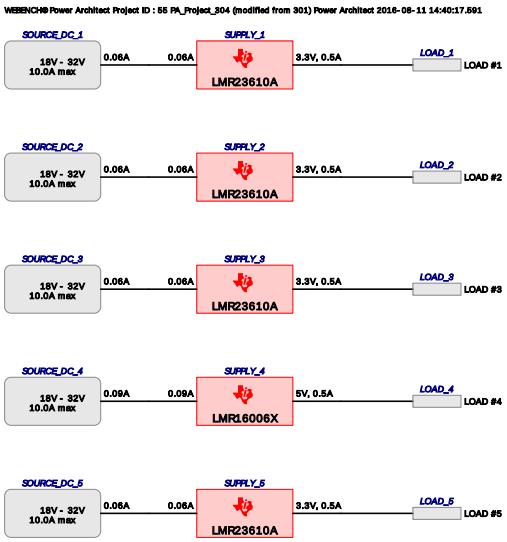
WEBENCH® Power Architect



Project Report

Project : 921712/55 : PA_Project_304 (modified from 301)
Created : 2016-08-11 14:40:17.591
Optimize project optFactor=3

Project Summary

1.	Total System Efficiency	86.905 %
2.	Total System BOM Count	45.0
3.	Total System Footprint	831.0 mm2
4.	Total System BOM Cost	$9.27
5.	Total System Power Dissipation	1.379 W

--> Launch WEBENCH Power Architect.

Sequencer Flag Table

Supply	Sequencer Flag	Load	Load Name
SUPPLY_1	0	LOAD_1	LOAD #1
SUPPLY_2	0	LOAD_2	LOAD #2
SUPPLY_3	0	LOAD_3	LOAD #3
SUPPLY_4	0	LOAD_4	LOAD #4
SUPPLY_5	0	LOAD_5	LOAD #5

Power Supplies

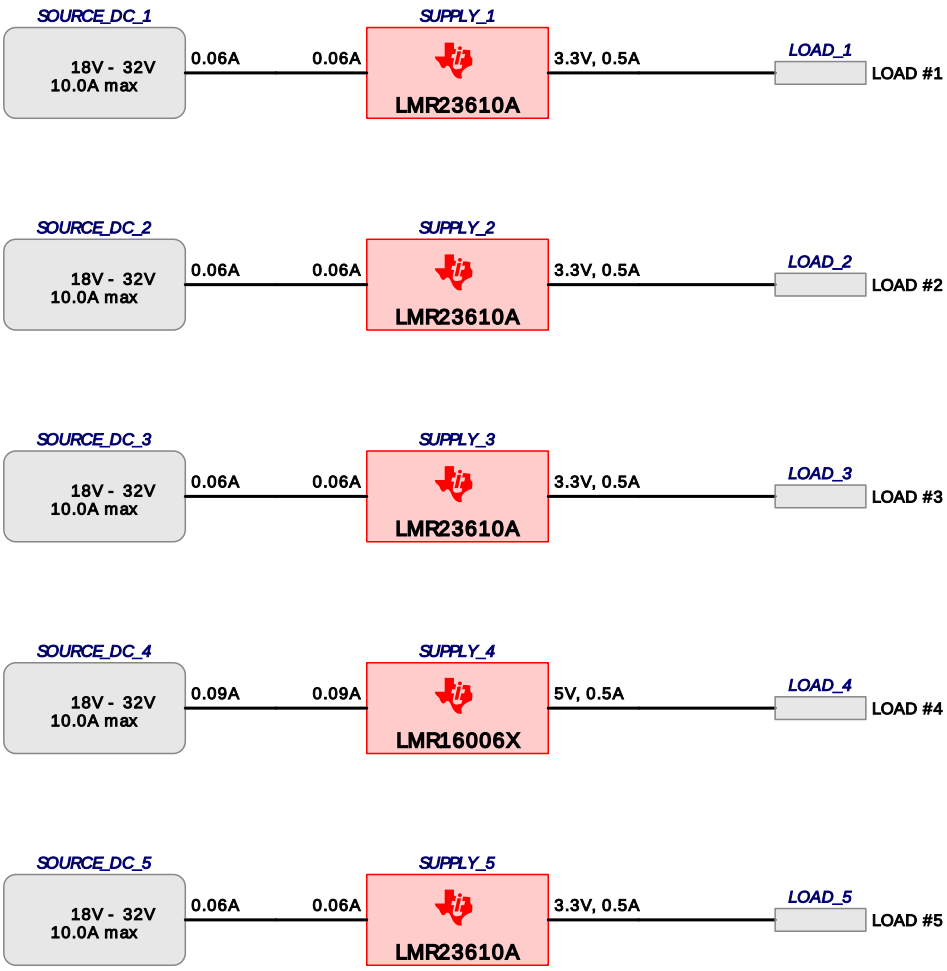
#	Name	NSID	Description	Vout	Iout	Efficiency	Foot-print	Cost	Design	Page
1.	SUPPLY_1	LMR23610A	Switcher : SIMPLE SWITCHER Step-Down Converter	3.3 V	0.5 A	87.1%	175	$1.89	278	4
2.	SUPPLY_2	LMR23610A	Switcher : SIMPLE SWITCHER Step-Down Converter	3.3 V	0.5 A	87.1%	175	$1.89	279	9
3.	SUPPLY_3	LMR23610A	Switcher : SIMPLE SWITCHER Step-Down Converter	3.3 V	0.5 A	87.1%	175	$1.89	280	14
4.	SUPPLY_4	LMR16006X	Switcher : SIMPLE SWITCHER Wide Vin Buck Regulator	5 V	0.5 A	86.2%	131	$1.71	281	19
5.	SUPPLY_5	LMR23610A	Switcher : SIMPLE SWITCHER Step-Down Converter	3.3 V	0.5 A	87.1%	175	$1.89	282	25

Power Loads

#	Name	VLoad	ILoad	Description
1.	LOAD #1	3.3 V	0.5 A	VoutRipple=10%
2.	LOAD #2	3.3 V	0.5 A	VoutRipple=10%
3.	LOAD #3	3.3 V	0.5 A	VoutRipple=10%
4.	LOAD #4	5 V	0.5 A	VoutRipple=10%
5.	LOAD #5	3.3 V	0.5 A	VoutRipple=10%

Project Diagram

WEBENCH® Power Architect Project ID : 55 PA_Project_304 (modified from 301) Power Architect 2016-08-11 14:40:17.591



Electrical Procurement BOM

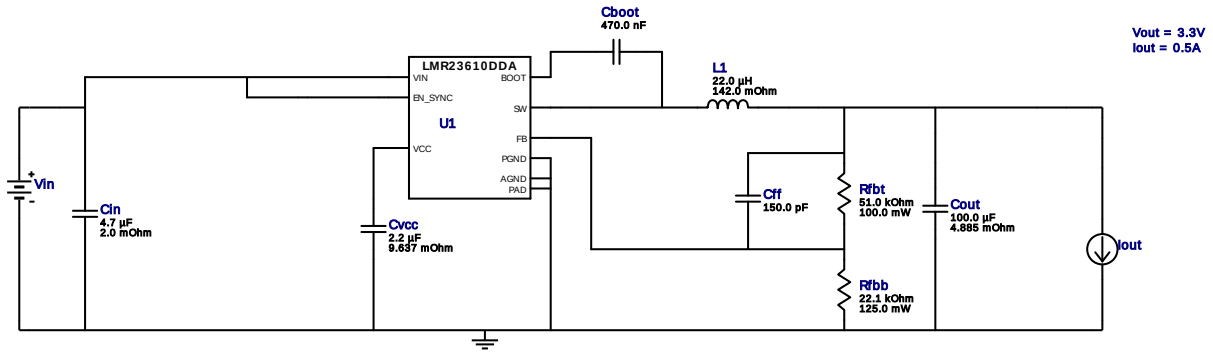
Manufacturer	Part Number	Description	Quantity	Budgetary Price	Footprint (mm^2)
Kemet	C0603C151K3GACTU	0603	4	$0.01	19
Kemet	C0805C104K5RACTU	0805	1	$0.01	7
TDK	C3225X7R2A225K230AB	1210_250	1	$0.19	15
Vishay-Dale	CRCW040257K6FKED	0402	1	$0.01	3
Panasonic	ERJ-6ENF2212V	0805	4	$0.01	27
MuRata	GRM188R60J225KE19D	0603	4	$0.02	19
MuRata	GRM21BR61A106KE19L	0805	2	$0.03	7
MuRata	GRM31CR60J107ME39L	1206_190	4	$0.14	44
MuRata	GRM32ER71H475KA88L	1210	4	$0.19	59
Texas Instruments	LMR16006XDDCR	DDC0006A	1	$1.20	10
Texas Instruments	LMR23610ADDAR	DDA0008E_N	4	$1.30	230
NXP Semiconductor	PMEG6010CEH,115	SOD-123F	1	$0.04	12
Yageo America	RC0603FR-0751KL	0603	4	$0.01	19
Yageo America	RT0805BRD0710K4L	0805	1	$0.04	7
Bourns	SRN6045-220M	SRN6045	4	$0.16	256
Bourns	SRN6045-680M	SRN6045	1	$0.16	64
Taiyo Yuden	UMK212B7474KG-T	0805	4	$0.05	27
Total			45	$9.22	822.3575000000001

WEBENCH® Design Report

Vout = 3.3V
Iout = 0.5A

Device = LMR23610ADDAR
Topology = Buck
Created = 8/11/16 2:40:14 PM
BOM Cost = $1.89
BOM Count = 9
Total Pd = 0.24W

Design : 921712/278 LMR23610ADDAR
LMR23610ADDAR 18.0V-32.0V to 3.30V @ 0.5A



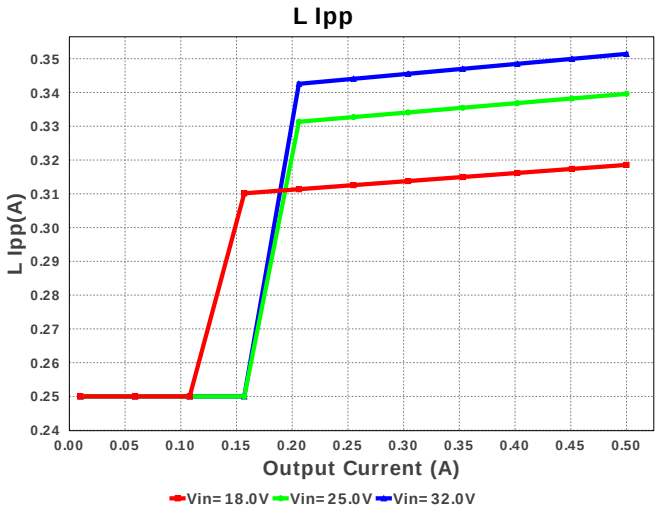
1. The input capacitor included in the BOM only contains a small filter capacitor that should be placed near the IC. Depending on where the power supply is laid out in the system additional bulk capacitance may need to be added to filter the line ripple.

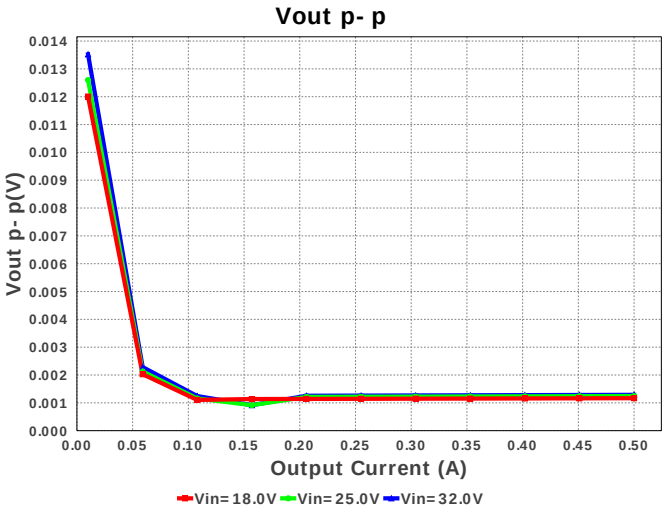
2. If there is no VinTyp specified, WEBENCH will use the VinMax value. To change the VinTyp value, click on the "Change Design Inputs" button under the Optimization Tuning knob. In some applications, while the design requires the input voltage to be a wide range, for a majority of the time, it is operating at a much lower voltage than the maximum input voltage. Sizing the inductor based on the maximum input voltage may yield an inductance much larger than typically needed, causing a larger footprint for the overall design. At the same time, components such as the input capacitor must be rated based on the maximum input voltage. WEBENCH now supports the use of this additional input voltage specification.

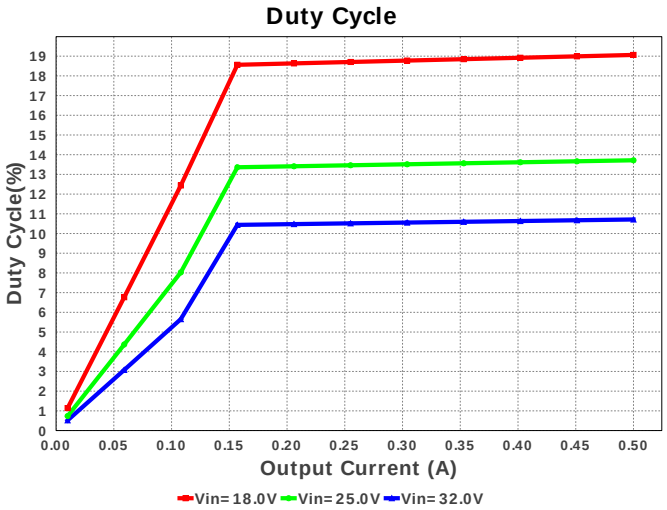
Electrical BOM

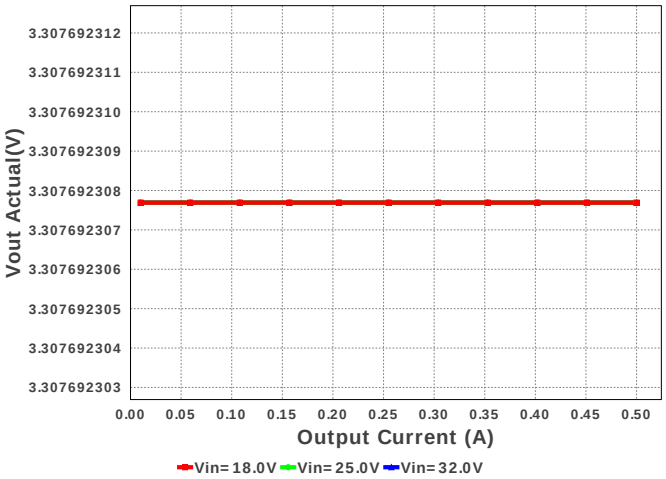
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Cboot	Taiyo Yuden	UMK212B7474KG-T Series= X7R	Cap= 470.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.05	0805 7 mm²
2.	Cff	Kemet	C0603C151K3GACTU Series= C0G/NP0	Cap= 150.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
3.	Cin	MuRata	GRM32ER71H475KA88L Series= X7R	Cap= 4.7 uF ESR= 2.0 mOhm VDC= 50.0 V IRMS= 5.35 A	1	$0.19	1210 15 mm²
4.	Cout	MuRata	GRM31CR60J107ME39L Series= X5R	Cap= 100.0 uF ESR= 4.885 mOhm VDC= 6.3 V IRMS= 4.4118 A	1	$0.14	1206_190 11 mm²
5.	Cvcc	MuRata	GRM188R60J225KE19D Series= X5R	Cap= 2.2 uF ESR= 9.637 mOhm VDC= 6.3 V IRMS= 1.32271 A	1	$0.02	0603 5 mm²
6.	L1	Bourns	SRN6045-220M	L= 22.0 µH DCR= 142.0 mOhm	1	$0.16	SRN6045 64 mm²
7.	Rfbb	Panasonic	ERJ-6ENF2212V Series= ERJ-6E	Res= 22.1 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
8.	Rfbt	Yageo America	RC0603FR-0751KL Series= ?	Res= 51.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²

#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
9.	U1	Texas Instruments	LMR23610ADDAR	Switcher	1	$1.30	DDA0008E_N 57 mm²

