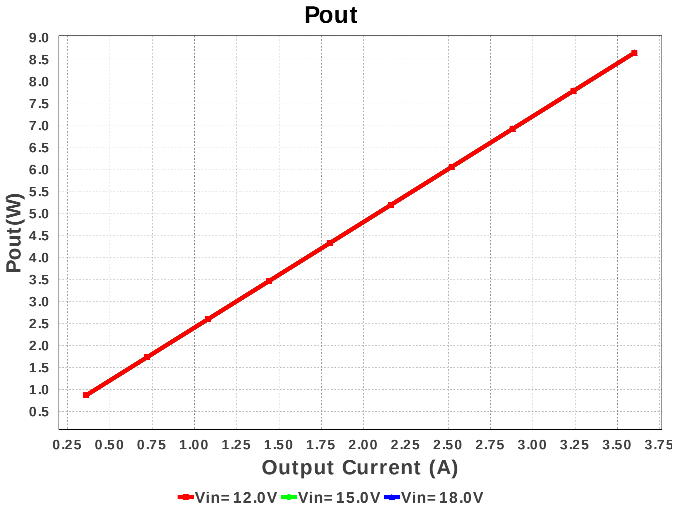

Vout p-p
Vout p-p(V)
0.0585
0.0580
0.0575
0.0570
0.0565
0.0560
0.0555
0.0550
0.0545
0.0540
0.0535
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75
Output Current (A)
Vin=12.0V Vin=15.0V Vin=18.0V

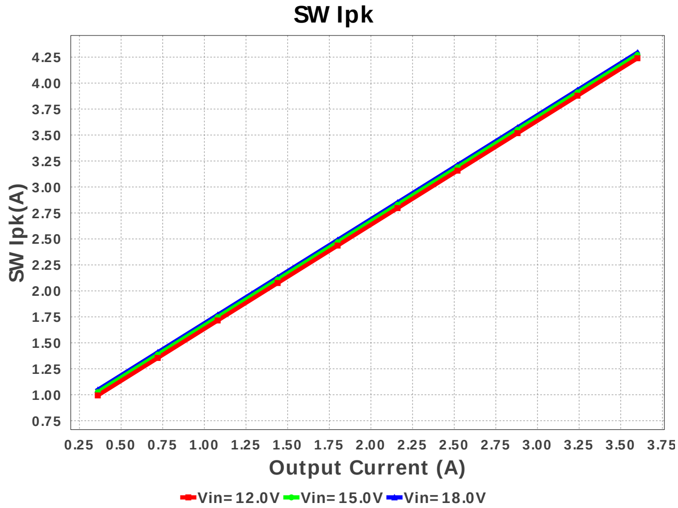

M1 PdCond
M1 PdCond(W)
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75
Output Current (A)
Vin=12.0V Vin=15.0V Vin=18.0V

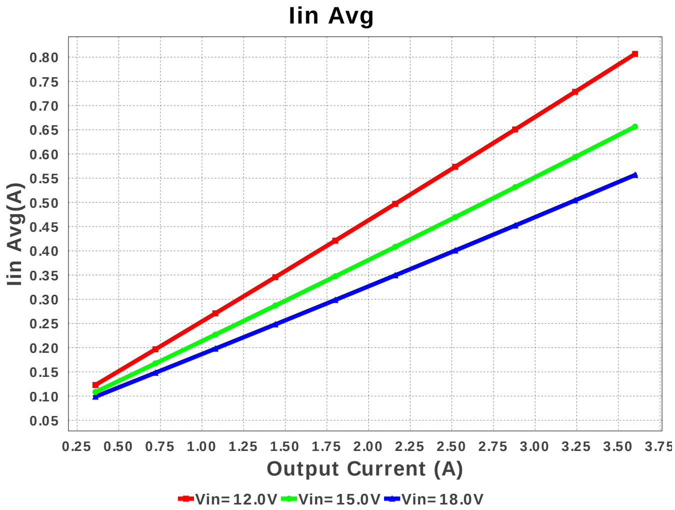

Cin Pd
Cin Pd(W)
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75
Output Current (A)
Vin=12.0V Vin=15.0V Vin=18.0V

