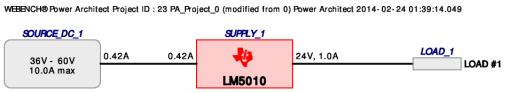


WEBENCH® Power Architect

Project Report

Project : 3930701/23 : PA_Project_0 (modified from 0)
Created : 2014-02-24 01:39:14.049
Optimize project optFactor=3

Project Summary

1.	Total System Efficiency	94.3 %
2.	Total System BOM Count	14.0
3.	Total System Footprint	384.0 mm2
4.	Total System BOM Cost	$2.48
5.	Total System Power Dissipation	1.451 W

--> Launch WEBENCH Power Architect.

Power Supplies

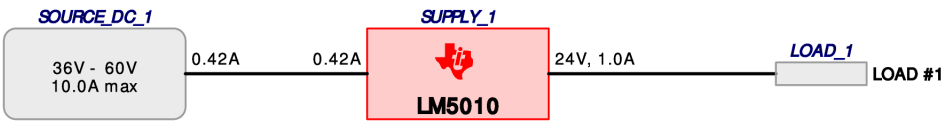
#	Name	NSID	Description	Vout	Iout	Efficiency	Foot-print	Cost	Design	Page
1.	SUPPLY_1	LM5010	Switcher : 75V 1.0A Step Down Regulator	24 V	1.0 A	94.3%	384	$2.48	26	4

Power Loads

#	Name	VLoad	ILoad	Description
1.	LOAD #1	24 V	1 A	VoutRipple=10%

Project Diagram

WEBENCH® Power Architect Project ID : 23 PA_Project_0 (modified from 0) Power Architect 2014-02-24 01:39:14.049



Electrical Procurement BOM

Manufacturer	Part Number	Description	Quantity	Budgetary Price	Footprint (mm^2)
Vishay-Semiconductor	BYS12-90-E3/TR	SMA	1	$0.08	37
Kemet	C0805C472K5RACTU	0805	1	$0.01	7
TDK	C2012X7R2A104K	0805	1	$0.03	7
TDK	C3216X7R2A105M	1206	1	$0.11	11
Vishay-Dale	CRCW0402340KFKED	0402	1	$0.01	3
Vishay-Dale	CRCW0402665RFKED	0402	1	$0.01	3
Taiyo Yuden	EMK212B7474KD-T	0805	1	$0.02	7
Panasonic	ERJ-6ENF5761V	0805	1	$0.01	7
MuRata	GRM155R61C223KA01D	0402	1	$0.01	3
MuRata	GRM188R72A682KA01D	0603	1	$0.01	5
MuRata	GRM31CR71H475KA12L	1206	1	$0.10	11
Texas Instruments	LM5010SD/NOPB	MXA14A	1	$1.43	59
Rohm	PMR25HZPFV1L00	1210	1	$0.24	15
Bourns	SRR1260-101M	SRR1260	1	$0.41	210
Total			**14**	**$2.48**	**384**

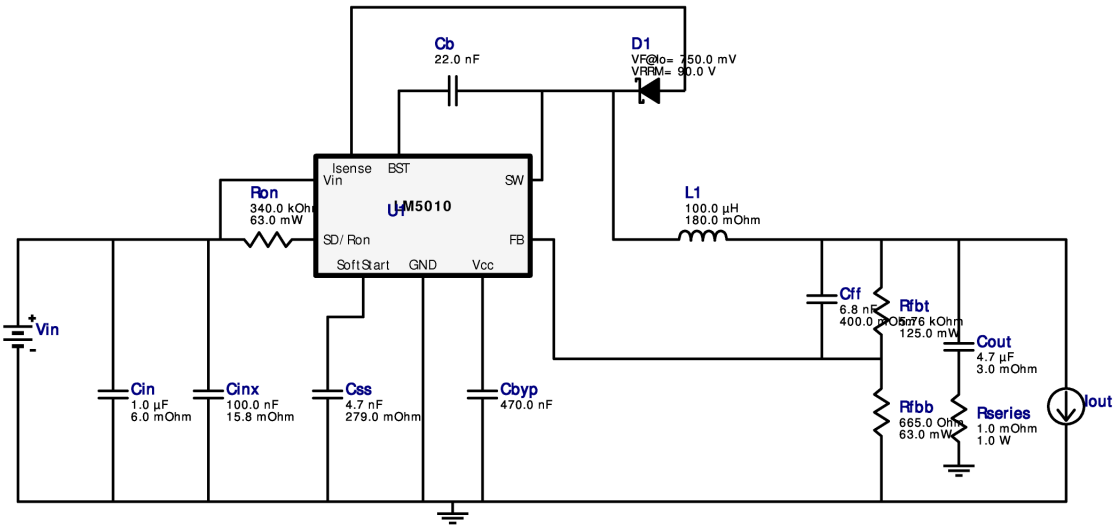
TEXAS INSTRUMENTS

WEBENCH® Design Report

VinMin = 36.0V
VinMax = 60.0V
Vout = 24.0V
Iout = 1.0A

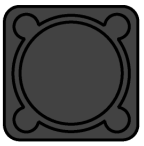
Device = LM5010SD/NOPB
Topology = Buck
Created = 2/24/14 1:39:06 AM
BOM Cost = $2.48
Total Pd = 1.45W
Footprint = 384.0mm2
BOM Count = 14