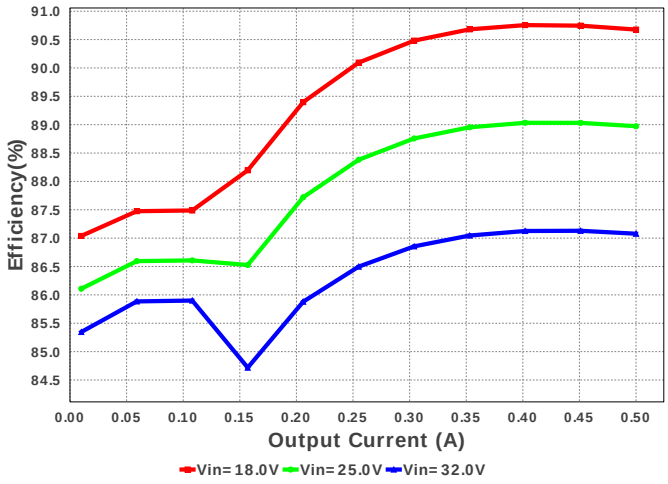




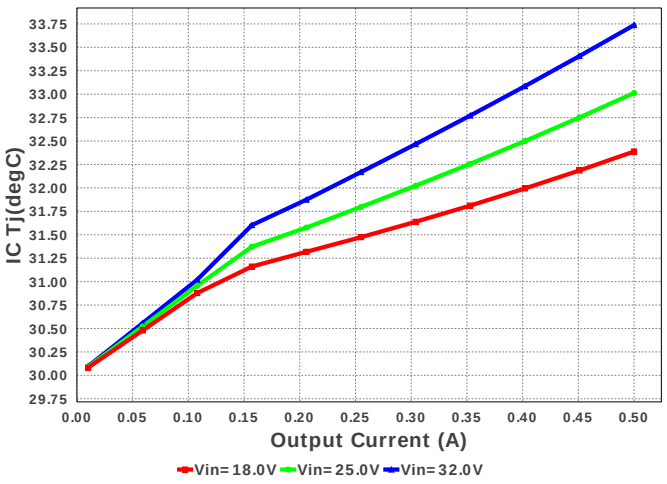




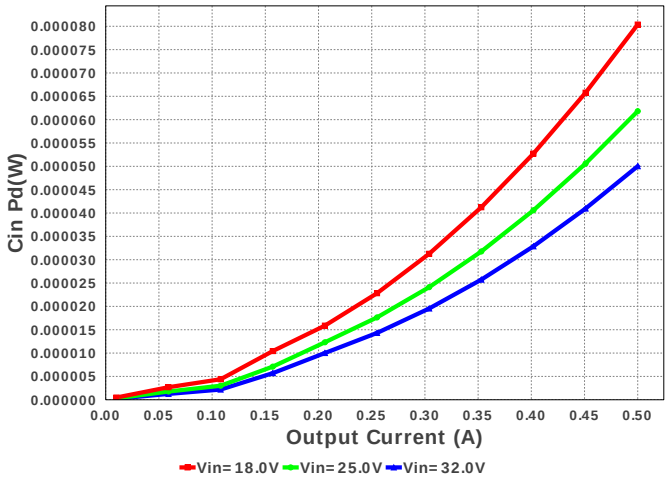
Efficiency



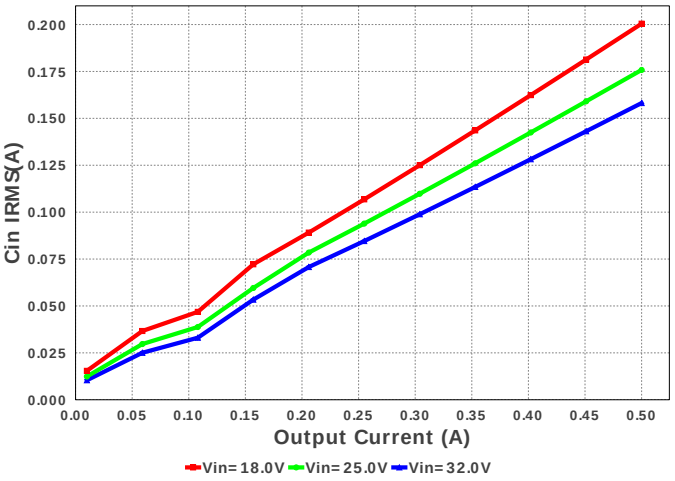
IC Tj



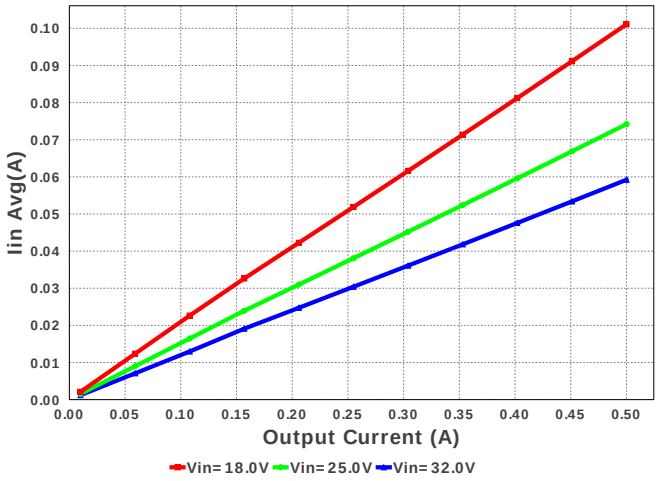
Cin Pd



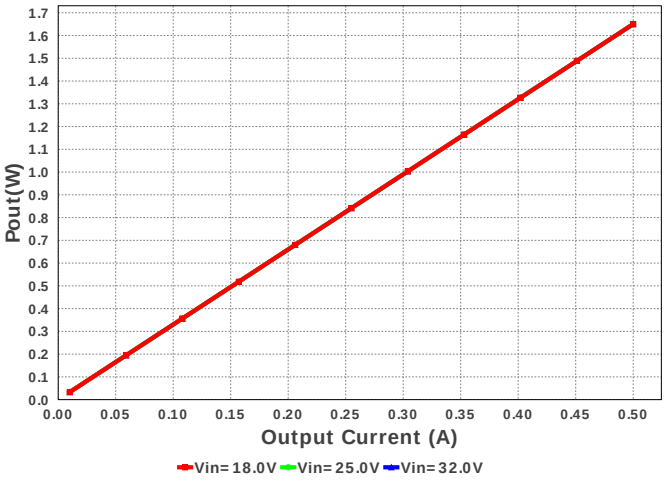
Cin IRMS

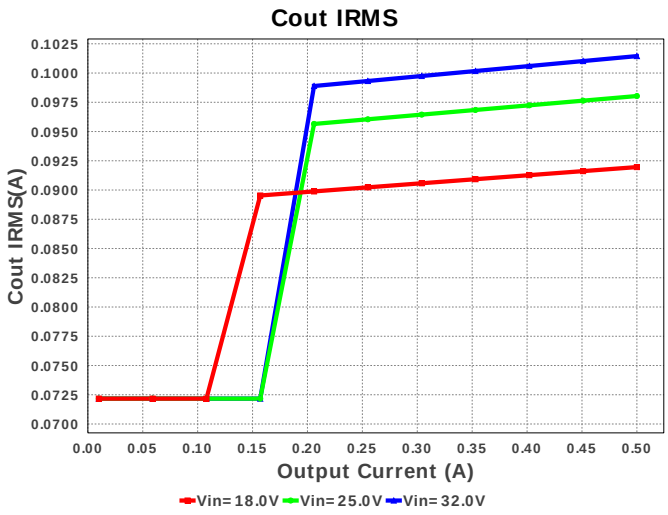


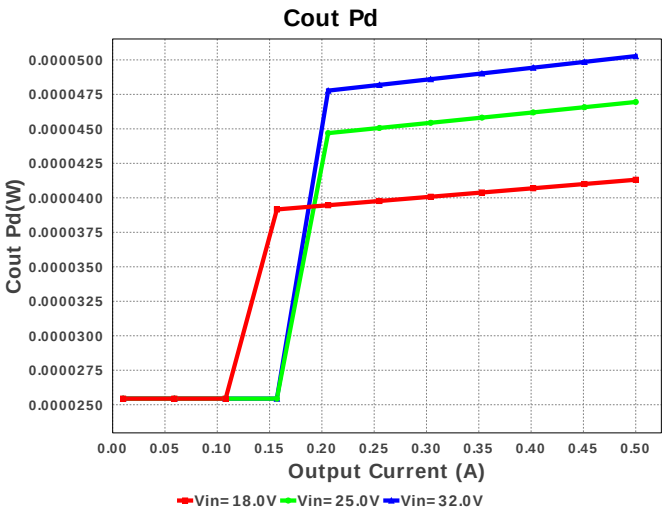
Iin Avg

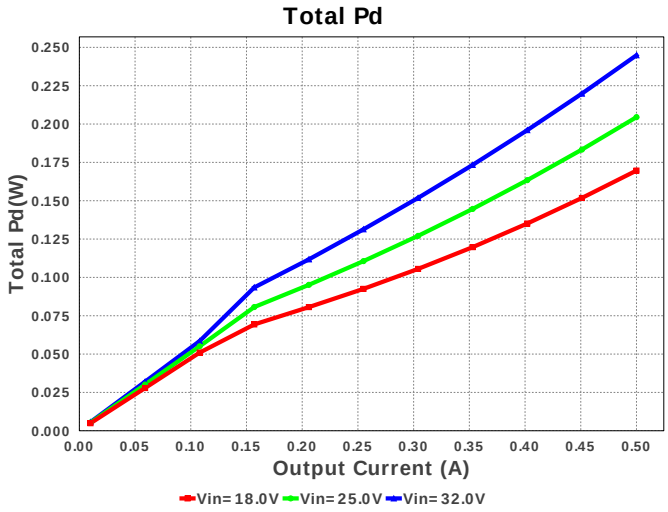


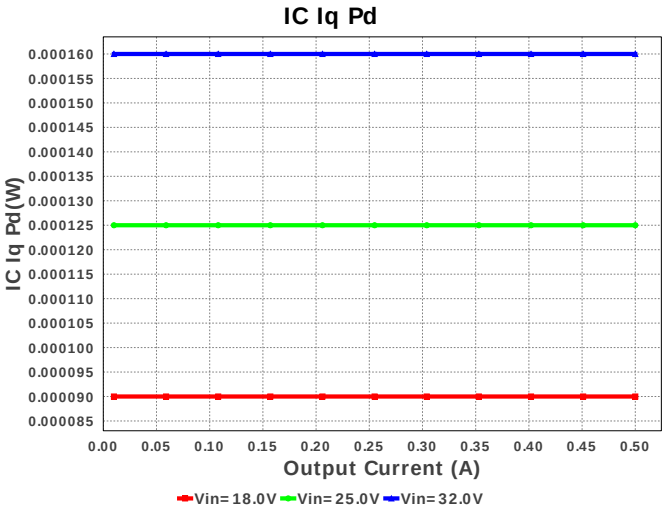
Pout

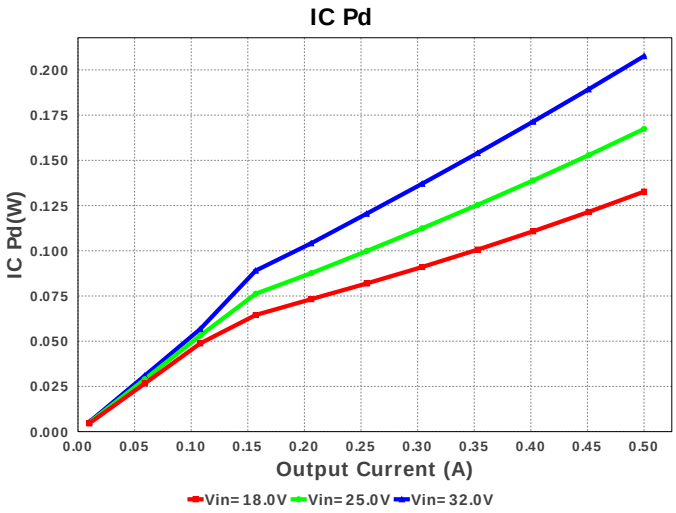


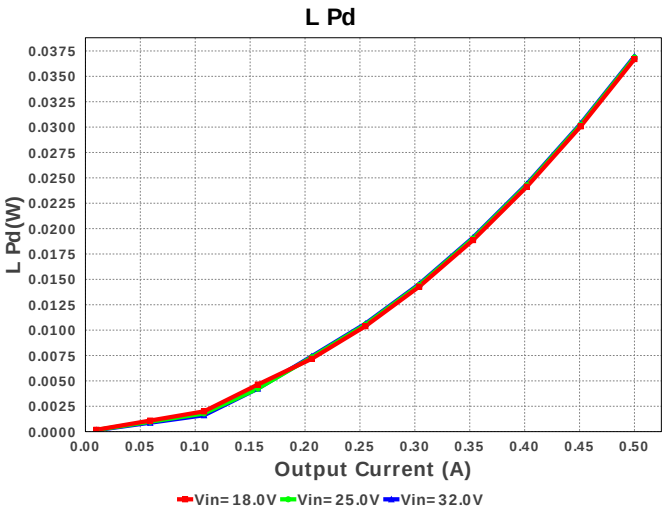


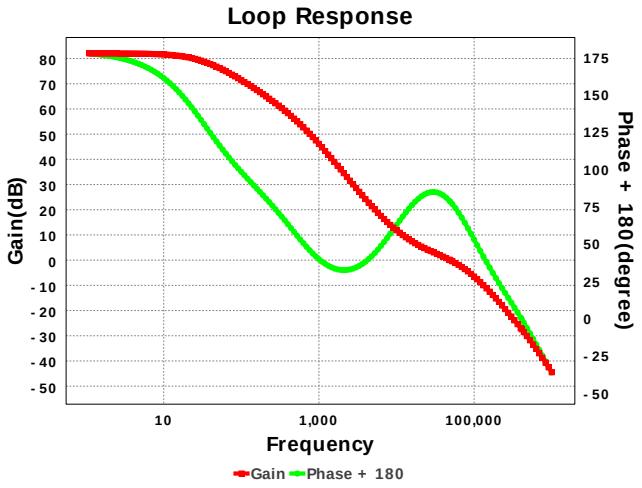


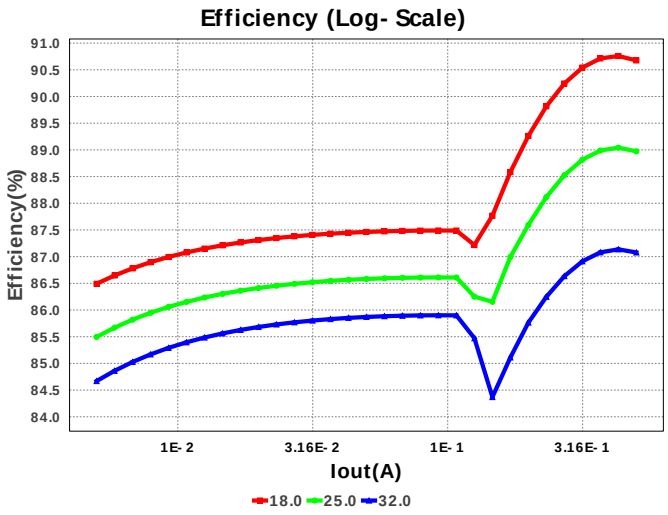












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	158.159 mA	Current	Input capacitor RMS ripple current
2.	Cout IRMS	101.448 mA	Current	Output capacitor RMS ripple current
3.	Iin Avg	59.214 mA	Current	Average input current
4.	L Ipp	351.43 mA	Current	Peak-to-peak inductor ripple current
5.	BOM Count	9	General	Total Design BOM count
6.	FootPrint	175.0 mm^2	General	Total Foot Print Area of BOM components
7.	Frequency	400.0 kHz	General	Switching frequency
8.	Mode	CCM	General	Conduction Mode
9.	Pout	1.65 W	General	Total output power
10.	Total BOM	$1.89	General	Total BOM Cost
11.	ICThetaJA Effective	18.0 degC/W	Op_Point	Effective IC Junction-to-Ambient Thermal Resistance
12.	Low Freq Gain	82.023 dB	Op_Point	Gain at 10Hz
13.	Vout Actual	3.308 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
14.	Vout OP	3.3 V	Op_Point	Operational Output Voltage
15.	Cross Freq	49.216 kHz	Op_point	Bode plot crossover frequency
16.	Duty Cycle	10.712 %	Op_point	Duty cycle
17.	Efficiency	87.078 %	Op_point	Steady state efficiency
18.	Gain Marg	-27.436 dB	Op_point	Bode Plot Gain Margin
19.	IC Tj	33.737 degC	Op_point	IC junction temperature
20.	IOUT_OP	500.0 mA	Op_point	Iout operating point
21.	Phase Marg	78.676 deg	Op_point	Bode Plot Phase Margin
22.	VIN_OP	32.0 V	Op_point	Vin operating point
23.	Vout p-p	1.288 mV	Op_point	Peak-to-peak output ripple voltage
24.	Cin Pd	50.029 µW	Power	Input capacitor power dissipation
25.	Cout Pd	50.275 µW	Power	Output capacitor power dissipation
26.	IC Iq Pd	160.0 µW	Power	IC Iq Pd
27.	IC Pd	207.635 mW	Power	IC power dissipation
28.	L Pd	36.961 mW	Power	Inductor power dissipation
29.	Total Pd	244.852 mW	Power	Total Power Dissipation
30.	Vout Tolerance	3.438 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable

Design Inputs

#	Name	Value	Description
1.	Iout	500.0 m	Maximum Output Current
2.	VinMax	32.0	Maximum input voltage
3.	VinMin	18.0	Minimum input voltage
4.	Vout	3.3	Output Voltage
5.	base_pn	LMR23610A	Base Product Number
6.	source	DC	Input Source Type
7.	Ta	30.0	Ambient temperature

Design Assistance

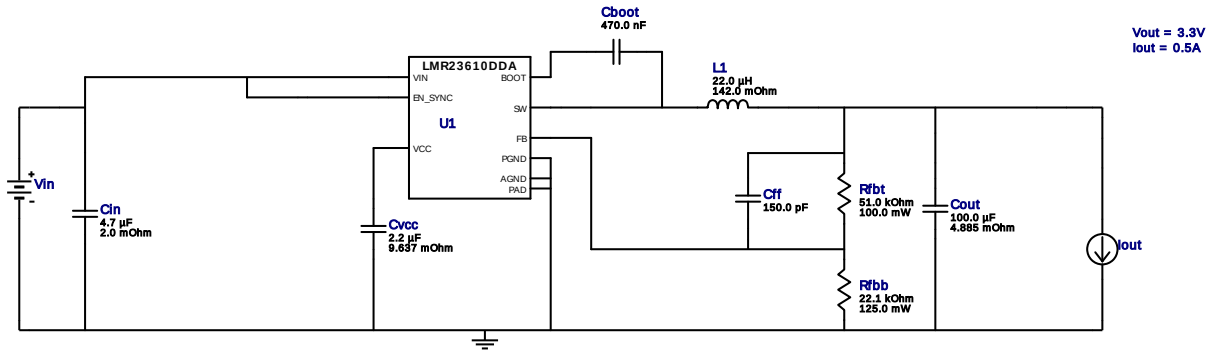
1. **LMR23610A** Product Folder : http://www.ti.com/product/LMR23610 : contains the data sheet and other resources.