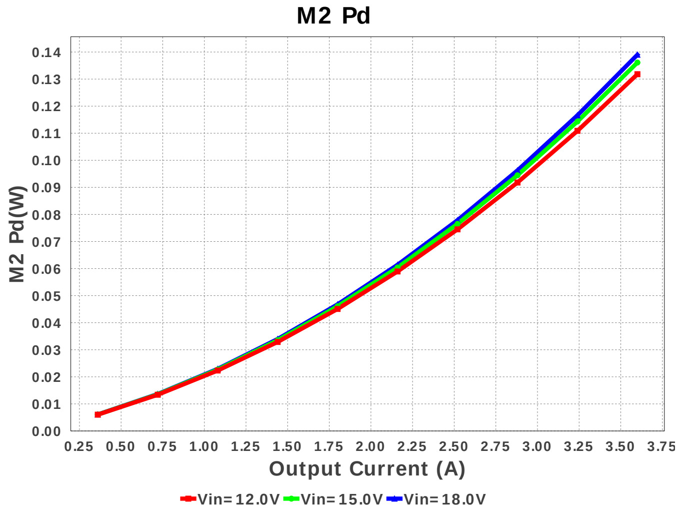

Cout Pd
Cout Pd(W)
0.00080
0.00079
0.00078
0.00077
0.00076
0.00075
0.00074
0.00073
0.00072
0.00071
0.00070
0.00069
0.00068
0.00067
0.00066
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75
Output Current (A)
Vin=12.0V Vin=15.0V Vin=18.0V

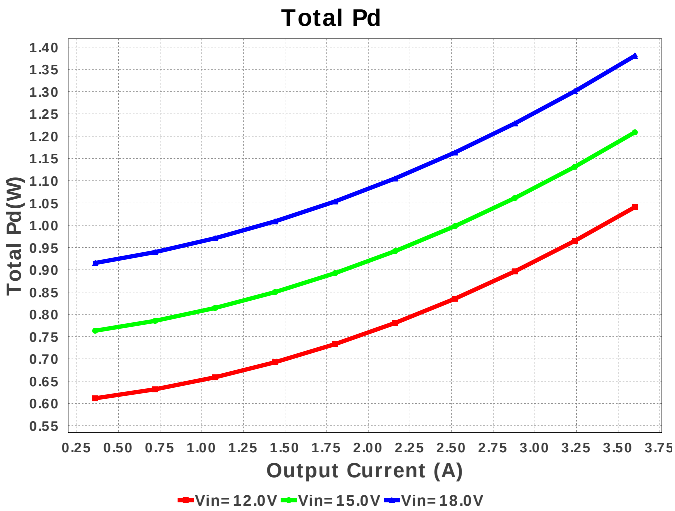

M1 Pd
M1 Pd(W)
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75
Output Current (A)
Vin=12.0V Vin=15.0V Vin=18.0V