Design : 3930701/26 LM5010SD/NOPB
LM5010SD/NOPB 36.0V-60.0V to 24.0V @ 1.0A

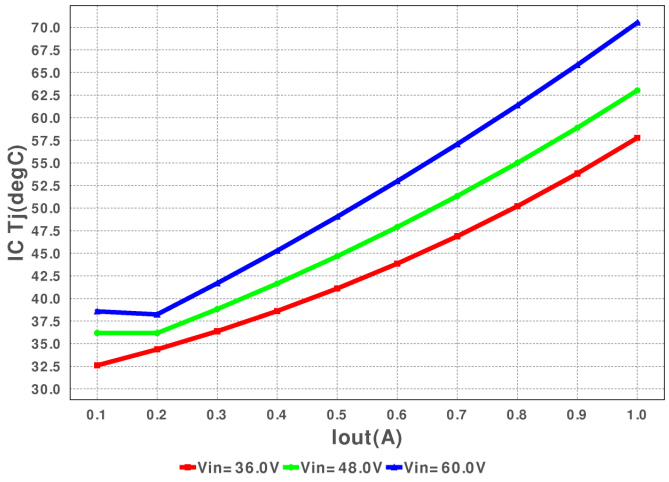


Electrical BOM

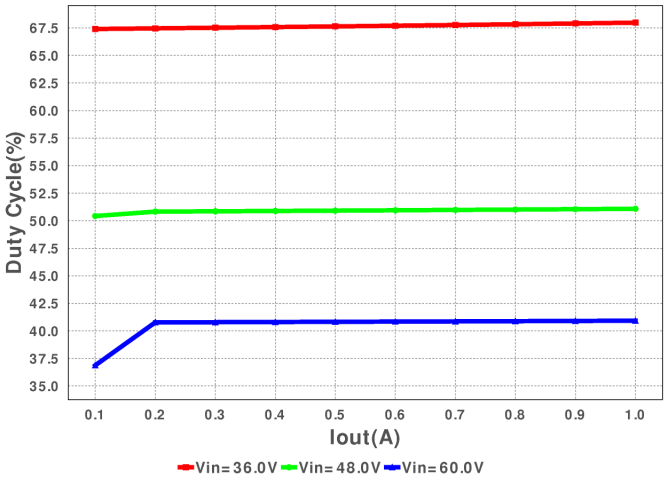
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Cb	MuRata	GRM155R61C223KA01D Series= X5R	Cap= 22.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3mm2
2.	Cbyp	Taiyo Yuden	EMK212B7474KD-T Series= X7R	Cap= 470.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0805 7mm2
3.	Cff	MuRata	GRM188R72A682KA01D Series= X7R	Cap= 6.8 nF ESR= 400.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.01	0603 5mm2
4.	Cin	TDK	C3216X7R2A105M Series= 285	Cap= 1.0 µF ESR= 6.0 mOhm VDC= 100.0 V IRMS= 4.5 A	1	$0.11	1206 11mm2
5.	Cinx	TDK	C2012X7R2A104K Series= X7R	Cap= 100.0 nF ESR= 15.8 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.03	0805 7mm2
6.	Cout	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 µF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	1	$0.10	1206 11mm2
7.	Css	Kemet	C0805C472K5RACTU Series= X7R	Cap= 4.7 nF ESR= 279.0 mOhm VDC= 50.0 V IRMS= 321.0 mA	1	$0.01	0805 7mm2
8.	D1	Vishay-Semiconductor	BYS12-90-E3/TR	VF@Io= 750.0 mV VRRM= 90.0 V	1	$0.08	SMA 37mm2

#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
9.	L1	Bourns	SRR1260-101M	L= 100.0 µH DCR= 180.0 mOhm	1	$0.41	 SRR1260 210mm2
10.	Rfbb	Vishay-Dale	CRCW0402665RFKED Series= CRCW..e3	Res= 665.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3mm2
11.	Rfbt	Panasonic	ERJ-6ENF5761V Series= 225	Res= 5.76 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	 0805 7mm2
12.	Ron	Vishay-Dale	CRCW0402340KFKED Series= CRCW..e3	Res= 340.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3mm2
13.	Rseries	Rohm	PMR25HZPFV1L00 Series= 313	Res= 1.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.24	 1210 15mm2
14.	U1	Texas Instruments	LM5010SD/NOPB	Switcher	1	$1.43	 MXA14A 59mm2