WEBENCH® Design Report

Vout = 3.3V
Iout = 0.5A

Device = LMR23610ADDAR
Topology = Buck
Created = 8/11/16 2:40:15 PM
BOM Cost = $1.89
BOM Count = 9
Total Pd = 0.24W

Design : 921712/279 LMR23610ADDAR
LMR23610ADDAR 18.0V-32.0V to 3.30V @ 0.5A



1. The input capacitor included in the BOM only contains a small filter capacitor that should be placed near the IC. Depending on where the power supply is laid out in the system additional bulk capacitance may need to be added to filter the line ripple.

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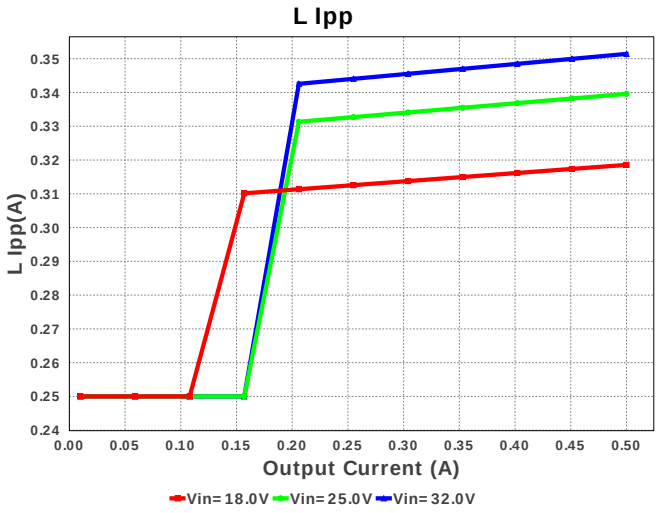
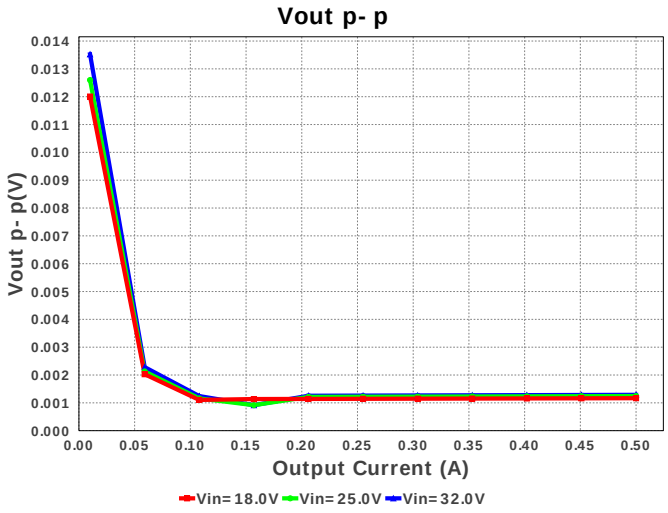
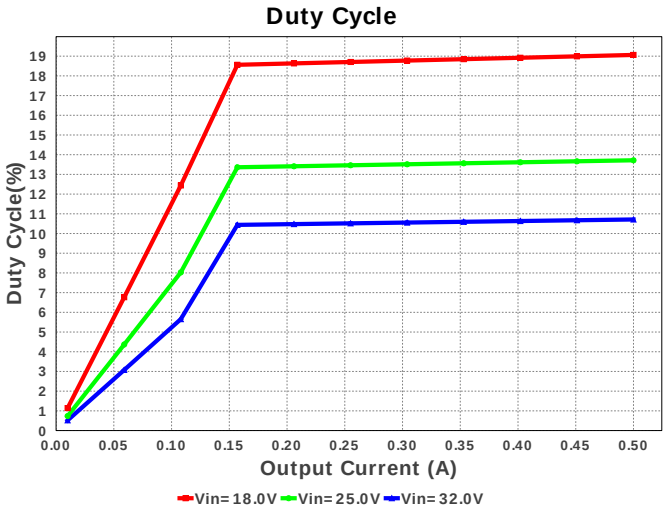
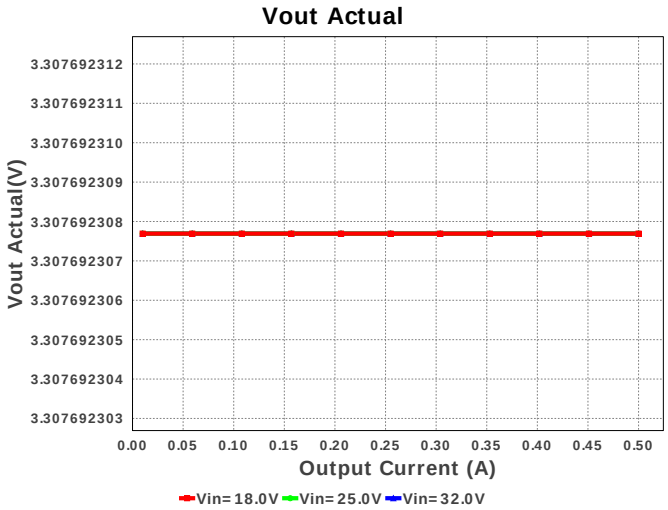
2.	Cff	Kemet	C0603C151K3GACTU Series= C0G/NP0	Cap= 150.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
3.	Cin	MuRata	GRM32ER71H475KA88L Series= X7R	Cap= 4.7 uF ESR= 2.0 mOhm VDC= 50.0 V IRMS= 5.35 A	1	$0.19	1210 15 mm²
4.	Cout	MuRata	GRM31CR60J107ME39L Series= X5R	Cap= 100.0 uF ESR= 4.885 mOhm VDC= 6.3 V IRMS= 4.4118 A	1	$0.14	1206_190 11 mm²
5.	Cvcc	MuRata	GRM188R60J225KE19D Series= X5R	Cap= 2.2 uF ESR= 9.637 mOhm VDC= 6.3 V IRMS= 1.32271 A	1	$0.02	0603 5 mm²
6.	L1	Bourns	SRN6045-220M	L= 22.0 µH DCR= 142.0 mOhm	1	$0.16	SRN6045 64 mm²
7.	Rfbb	Panasonic	ERJ-6ENF2212V Series= ERJ-6E	Res= 22.1 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
8.	Rfbt	Yageo America	RC0603FR-0751KL Series= ?	Res= 51.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²

#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
9.	U1	Texas Instruments	LMR23610ADDAR	Switcher	1	$1.30	DDA0008E_N 57 mm²