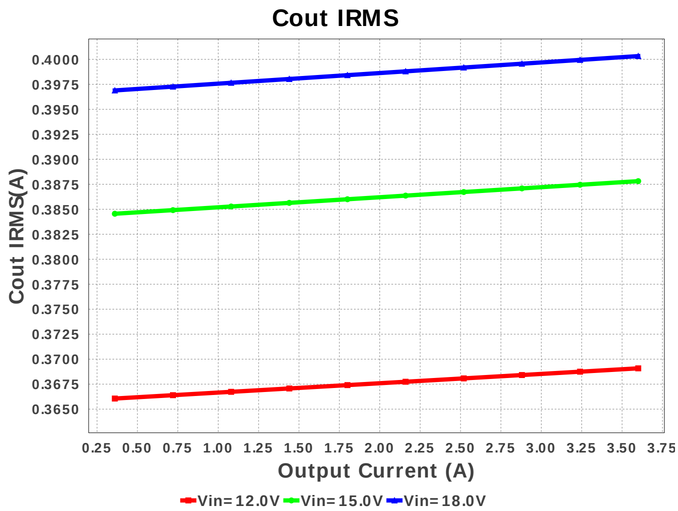

Pout
Pout(W)
Output Current (A)
Vin=12.0V
Vin=15.0V
Vin=18.0V


SW Ipk
SW Ipk(A)
Output Current (A)
Vin=12.0V
Vin=15.0V
Vin=18.0V

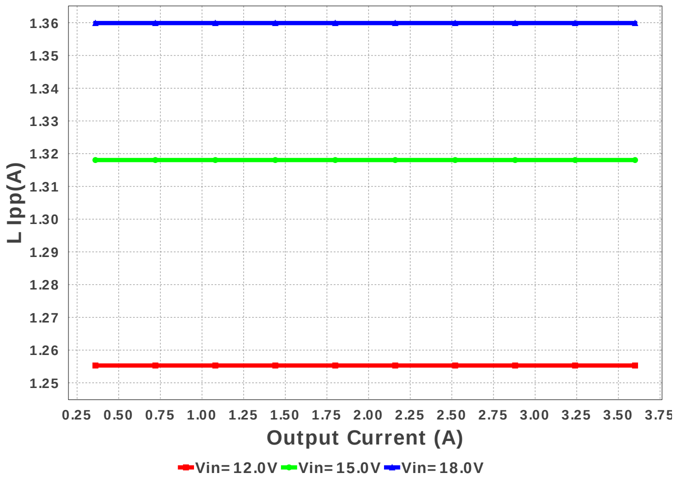

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=12.0V
Vin=15.0V
Vin=18.0V


M2 Pd
M2 Pd(W)
Output Current (A)
Vin=12.0V
Vin=15.0V
Vin=18.0V

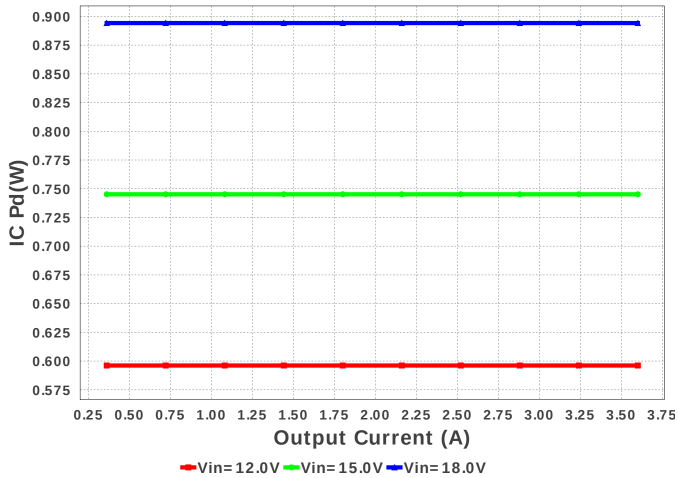

Total Pd
Total Pd(W)
Output Current (A)
Vin=12.0V
Vin=15.0V
Vin=18.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=12.0V
Vin=15.0V
Vin=18.0V

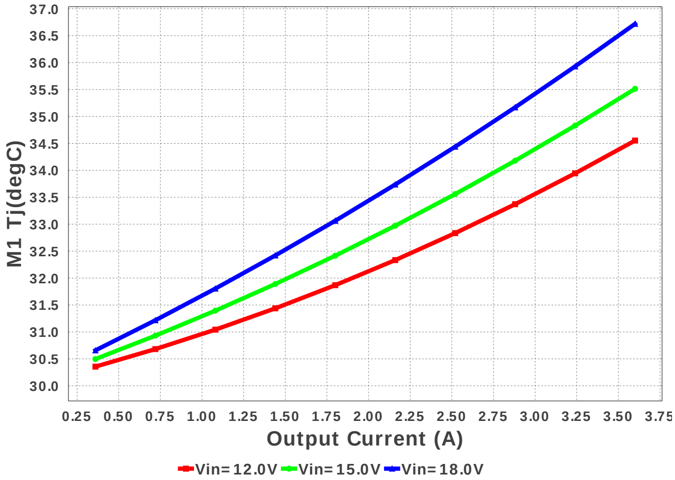
L Ipp



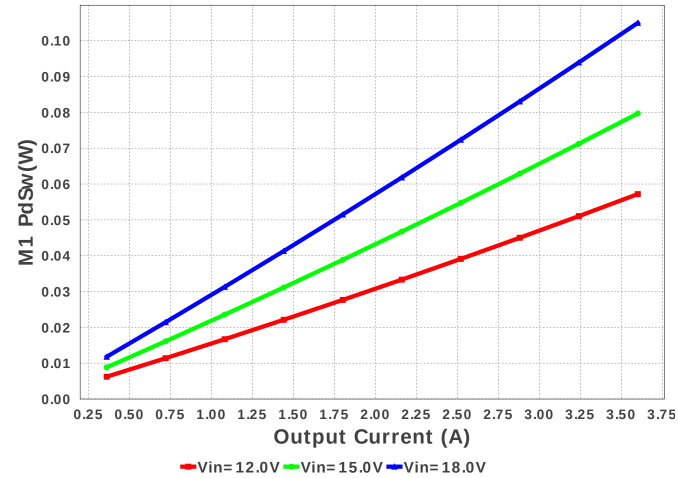
IC Pd



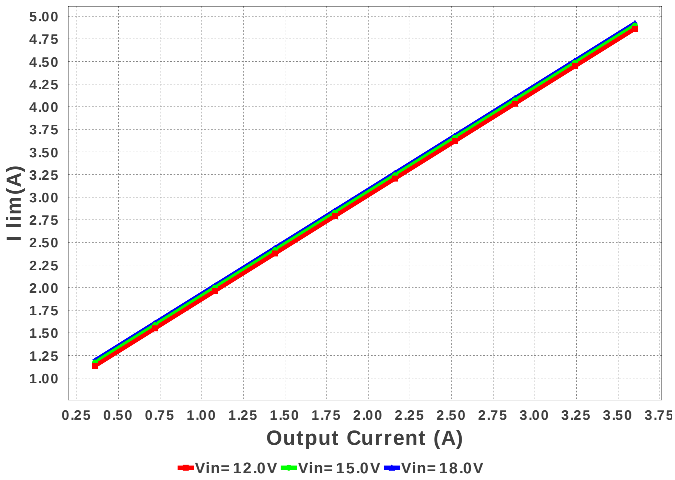
M1 Tj



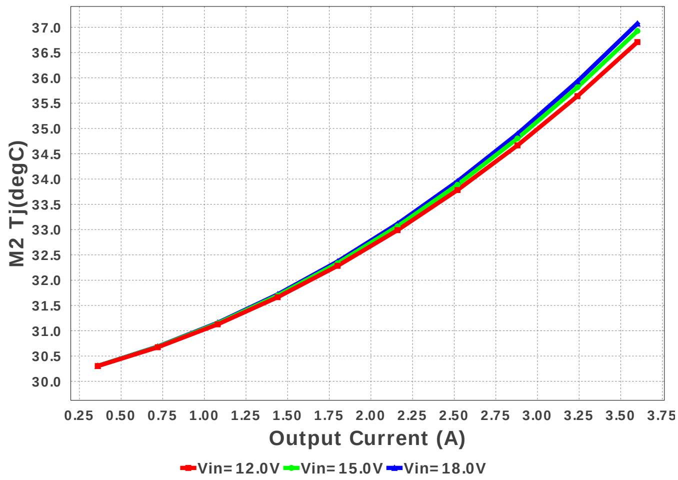
M1 PdSw

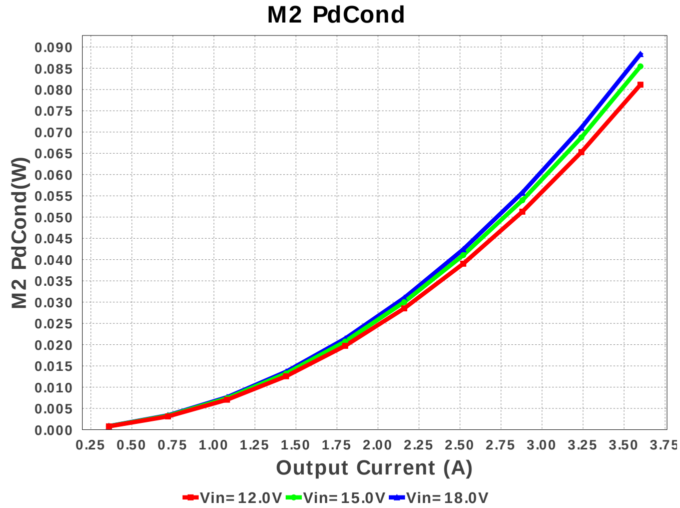


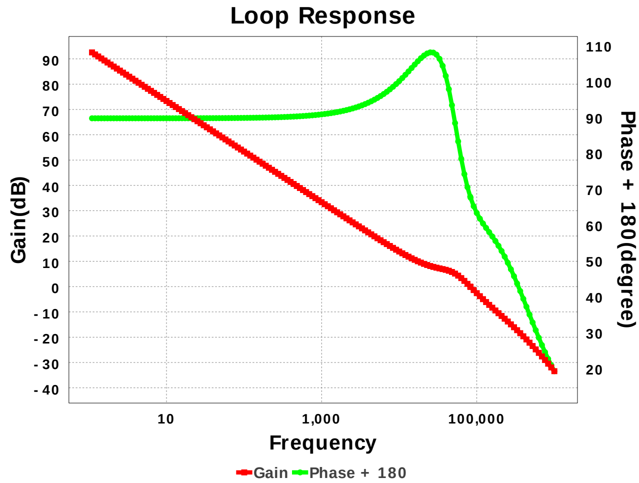
I lim



M2 Tj







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.234 A	Current	Input capacitor RMS ripple current
2.	Cout IRMS	400.324 mA	Current	Output capacitor RMS ripple current
3.	I lim	4.922 A	Current	Current limit threshold
4.	Iin Avg	556.69 mA	Current	Average input current
5.	L Ipp	1.387 A	Current	Peak-to-peak inductor ripple current
6.	SW Ipk	4.293 A	Current	Peak switch current
7.	BOM Count	26	General	Total Design BOM count
8.	FootPrint	326.0 mm^2	General	Total Foot Print Area of BOM components
9.	Frequency	695.238 kHz	General	Switching frequency
10.	IC Tolerance	6.0 mV	General	IC Feedback Tolerance
11.	Pout	8.64 W	General	Total output power
12.	Total BOM	$2.31	General	Total BOM Cost
13.	Low Freq Gain	92.559 dB	Op_Point	Gain at 10Hz
14.	Vout Actual	2.405 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
15.	Cross Freq	82.32 kHz	Op_point	Bode plot crossover frequency
16.	Duty Cycle	13.597 %	Op_point	Duty cycle
17.	Efficiency	86.225 %	Op_point	Steady state efficiency
18.	Gain Marg	-45.235 dB	Op_point	Bode Plot Gain Margin
19.	IC Tj	65.768 degC	Op_point	IC junction temperature
20.	IOUT_OP	3.6 A	Op_point	Iout operating point
21.	M1 Tj	36.719 degC	Op_point	M1 MOSFET junction temperature
22.	M2 Tj	37.073 degC	Op_point	M2 MOSFET junction temperature
23.	Phase Marg	68.149 deg	Op_point	Bode Plot Phase Margin
24.	VIN_OP	18.0 V	Op_point	Vin operating point
25.	Vout p-p	58.515 mV	Op_point	Peak-to-peak output ripple voltage
26.	Cin Pd	13.485 mW	Power	Input capacitor power dissipation
27.	Cout Pd	801.298 µW	Power	Output capacitor power dissipation
28.	IC Pd	894.199 mW	Power	IC power dissipation
29.	L Pd	210.6 mW	Power	Inductor power dissipation
30.	M1 Pd	122.253 mW	Power	M1 MOSFET total power dissipation
31.	M1 PdCond	17.289 mW	Power	M1 MOSFET conduction losses
32.	M1 PdSw	104.964 mW	Power	M1 MOSFET switching losses
33.	M2 Pd	139.013 mW	Power	M2 MOSFET total power dissipation
34.	M2 PdCond	88.35 mW	Power	M2 MOSFET conduction losses
35.	M2 PdSw	50.663 mW	Power	M2 MOSFET switching losses