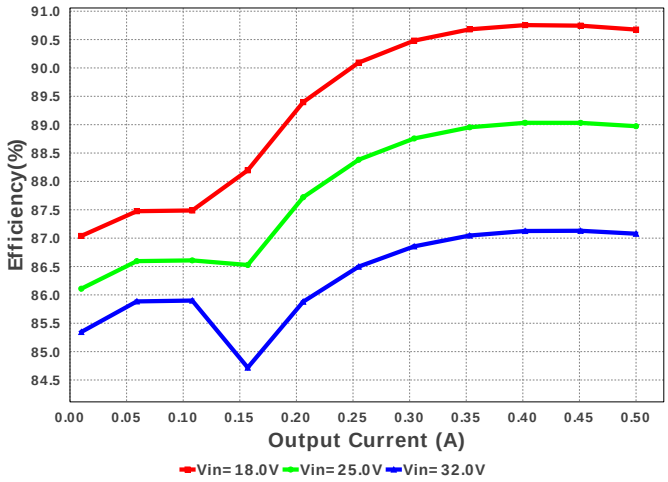




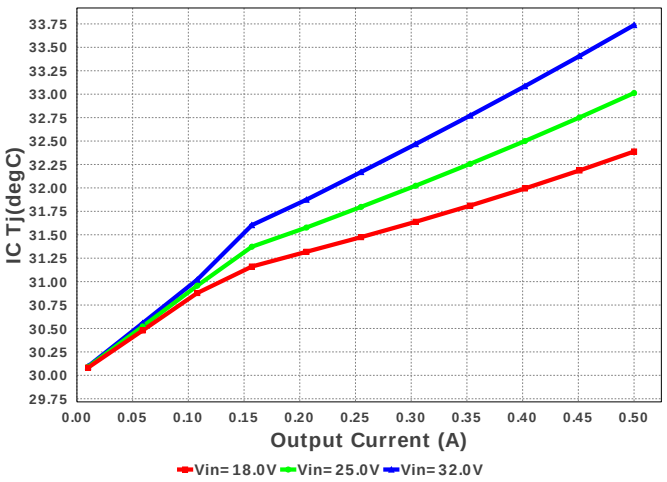




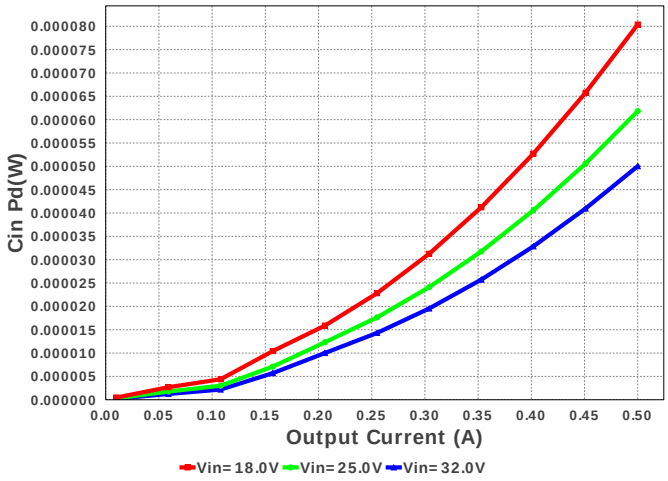
Efficiency



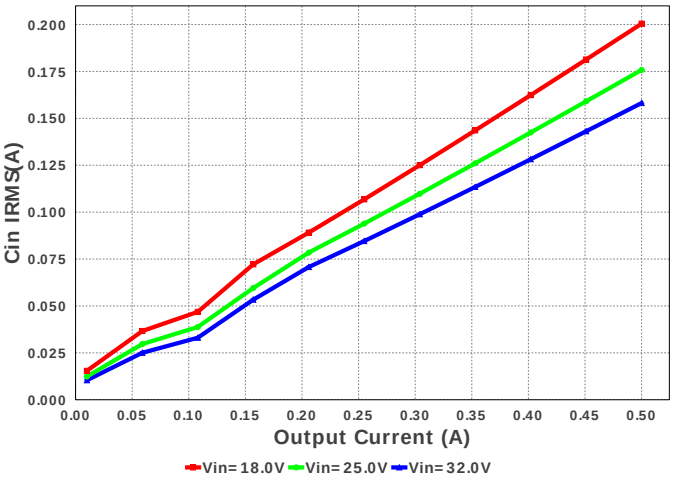
IC Tj



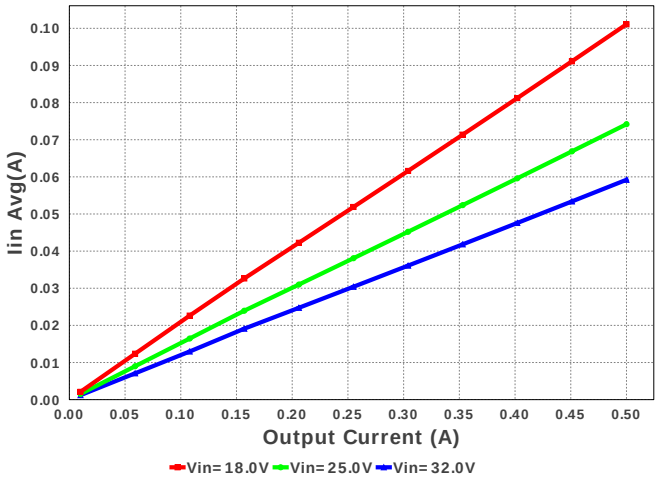
Cin Pd



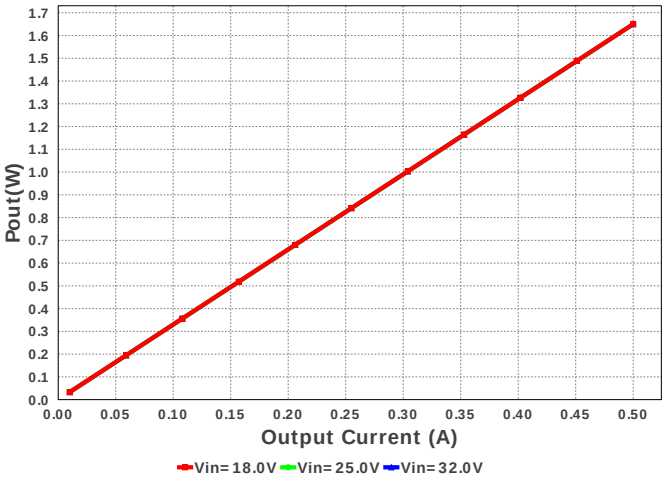
Cin IRMS



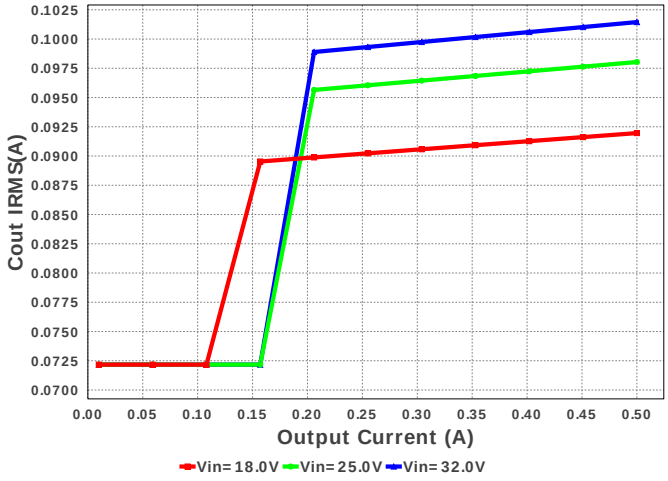
Iin Avg



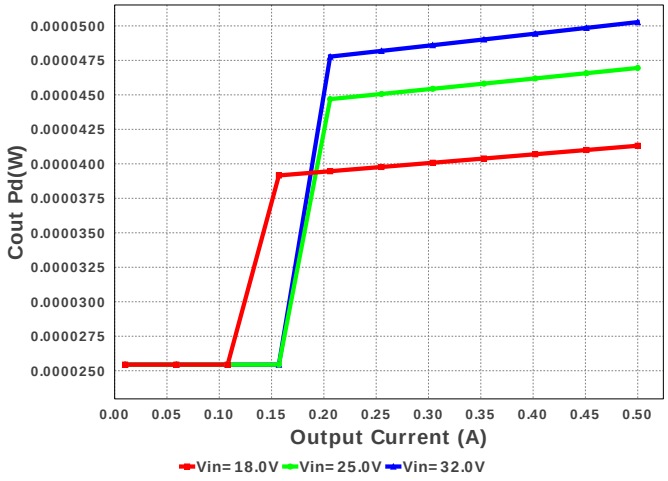
Pout



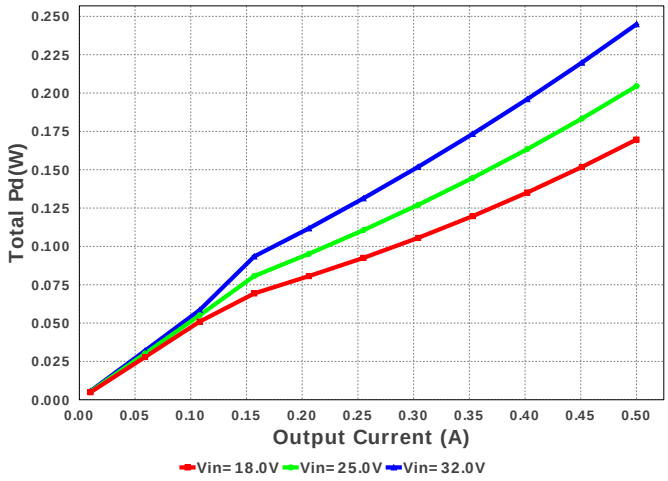
Cout IRMS



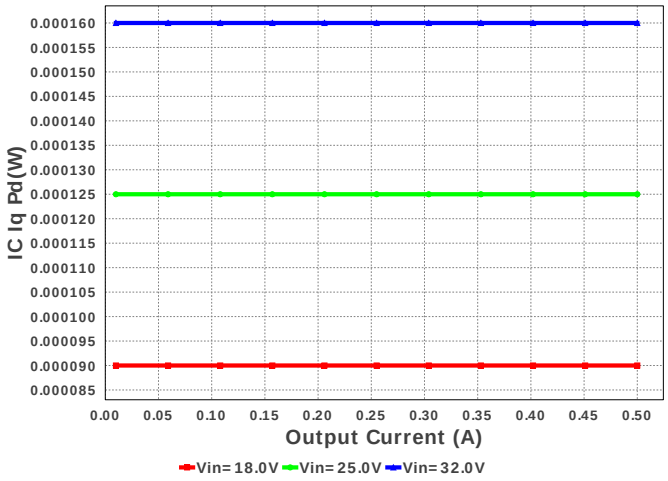
Cout Pd



Total Pd



IC Iq Pd



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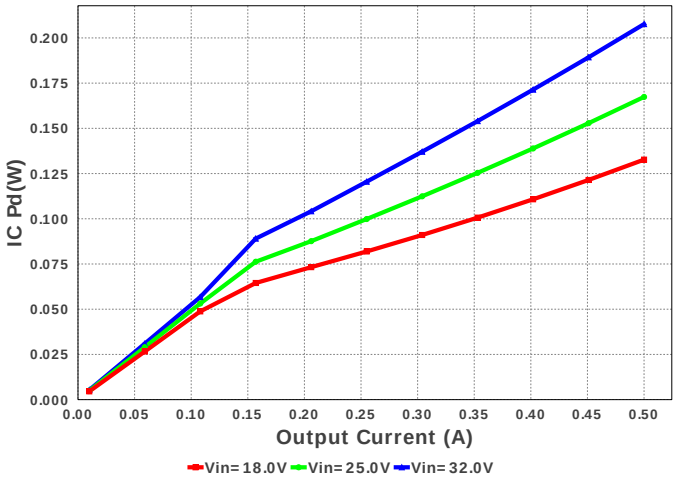
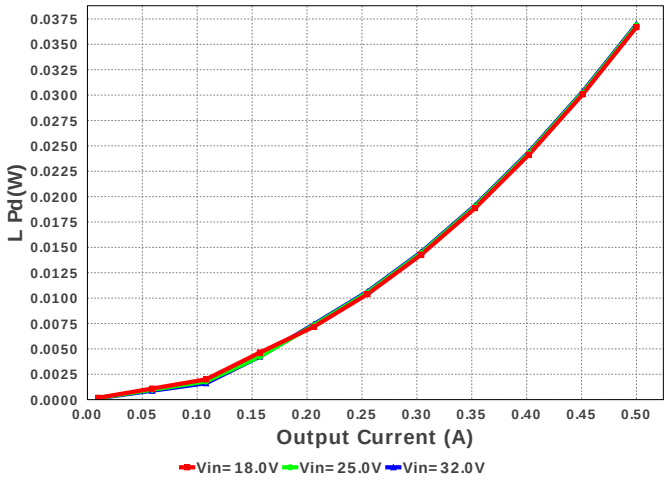
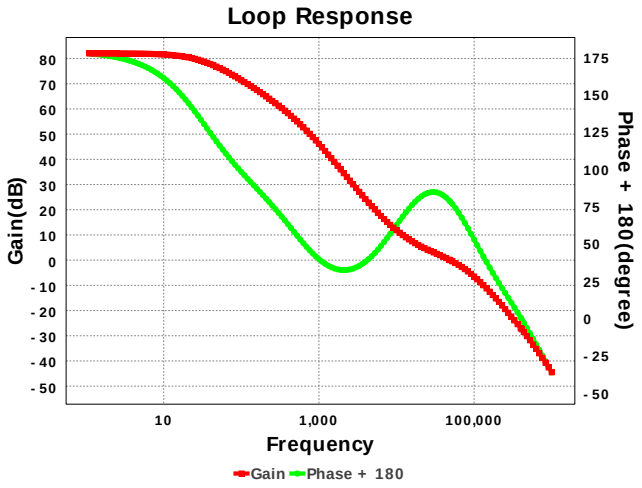
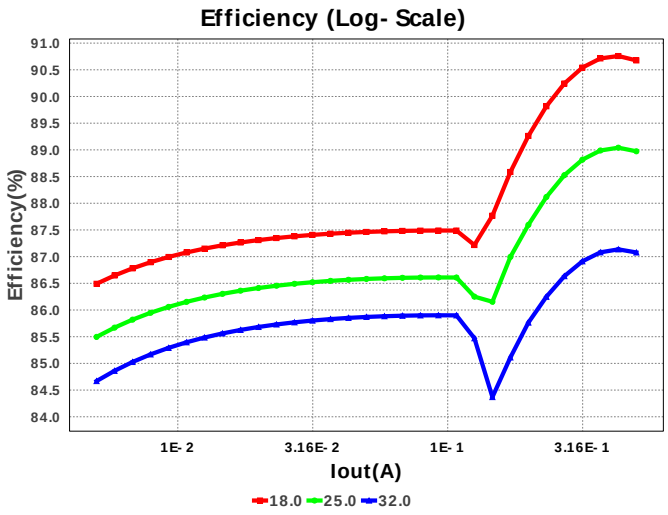


L Pd







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	158.159 mA	Current	Input capacitor RMS ripple current
2.	Cout IRMS	101.448 mA	Current	Output capacitor RMS ripple current
3.	Iin Avg	59.214 mA	Current	Average input current
4.	L Ipp	351.43 mA	Current	Peak-to-peak inductor ripple current
5.	BOM Count	9	General	Total Design BOM count
6.	FootPrint	175.0 mm^2	General	Total Foot Print Area of BOM components
7.	Frequency	400.0 kHz	General	Switching frequency
8.	Mode	CCM	General	Conduction Mode
9.	Pout	1.65 W	General	Total output power
10.	Total BOM	$1.89	General	Total BOM Cost
11.	ICThetaJA Effective	18.0 degC/W	Op_Point	Effective IC Junction-to-Ambient Thermal Resistance
12.	Low Freq Gain	82.023 dB	Op_Point	Gain at 10Hz
13.	Vout Actual	3.308 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
14.	Vout OP	3.3 V	Op_Point	Operational Output Voltage
15.	Cross Freq	49.216 kHz	Op_point	Bode plot crossover frequency
16.	Duty Cycle	10.712 %	Op_point	Duty cycle
17.	Efficiency	87.078 %	Op_point	Steady state efficiency
18.	Gain Marg	-27.436 dB	Op_point	Bode Plot Gain Margin
19.	IC Tj	33.737 degC	Op_point	IC junction temperature
20.	IOUT_OP	500.0 mA	Op_point	Iout operating point
21.	Phase Marg	78.676 deg	Op_point	Bode Plot Phase Margin
22.	VIN_OP	32.0 V	Op_point	Vin operating point
23.	Vout p-p	1.288 mV	Op_point	Peak-to-peak output ripple voltage
24.	Cin Pd	50.029 µW	Power	Input capacitor power dissipation
25.	Cout Pd	50.275 µW	Power	Output capacitor power dissipation
26.	IC Iq Pd	160.0 µW	Power	IC Iq Pd
27.	IC Pd	207.635 mW	Power	IC power dissipation
28.	L Pd	36.961 mW	Power	Inductor power dissipation
29.	Total Pd	244.852 mW	Power	Total Power Dissipation
30.	Vout Tolerance	3.438 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable

Design Inputs

#	Name	Value	Description
1.	Iout	500.0 m	Maximum Output Current
2.	VinMax	32.0	Maximum input voltage
3.	VinMin	18.0	Minimum input voltage
4.	Vout	3.3	Output Voltage
5.	base_pn	LMR23610A	Base Product Number
6.	source	DC	Input Source Type
7.	Ta	30.0	Ambient temperature

Design Assistance

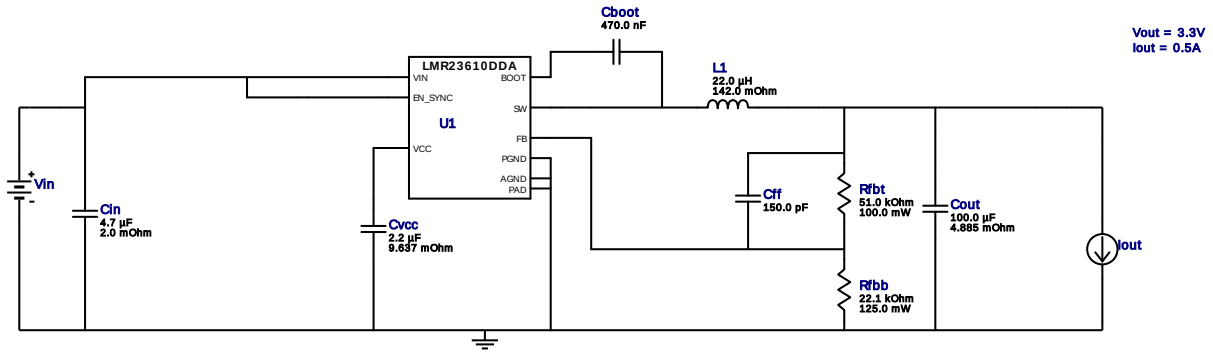
1. **LMR23610A** Product Folder : http://www.ti.com/product/LMR23610 : contains the data sheet and other resources.

WEBENCH® Design Report

Vout = 3.3V
Iout = 0.5A

Device = LMR23610ADDAR
Topology = Buck
Created = 8/11/16 2:40:15 PM
BOM Cost = $1.89
BOM Count = 9
Total Pd = 0.24W

Design : 921712/280 LMR23610ADDAR
LMR23610ADDAR 18.0V-32.0V to 3.30V @ 0.5A



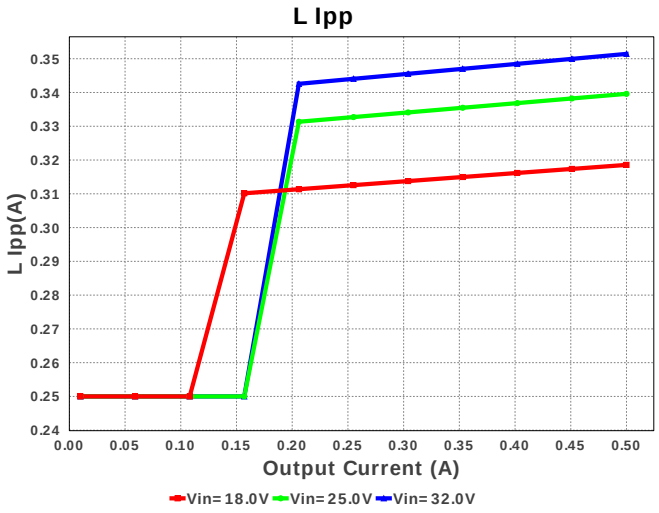
1. The input capacitor included in the BOM only contains a small filter capacitor that should be placed near the IC. Depending on where the power supply is laid out in the system additional bulk capacitance may need to be added to filter the line ripple.

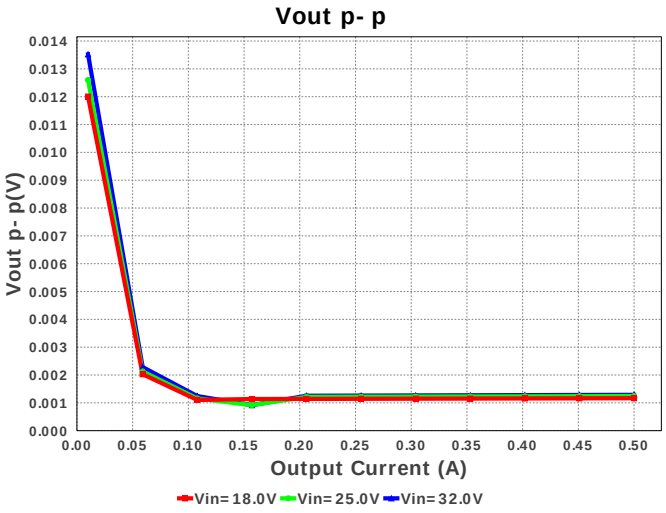
2. If there is no VinTyp specified, WEBENCH will use the VinMax value. To change the VinTyp value, click on the "Change Design Inputs" button under the Optimization Tuning knob. In some applications, while the design requires the input voltage to be a wide range, for a majority of the time, it is operating at a much lower voltage than the maximum input voltage. Sizing the inductor based on the maximum input voltage may yield an inductance much larger than typically needed, causing a larger footprint for the overall design. At the same time, components such as the input capacitor must be rated based on the maximum input voltage. WEBENCH now supports the use of this additional input voltage specification.

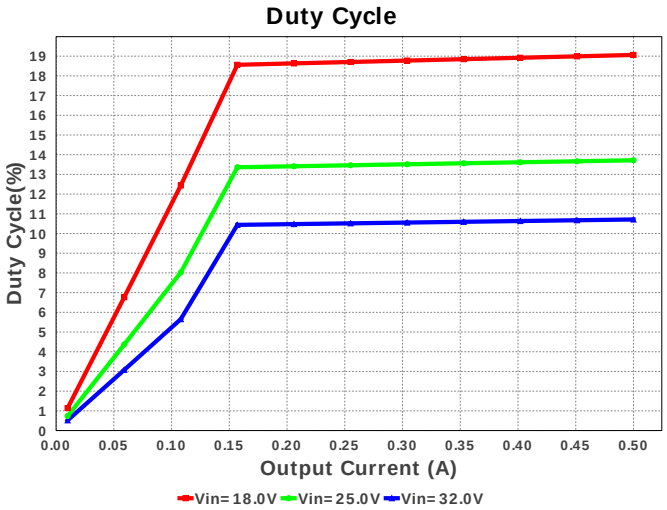
Electrical BOM

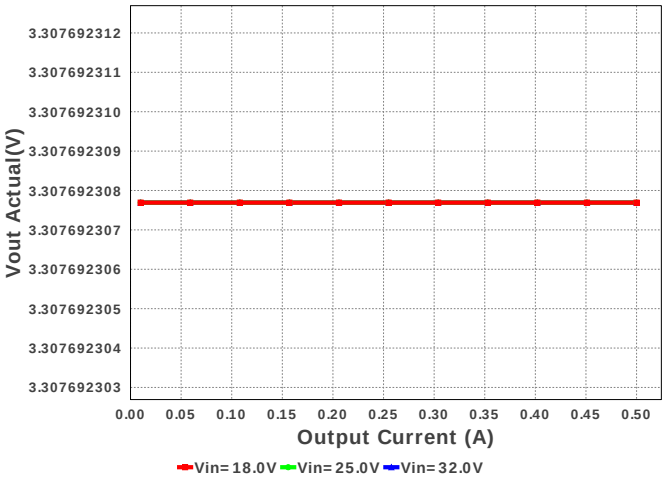
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Cboot	Taiyo Yuden	UMK212B7474KG-T Series= X7R	Cap= 470.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.05	0805 7 mm²
2.	Cff	Kemet	C0603C151K3GACTU Series= C0G/NP0	Cap= 150.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
3.	Cin	MuRata	GRM32ER71H475KA88L Series= X7R	Cap= 4.7 uF ESR= 2.0 mOhm VDC= 50.0 V IRMS= 5.35 A	1	$0.19	1210 15 mm²
4.	Cout	MuRata	GRM31CR60J107ME39L Series= X5R	Cap= 100.0 uF ESR= 4.885 mOhm VDC= 6.3 V IRMS= 4.4118 A	1	$0.14	1206_190 11 mm²
5.	Cvcc	MuRata	GRM188R60J225KE19D Series= X5R	Cap= 2.2 uF ESR= 9.637 mOhm VDC= 6.3 V IRMS= 1.32271 A	1	$0.02	0603 5 mm²
6.	L1	Bourns	SRN6045-220M	L= 22.0 µH DCR= 142.0 mOhm	1	$0.16	SRN6045 64 mm²
7.	Rfbb	Panasonic	ERJ-6ENF2212V Series= ERJ-6E	Res= 22.1 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
8.	Rfbt	Yageo America	RC0603FR-0751KL Series= ?	Res= 51.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²

#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
9.	U1	Texas Instruments	LMR23610ADDAR	Switcher	1	$1.30	DDA0008E_N 57 mm²

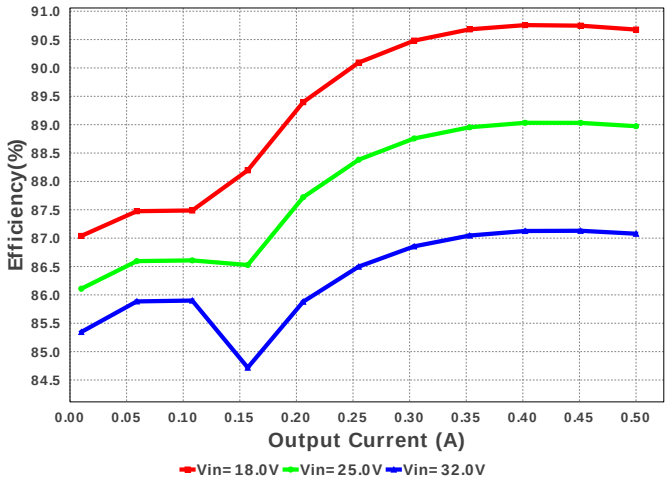




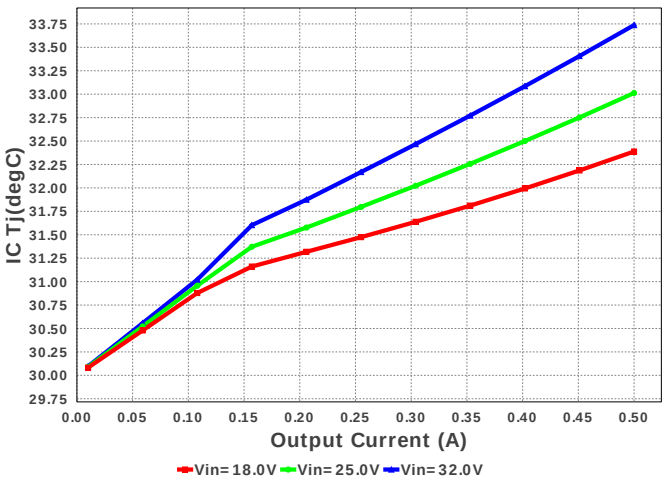




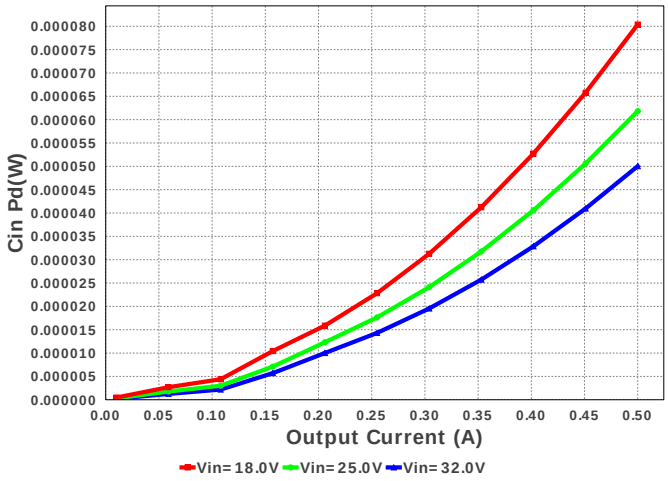
Efficiency



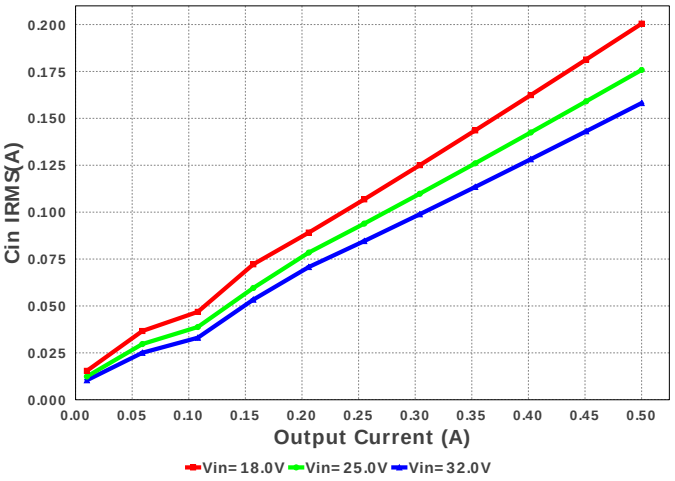
IC Tj



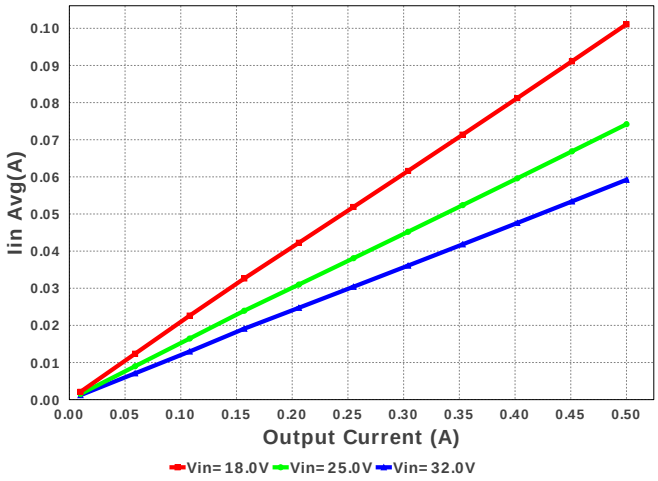
Cin Pd



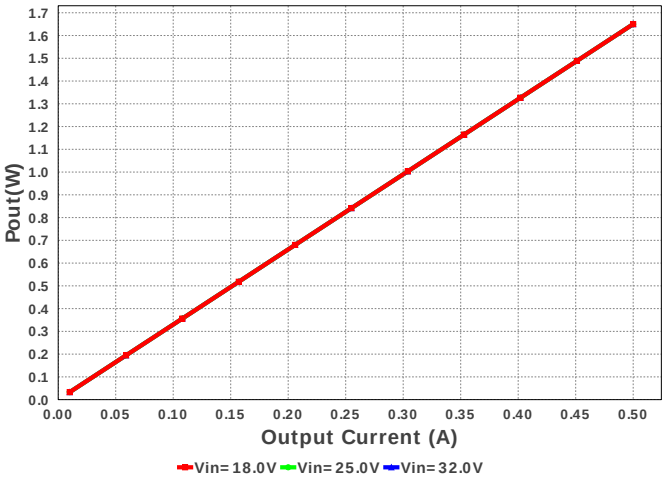
Cin IRMS

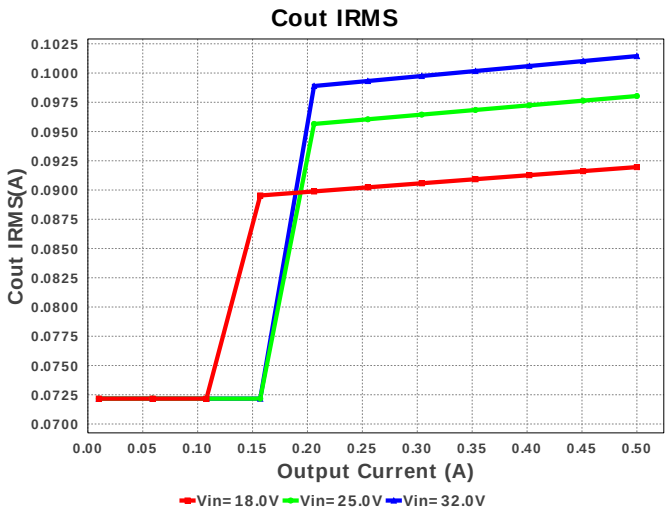


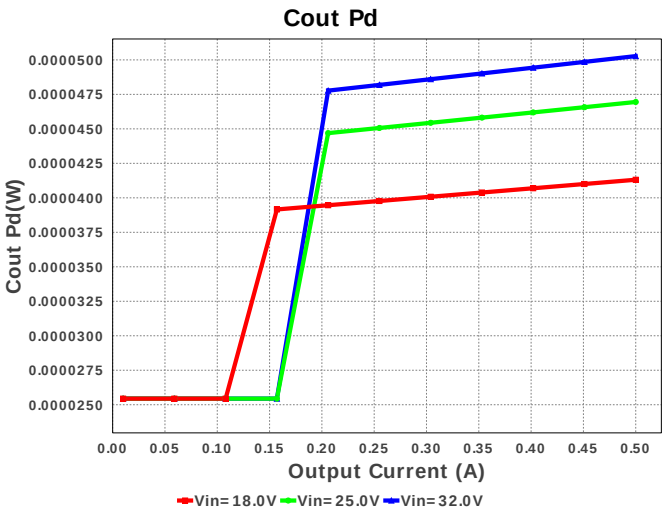
Iin Avg

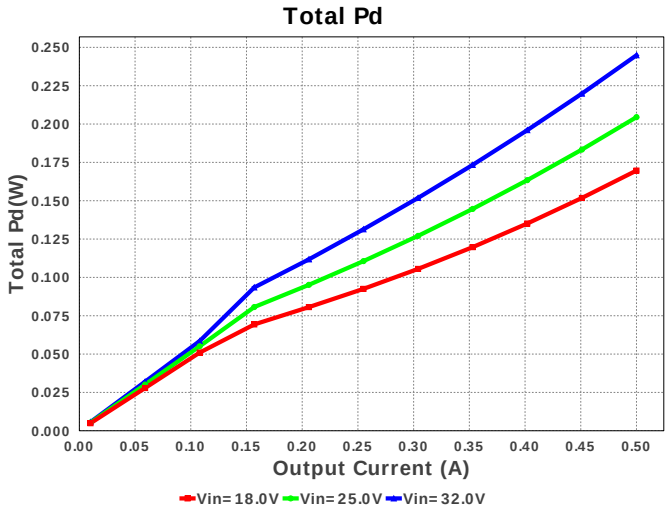


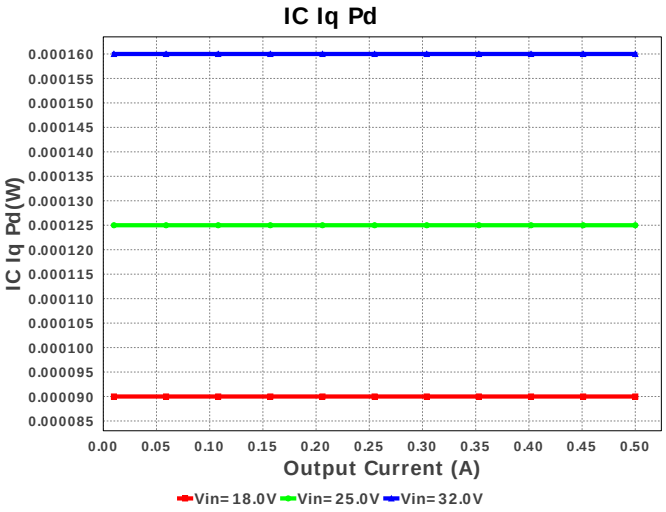
Pout

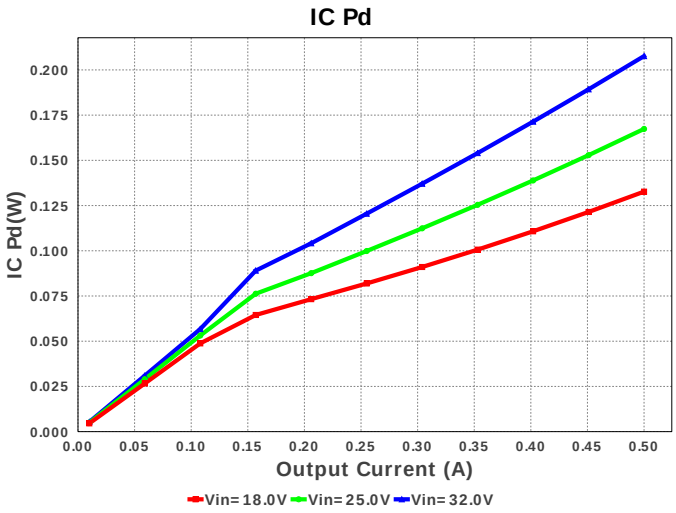


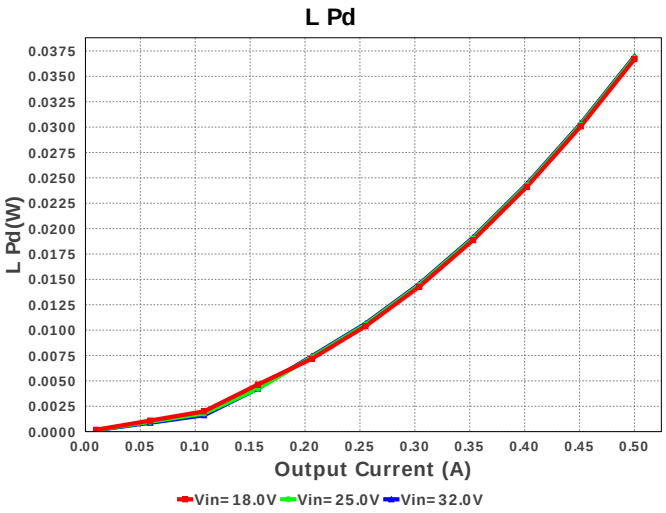


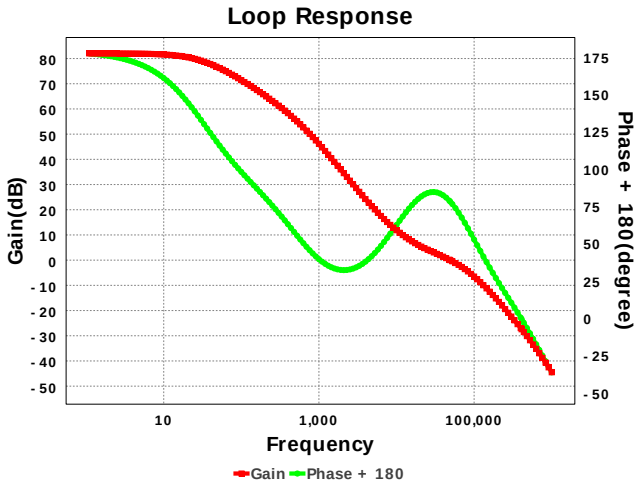


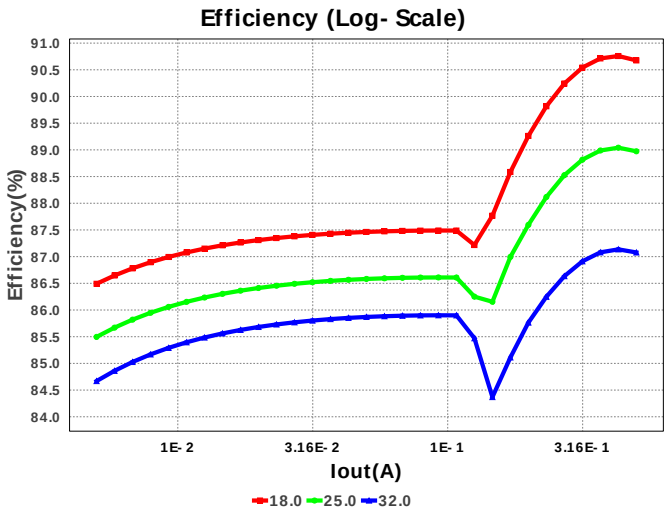












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	158.159 mA	Current	Input capacitor RMS ripple current
2.	Cout IRMS	101.448 mA	Current	Output capacitor RMS ripple current
3.	Iin Avg	59.214 mA	Current	Average input current
4.	L Ipp	351.43 mA	Current	Peak-to-peak inductor ripple current
5.	BOM Count	9	General	Total Design BOM count
6.	FootPrint	175.0 mm^2	General	Total Foot Print Area of BOM components
7.	Frequency	400.0 kHz	General	Switching frequency
8.	Mode	CCM	General	Conduction Mode
9.	Pout	1.65 W	General	Total output power
10.	Total BOM	$1.89	General	Total BOM Cost
11.	ICThetaJA Effective	18.0 degC/W	Op_Point	Effective IC Junction-to-Ambient Thermal Resistance
12.	Low Freq Gain	82.023 dB	Op_Point	Gain at 10Hz
13.	Vout Actual	3.308 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
14.	Vout OP	3.3 V	Op_Point	Operational Output Voltage
15.	Cross Freq	49.216 kHz	Op_point	Bode plot crossover frequency
16.	Duty Cycle	10.712 %	Op_point	Duty cycle
17.	Efficiency	87.078 %	Op_point	Steady state efficiency
18.	Gain Marg	-27.436 dB	Op_point	Bode Plot Gain Margin
19.	IC Tj	33.737 degC	Op_point	IC junction temperature
20.	IOUT_OP	500.0 mA	Op_point	Iout operating point
21.	Phase Marg	78.676 deg	Op_point	Bode Plot Phase Margin
22.	VIN_OP	32.0 V	Op_point	Vin operating point
23.	Vout p-p	1.288 mV	Op_point	Peak-to-peak output ripple voltage
24.	Cin Pd	50.029 µW	Power	Input capacitor power dissipation
25.	Cout Pd	50.275 µW	Power	Output capacitor power dissipation
26.	IC Iq Pd	160.0 µW	Power	IC Iq Pd
27.	IC Pd	207.635 mW	Power	IC power dissipation
28.	L Pd	36.961 mW	Power	Inductor power dissipation
29.	Total Pd	244.852 mW	Power	Total Power Dissipation
30.	Vout Tolerance	3.438 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable

Design Inputs

#	Name	Value	Description
1.	Iout	500.0 m	Maximum Output Current
2.	VinMax	32.0	Maximum input voltage
3.	VinMin	18.0	Minimum input voltage
4.	Vout	3.3	Output Voltage
5.	base_pn	LMR23610A	Base Product Number
6.	source	DC	Input Source Type
7.	Ta	30.0	Ambient temperature

Design Assistance

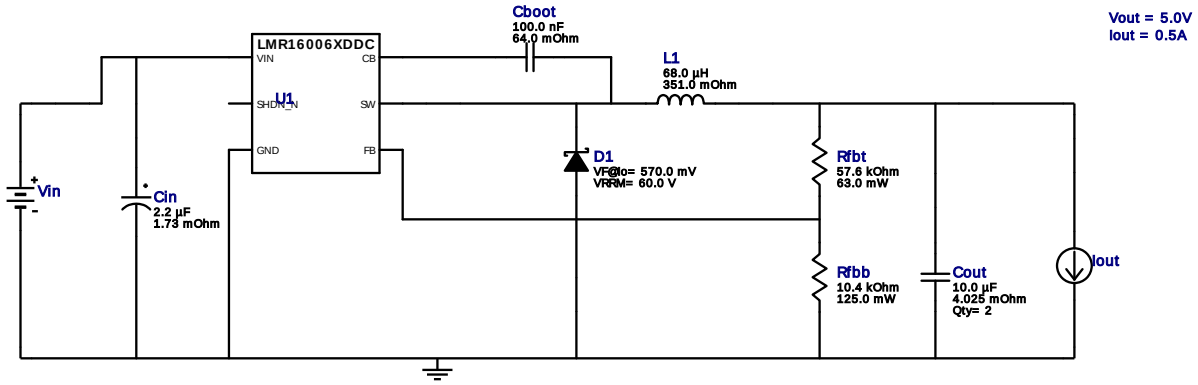
1. **LMR23610A** Product Folder : http://www.ti.com/product/LMR23610 : contains the data sheet and other resources.