36.	Total Pd	1.38 W	Power	Total Power Dissipation
37.	Vout Tolerance	2.531 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable

Design Inputs

#	Name	Value	Description
1.	Iout	3.6	Maximum Output Current
2.	VinMax	18.0	Maximum input voltage
3.	VinMin	12.0	Minimum input voltage
4.	Vout	2.4	Output Voltage
5.	base_pn	LM27402	Base Product Number
6.	source	DC	Input Source Type
7.	Ta	30.0	Ambient temperature

Design Assistance

1. Tip: LM27402 High Current PCB Layout Design Guidance For higher current designs, please take care in designing the PCB layout. Consider good thermal management practices and proper routing of traces. Please see the following for more guidelines. Best Layout Practices for Switching Power Supplies http://sva.ti.com/assets/en/appnotes/national_power_designer114.pdf SIMPLE SWITCHER Layout Guidelines http://www.ti.com/lit/an/snva054c/snva054c.pdf Thermal Design by Insight, not Hindsight http://www.ti.com/lit/an/snva419c/snva419c.pdf

2. General Description: The LM27402 is a synchronous voltage mode buck controller with inductor DCR current sense capability. Sensing the inductor current eliminates the need to add resistive powertrain elements which increases overall efficiency and allows for accurate continuous current limit sensing. A 0.6V +/-1% voltage reference permits high accuracy and low voltage capability at the output. An operating voltage range of 3V to 20V makes the LM27402 suitable for a large variety of input rails. The LM27402 voltage mode control loop incorporates input voltage feed-forward to maintain stability throughout the entire input voltage range. The switching frequency is adjustable from 200 kHz to 1.2 MHz allowing a flexible design space. A power good indicator provides power rail sequencing capability and output fault detection. Programmable external softstart capability limits inrush current and provides monotonic output control at startup. Other features include external tracking of other power supplies, integrated LDO bias supply, and synchronization capability.

3. General Description: The LM27402 is offered in a 16 pin eTSSOP package and a 4mm x 4mm 16 pin exposed LLP.

4. **LM27402** Product Folder : http://www.ti.com/product/LM27402 : contains the data sheet and other resources.