WEBENCH® Design Report

Vout = 5.0V
Iout = 0.5A

Device = LMR16006XDDCR
Topology = Buck
Created = 8/11/16 2:40:16 PM
BOM Cost = $1.71
BOM Count = 9
Total Pd = 0.4W

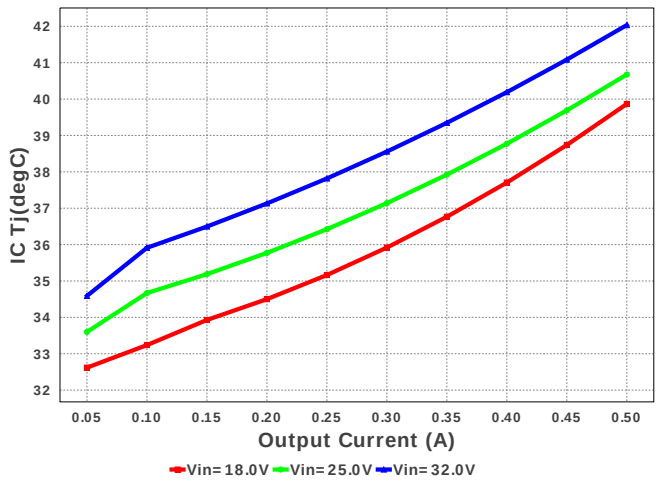
Design : 921712/281 LMR16006XDDCR
LMR16006XDDCR 18.0V-32.0V to 5.00V @ 0.5A



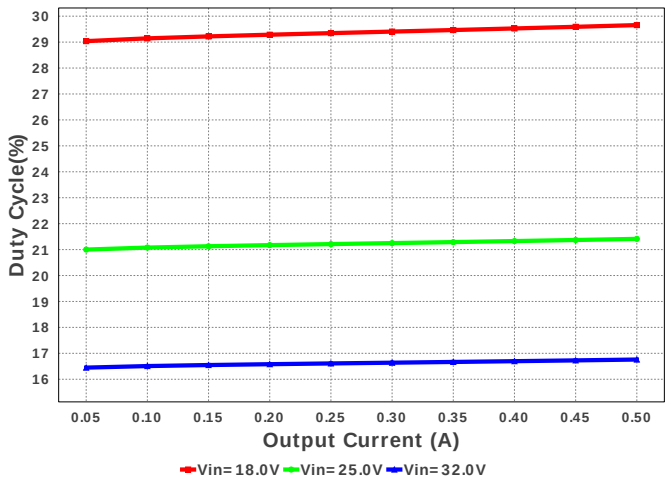
Electrical BOM

#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Cboot	Kemet	C0805C104K5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	$0.01	0805 7 mm²
2.	Cin	TDK	C3225X7R2A225K230AB Series= X7R	Cap= 2.2 uF ESR= 1.73 mOhm VDC= 100.0 V IRMS= 5.5932 A	1	$0.19	1210_250 15 mm²
3.	Cout	MuRata	GRM21BR61A106KE19L Series= X5R	Cap= 10.0 uF ESR= 4.025 mOhm VDC= 10.0 V IRMS= 2.445 A	2	$0.03	0805 7 mm²
4.	D1	NXP Semiconductor	PMEG6010CEH,115	VF@Io= 570.0 mV VRRM= 60.0 V	1	$0.04	SOD-123F 12 mm²
5.	L1	Bourns	SRN6045-680M	L= 68.0 µH DCR= 351.0 mOhm	1	$0.16	SRN6045 64 mm²
6.	Rfbb	Yageo America	RT0805BRD0710K4L Series= RT0805	Res= 10.4 kOhm Power= 125.0 mW Tolerance= 0.1%	1	$0.04	0805 7 mm²
7.	Rfbt	Vishay-Dale	CRCW040257K6FKED Series= CRCW..e3	Res= 57.6 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
8.	U1	Texas Instruments	LMR16006XDDCR	Switcher	1	$1.20	DDC0006A 10 mm²

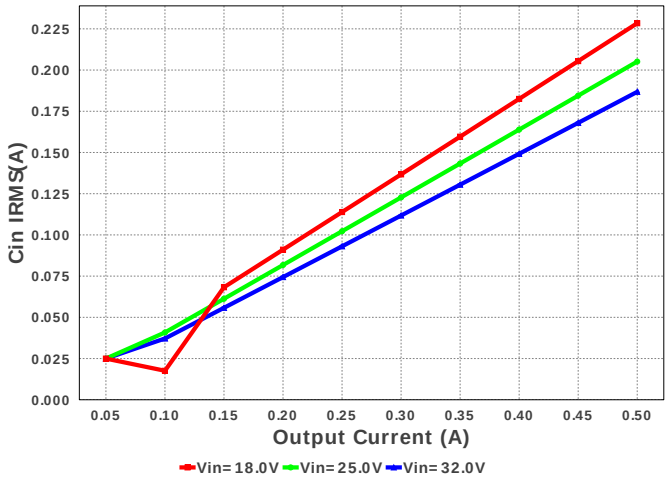
IC Tj



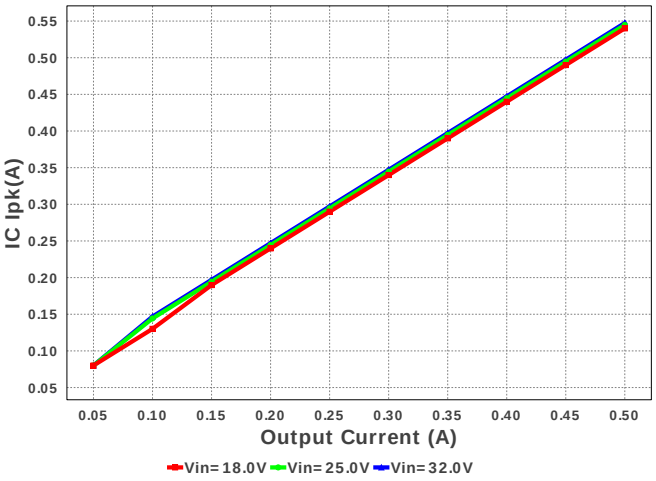
Duty Cycle



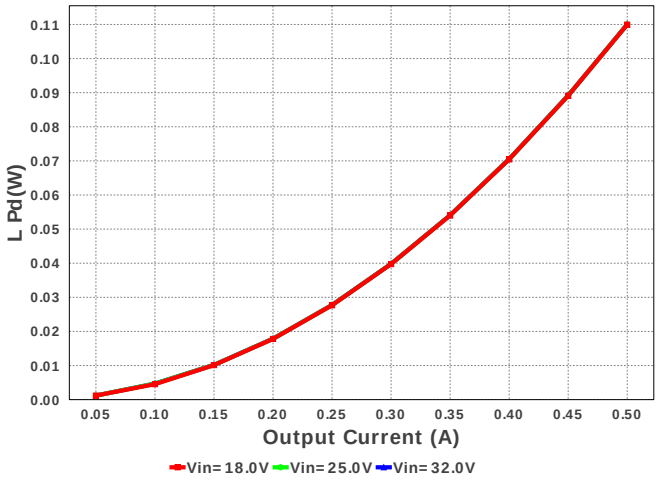
Cin IRMS



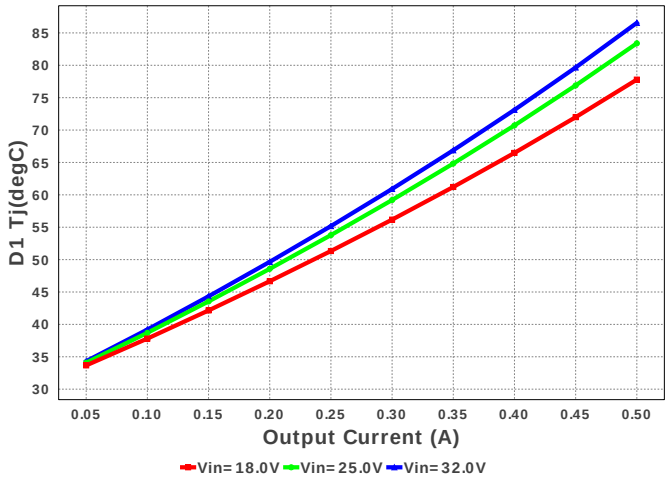
IC Ipk



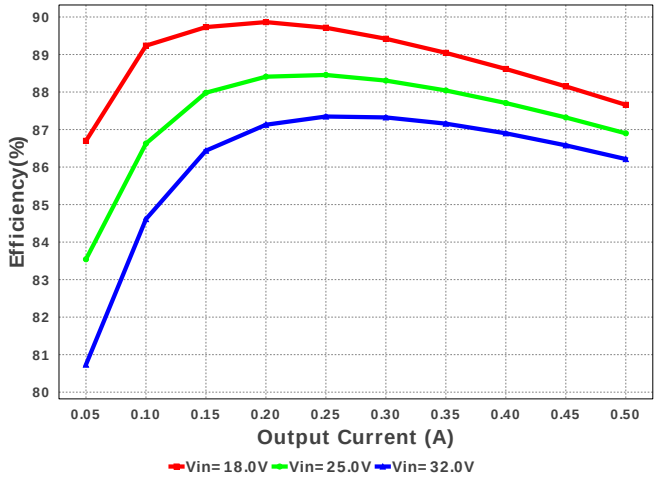
L Pd



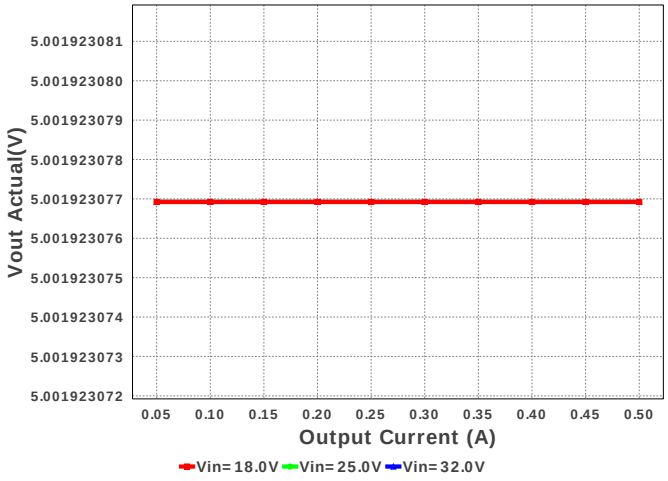
D1 Tj



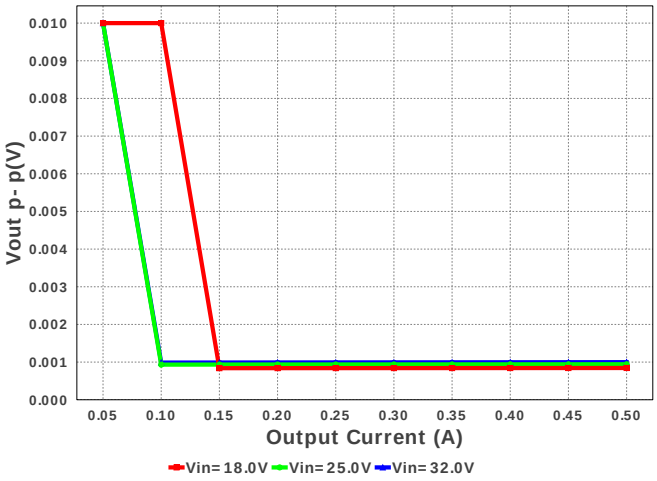
Efficiency



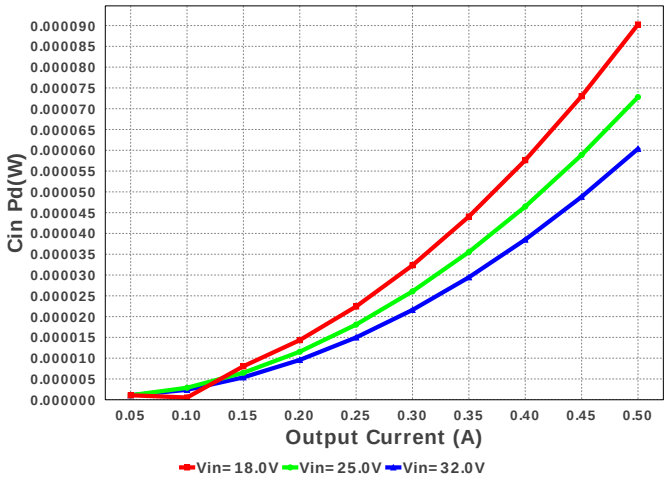
Vout Actual



Vout p- p



Cin Pd



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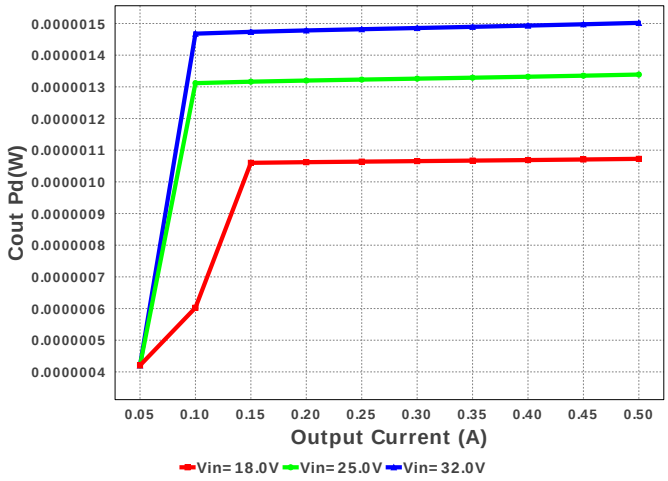
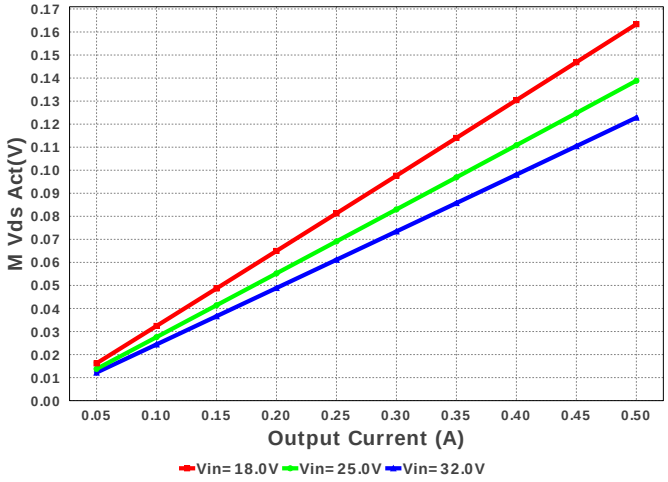
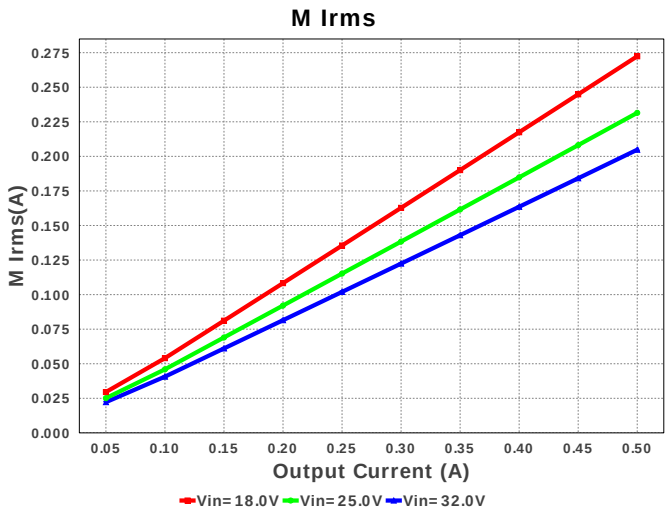
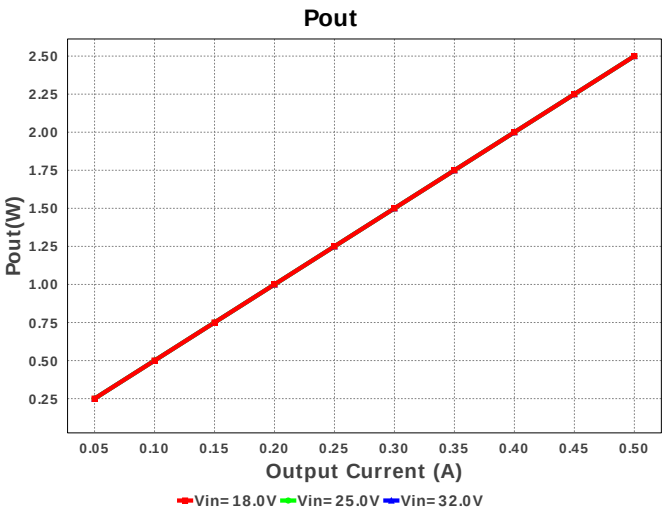
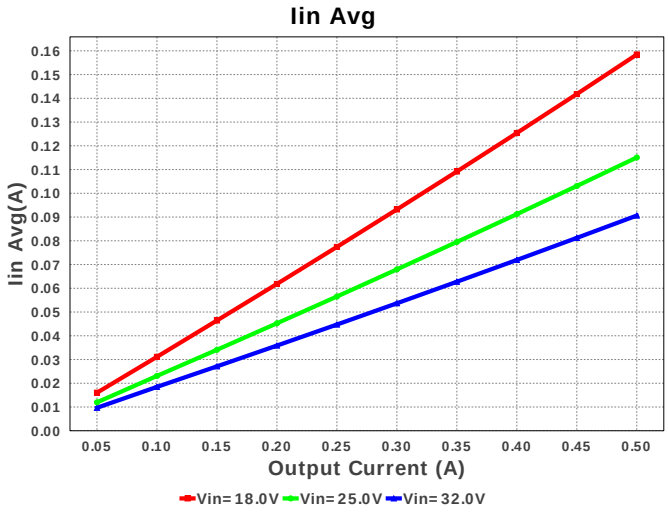


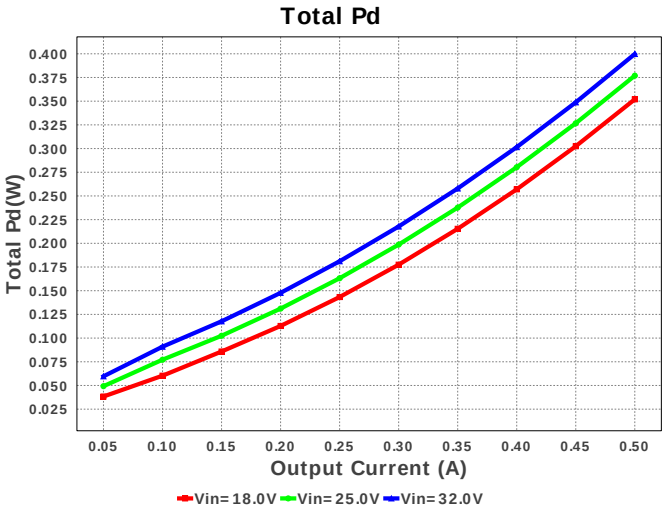
M Vds Act

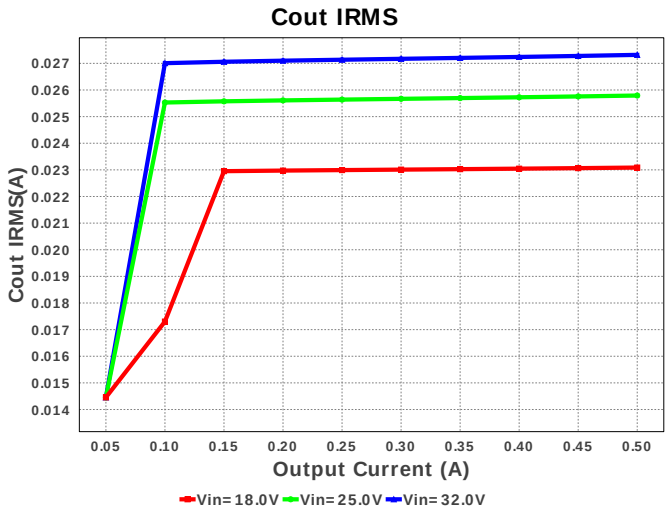


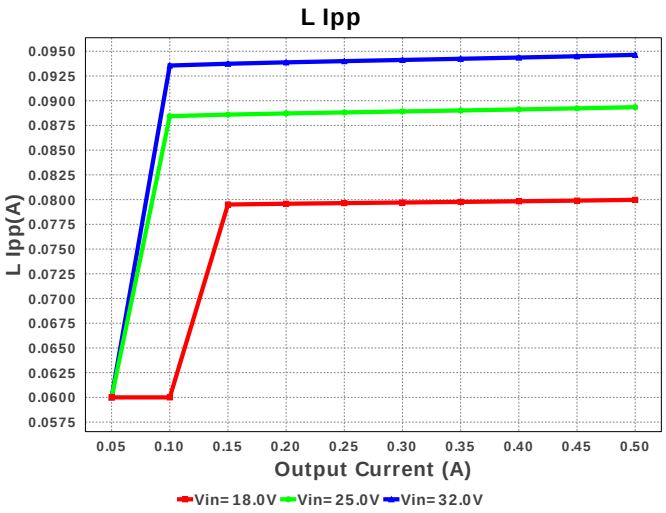


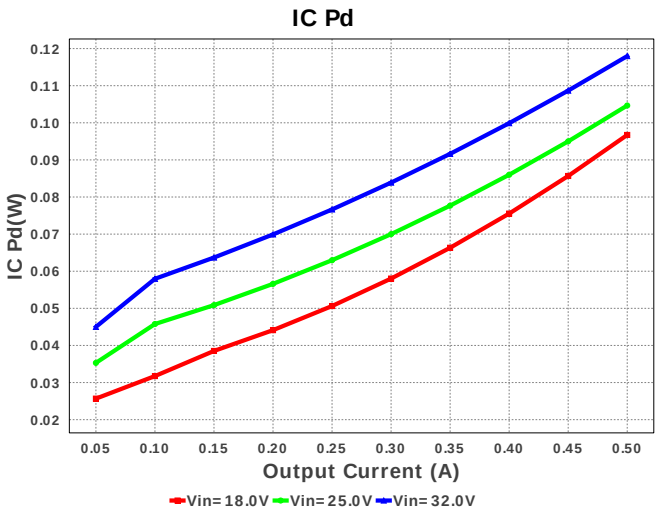


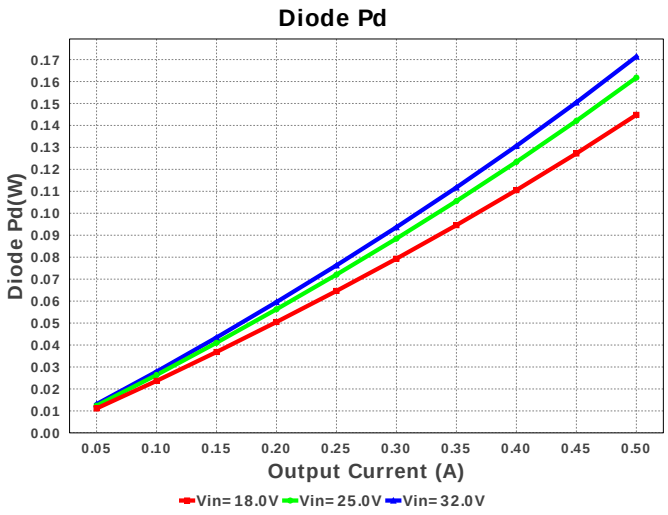


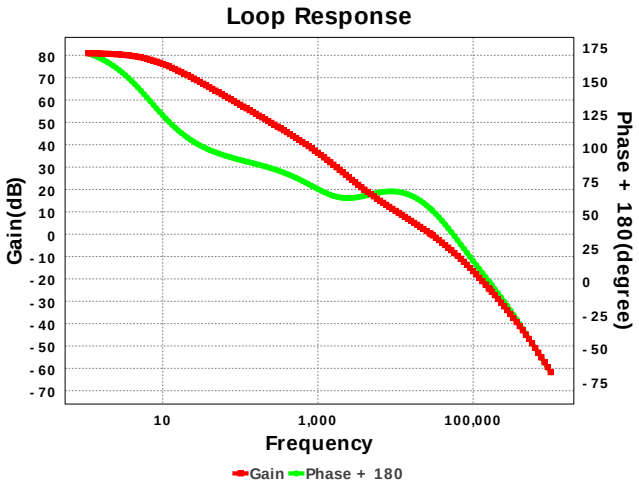












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	186.784 mA	Current	Input capacitor RMS ripple current
2.	Cout IRMS	27.319 mA	Current	Output capacitor RMS ripple current
3.	IC Ipk	547.391 mA	Current	Peak switch current in IC
4.	Iin Avg	90.619 mA	Current	Average input current
5.	L Ipp	94.636 mA	Current	Peak-to-peak inductor ripple current
6.	M1 Irms	204.803 mA	Current	Q Iavg
7.	BOM Count	9	General	Total Design BOM count
8.	FootPrint	131.0 mm^2	General	Total Foot Print Area of BOM components
9.	Frequency	700.0 kHz	General	Switching frequency
10.	IC Tolerance	18.0 mV	General	IC Feedback Tolerance
11.	M Vds Act	122.836 mV	General	Voltage drop across the MosFET
12.	Mode	CCM	General	Conduction Mode
13.	Pout	2.5 W	General	Total output power
14.	Total BOM	$1.71	General	Total BOM Cost
15.	D1 Tj	86.549 degC	Op_Point	D1 junction temperature
16.	Vout Actual	5.002 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
17.	Vout OP	5.0 V	Op_Point	Operational Output Voltage
18.	Cross Freq	28.637 kHz	Op_point	Bode plot crossover frequency
19.	Duty Cycle	16.76 %	Op_point	Duty cycle
20.	Efficiency	86.213 %	Op_point	Steady state efficiency
21.	IC Tj	42.033 degC	Op_point	IC junction temperature
22.	ICThetaJA	102.0 degC/W	Op_point	IC junction-to-ambient thermal resistance
23.	IOUT_OP	500.0 mA	Op_point	Iout operating point
24.	Phase Marg	54.598 deg	Op_point	Bode Plot Phase Margin
25.	VIN_OP	32.0 V	Op_point	Vin operating point
26.	Vout p-p	997.979 µV	Op_point	Peak-to-peak output ripple voltage
27.	Cin Pd	60.356 µW	Power	Input capacitor power dissipation
28.	Cout Pd	1.502 µW	Power	Output capacitor power dissipation
29.	Diode Pd	171.361 mW	Power	Diode power dissipation
30.	IC Pd	117.973 mW	Power	IC power dissipation
31.	L Pd	110.047 mW	Power	Inductor power dissipation

#	Name	Value	Category	Description
32.	Total Pd	399.797 mW	Power	Total Power Dissipation
33.	Vout Tolerance	3.308 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable

Design Inputs

#	Name	Value	Description
1.	Iout	500.0 m	Maximum Output Current
2.	VinMax	32.0	Maximum input voltage
3.	VinMin	18.0	Minimum input voltage
4.	Vout	5.0	Output Voltage
5.	base_pn	LMR16006X	Base Product Number
6.	source	DC	Input Source Type
7.	Ta	30.0	Ambient temperature

Design Assistance

1. **LMR16006X** Product Folder : http://www.ti.com/product/LMR16006 : contains the data sheet and other resources.

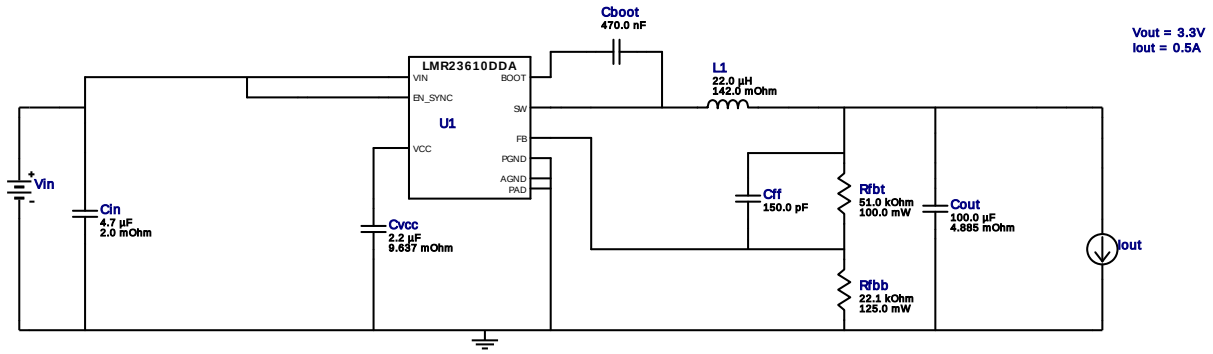
TEXAS INSTRUMENTS

WEBENCH® Design Report

Vout = 3.3V
Iout = 0.5A

Device = LMR23610ADDAR
Topology = Buck
Created = 8/11/16 2:40:16 PM
BOM Cost = $1.89
BOM Count = 9
Total Pd = 0.24W

Design : 921712/282 LMR23610ADDAR
LMR23610ADDAR 18.0V-32.0V to 3.30V @ 0.5A



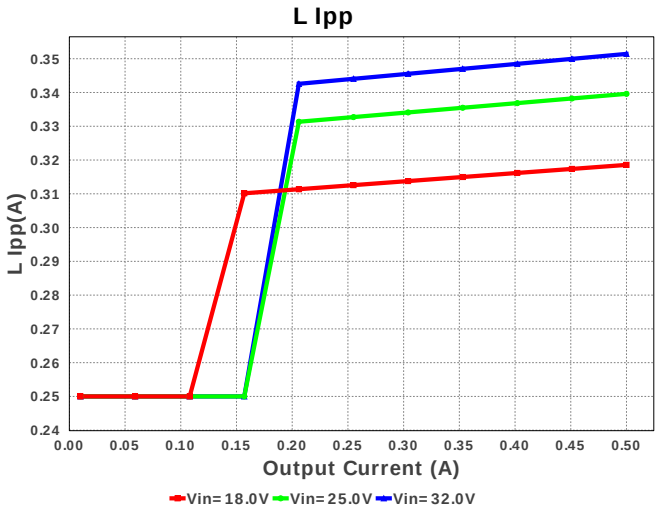
1. The input capacitor included in the BOM only contains a small filter capacitor that should be placed near the IC. Depending on where the power supply is laid out in the system additional bulk capacitance may need to be added to filter the line ripple.

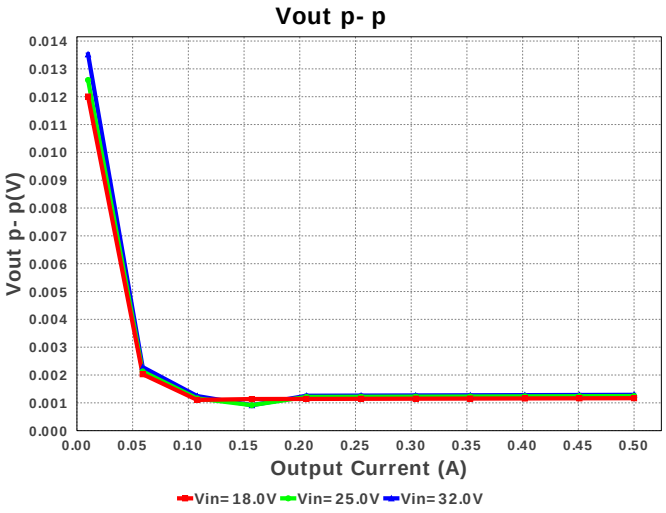
2. If there is no VinTyp specified, WEBENCH will use the VinMax value. To change the VinTyp value, click on the "Change Design Inputs" button under the Optimization Tuning knob. In some applications, while the design requires the input voltage to be a wide range, for a majority of the time, it is operating at a much lower voltage than the maximum input voltage. Sizing the inductor based on the maximum input voltage may yield an inductance much larger than typically needed, causing a larger footprint for the overall design. At the same time, components such as the input capacitor must be rated based on the maximum input voltage. WEBENCH now supports the use of this additional input voltage specification.

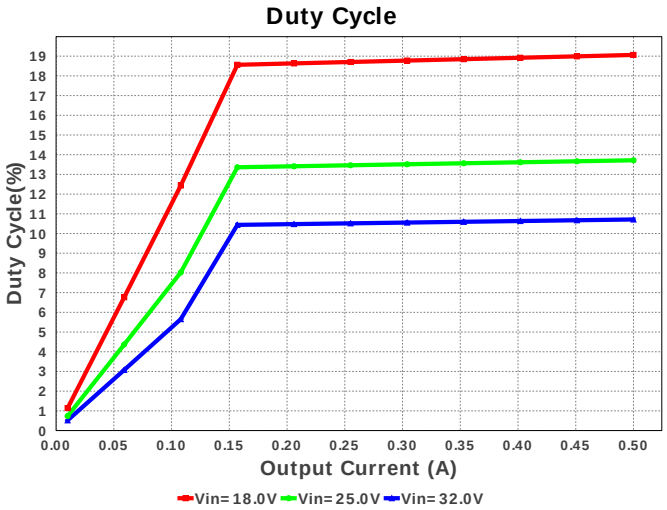
Electrical BOM

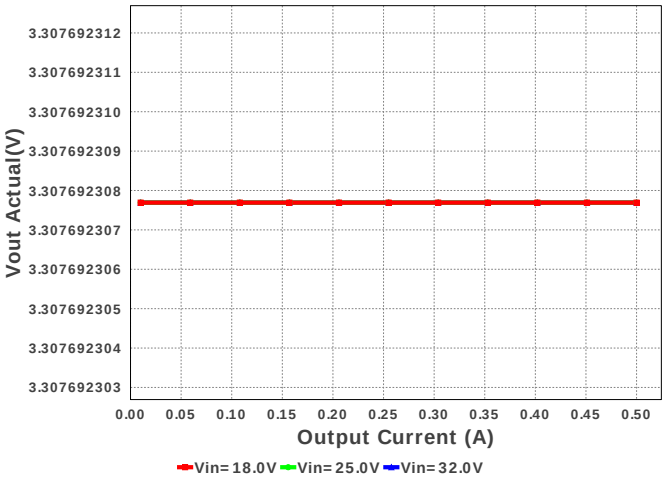
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Cboot	Taiyo Yuden	UMK212B7474KG-T Series= X7R	Cap= 470.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.05	0805 7 mm²
2.	Cff	Kemet	C0603C151K3GACTU Series= C0G/NP0	Cap= 150.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
3.	Cin	MuRata	GRM32ER71H475KA88L Series= X7R	Cap= 4.7 uF ESR= 2.0 mOhm VDC= 50.0 V IRMS= 5.35 A	1	$0.19	1210 15 mm²
4.	Cout	MuRata	GRM31CR60J107ME39L Series= X5R	Cap= 100.0 uF ESR= 4.885 mOhm VDC= 6.3 V IRMS= 4.4118 A	1	$0.14	1206_190 11 mm²
5.	Cvcc	MuRata	GRM188R60J225KE19D Series= X5R	Cap= 2.2 uF ESR= 9.637 mOhm VDC= 6.3 V IRMS= 1.32271 A	1	$0.02	0603 5 mm²
6.	L1	Bourns	SRN6045-220M	L= 22.0 µH DCR= 142.0 mOhm	1	$0.16	SRN6045 64 mm²
7.	Rfbb	Panasonic	ERJ-6ENF2212V Series= ERJ-6E	Res= 22.1 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
8.	Rfbt	Yageo America	RC0603FR-0751KL Series= ?	Res= 51.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²

#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
9.	U1	Texas Instruments	LMR23610ADDAR	Switcher	1	$1.30	DDA0008E_N 57 mm²

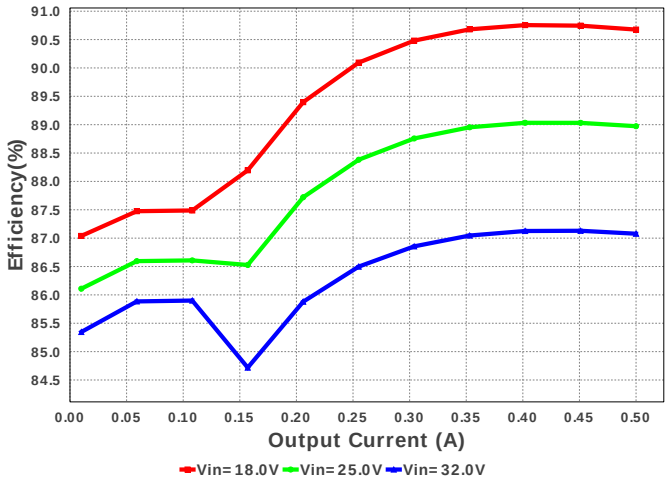




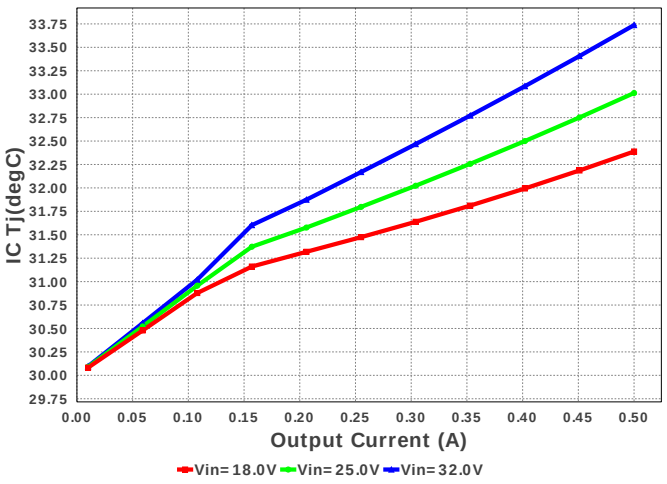




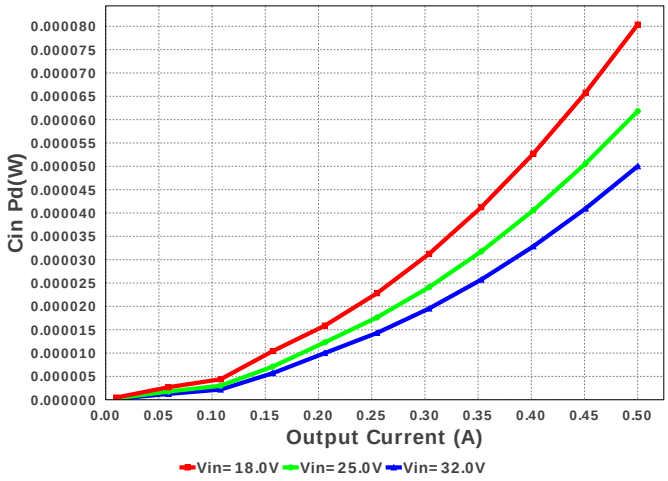
Efficiency



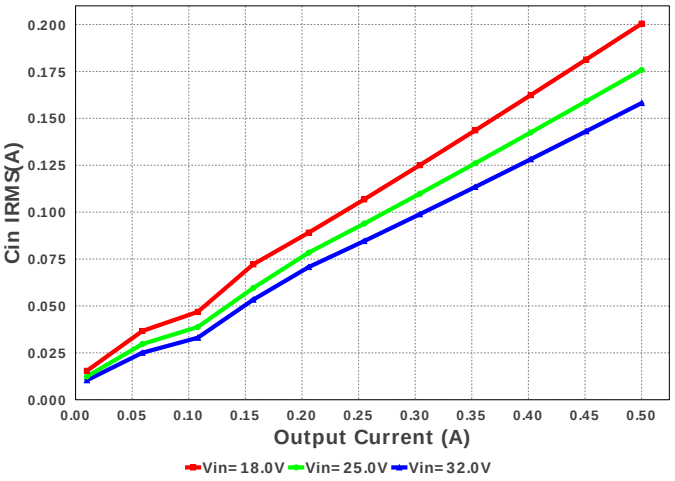
IC Tj



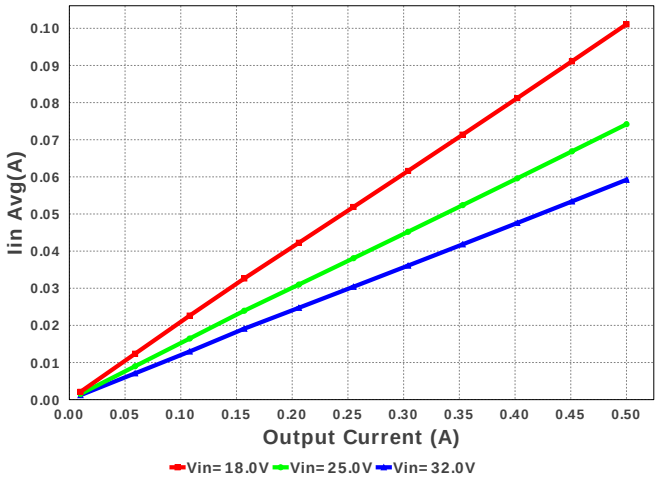
Cin Pd



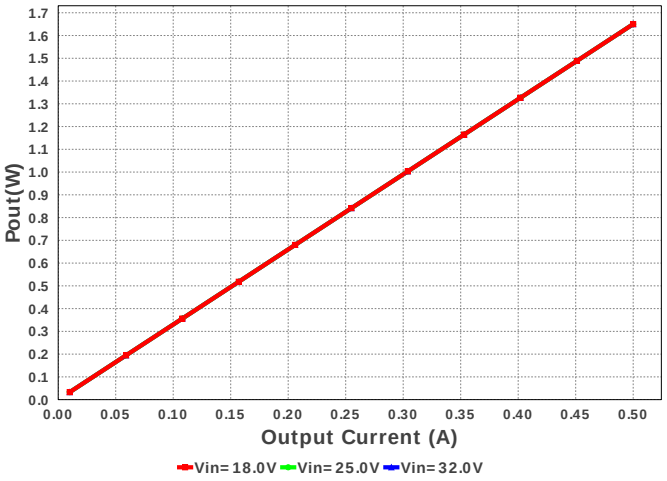
Cin IRMS

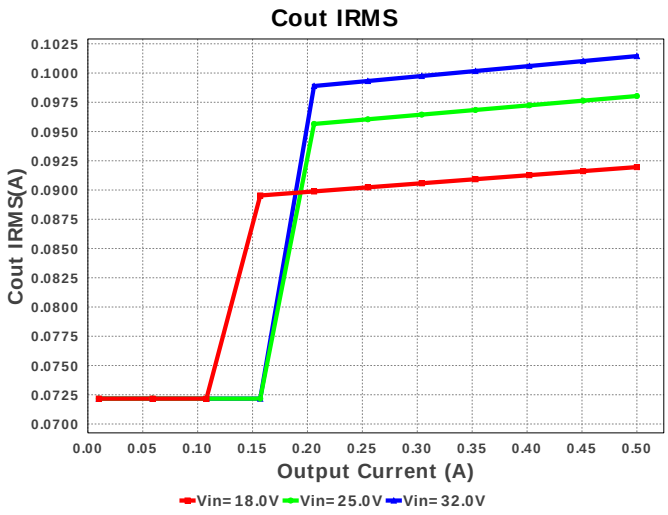


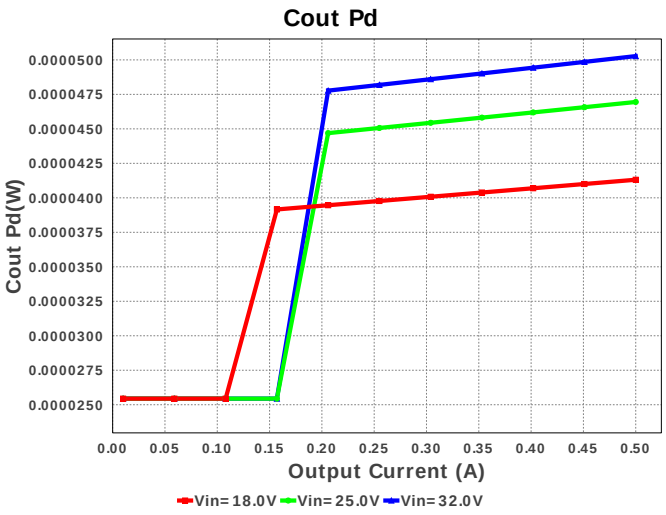
Iin Avg

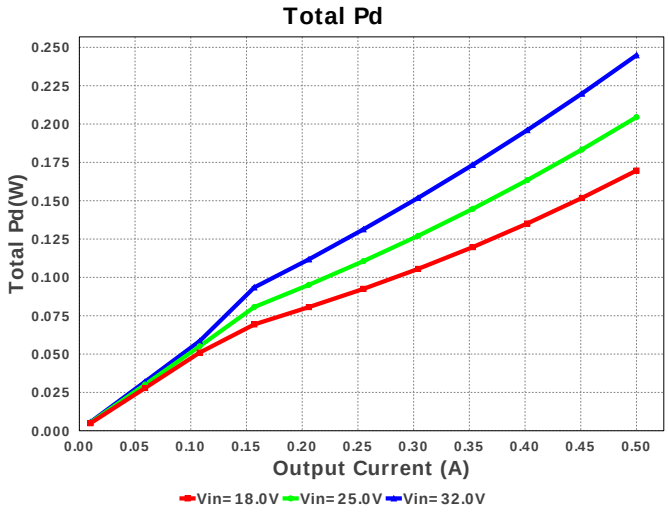


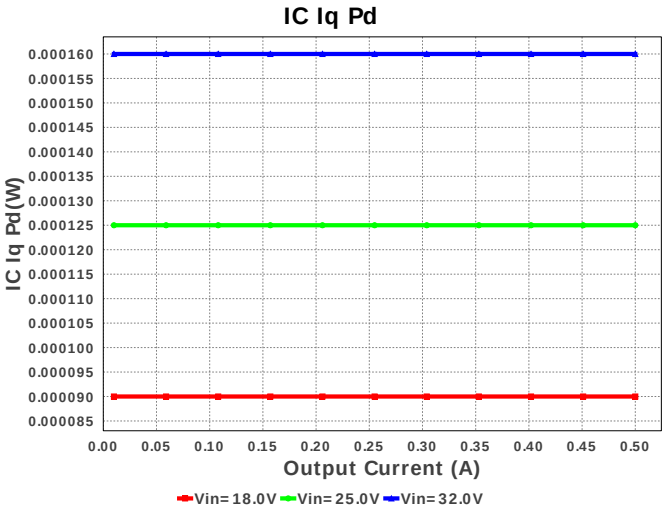
Pout

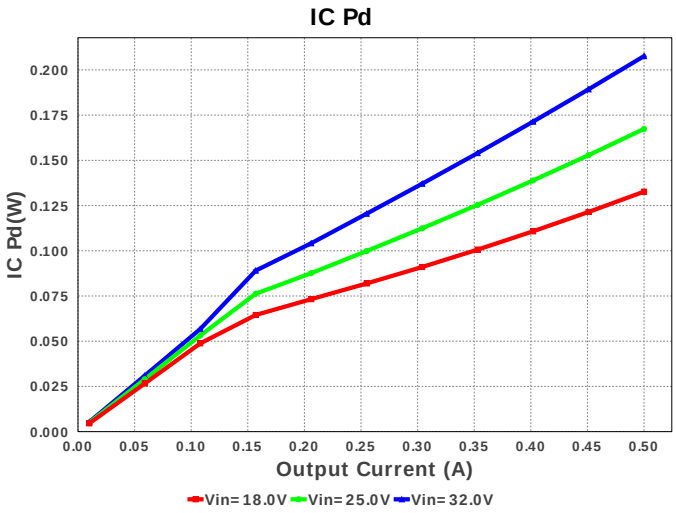


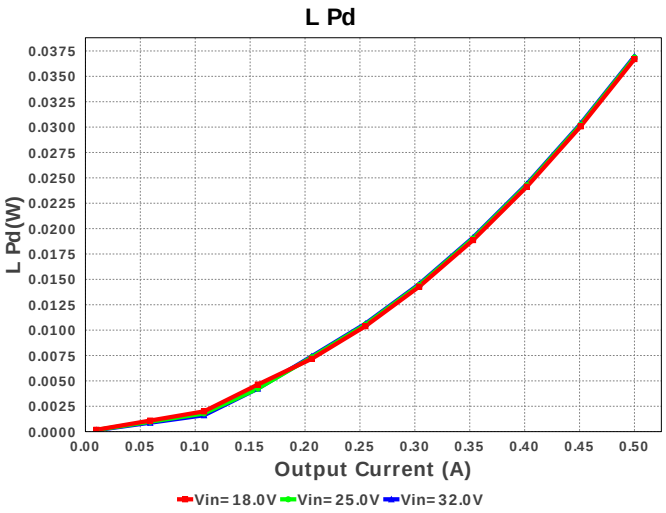


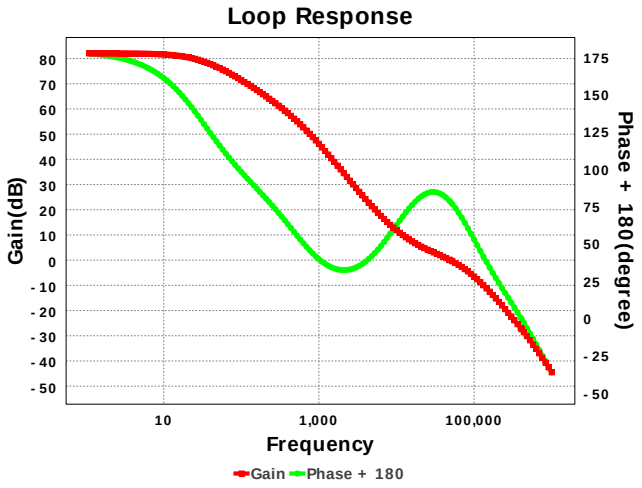


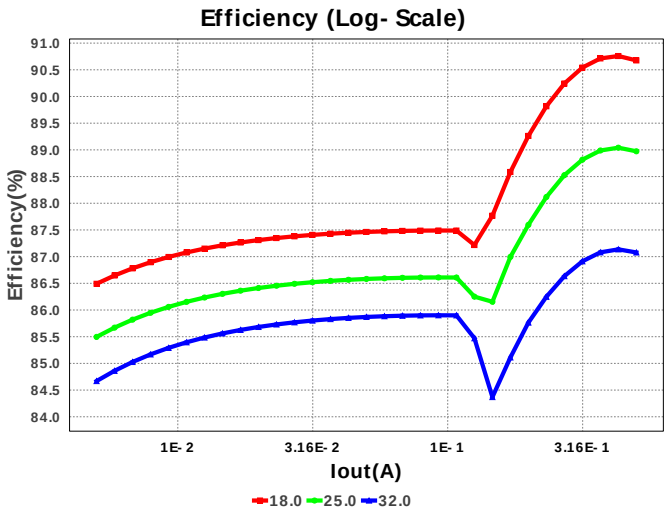












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	158.159 mA	Current	Input capacitor RMS ripple current
2.	Cout IRMS	101.448 mA	Current	Output capacitor RMS ripple current
3.	Iin Avg	59.214 mA	Current	Average input current
4.	L Ipp	351.43 mA	Current	Peak-to-peak inductor ripple current
5.	BOM Count	9	General	Total Design BOM count
6.	FootPrint	175.0 mm^2	General	Total Foot Print Area of BOM components
7.	Frequency	400.0 kHz	General	Switching frequency
8.	Mode	CCM	General	Conduction Mode
9.	Pout	1.65 W	General	Total output power
10.	Total BOM	$1.89	General	Total BOM Cost
11.	ICThetaJA Effective	18.0 degC/W	Op_Point	Effective IC Junction-to-Ambient Thermal Resistance
12.	Low Freq Gain	82.023 dB	Op_Point	Gain at 10Hz
13.	Vout Actual	3.308 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
14.	Vout OP	3.3 V	Op_Point	Operational Output Voltage
15.	Cross Freq	49.216 kHz	Op_point	Bode plot crossover frequency
16.	Duty Cycle	10.712 %	Op_point	Duty cycle
17.	Efficiency	87.078 %	Op_point	Steady state efficiency
18.	Gain Marg	-27.436 dB	Op_point	Bode Plot Gain Margin
19.	IC Tj	33.737 degC	Op_point	IC junction temperature
20.	IOUT_OP	500.0 mA	Op_point	Iout operating point
21.	Phase Marg	78.676 deg	Op_point	Bode Plot Phase Margin
22.	VIN_OP	32.0 V	Op_point	Vin operating point
23.	Vout p-p	1.288 mV	Op_point	Peak-to-peak output ripple voltage
24.	Cin Pd	50.029 µW	Power	Input capacitor power dissipation
25.	Cout Pd	50.275 µW	Power	Output capacitor power dissipation
26.	IC Iq Pd	160.0 µW	Power	IC Iq Pd
27.	IC Pd	207.635 mW	Power	IC power dissipation
28.	L Pd	36.961 mW	Power	Inductor power dissipation
29.	Total Pd	244.852 mW	Power	Total Power Dissipation
30.	Vout Tolerance	3.438 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable

Design Inputs

#	Name	Value	Description
1.	Iout	500.0 m	Maximum Output Current
2.	VinMax	32.0	Maximum input voltage
3.	VinMin	18.0	Minimum input voltage
4.	Vout	3.3	Output Voltage
5.	base_pn	LMR23610A	Base Product Number
6.	source	DC	Input Source Type
7.	Ta	30.0	Ambient temperature

Design Assistance

1. **LMR23610A** Product Folder : http://www.ti.com/product/LMR23610 : contains the data sheet and other resources.