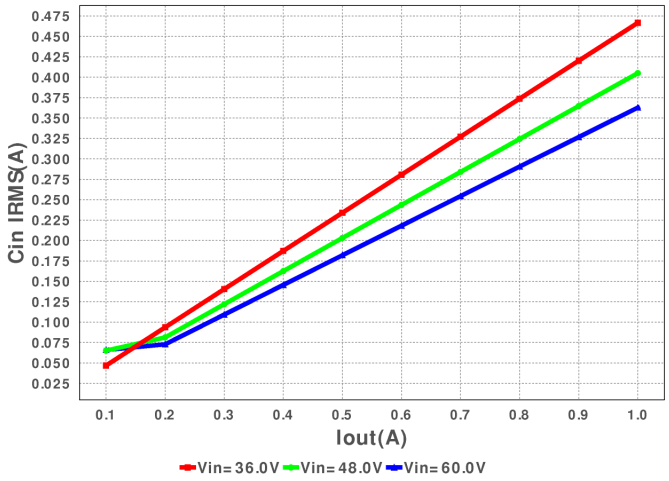
IC Tj



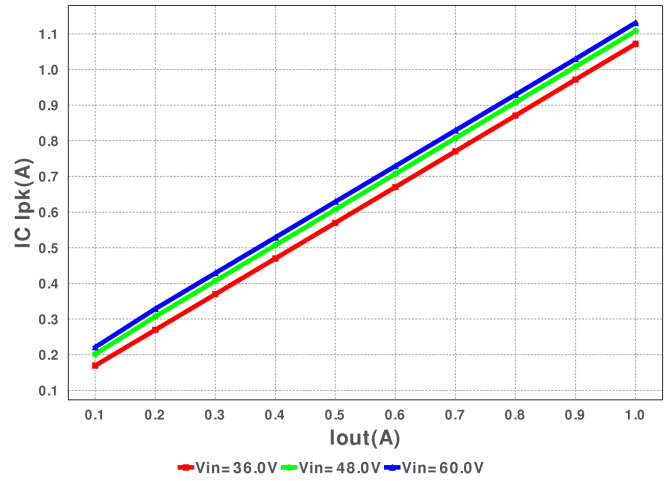
Duty Cycle



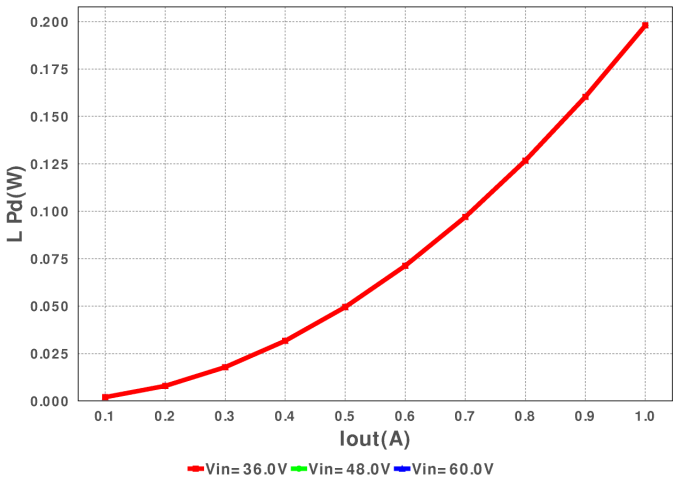
Cin IRMS



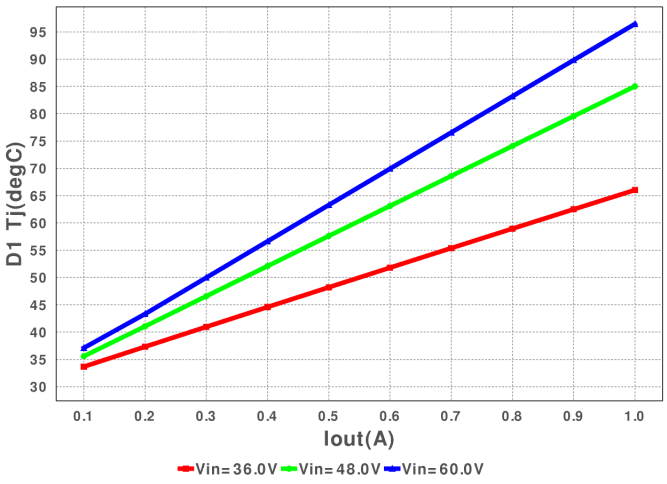
IC Ipk



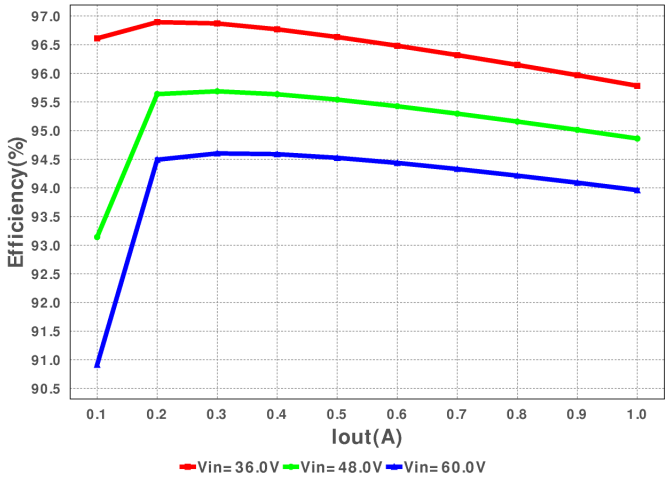
L Pd



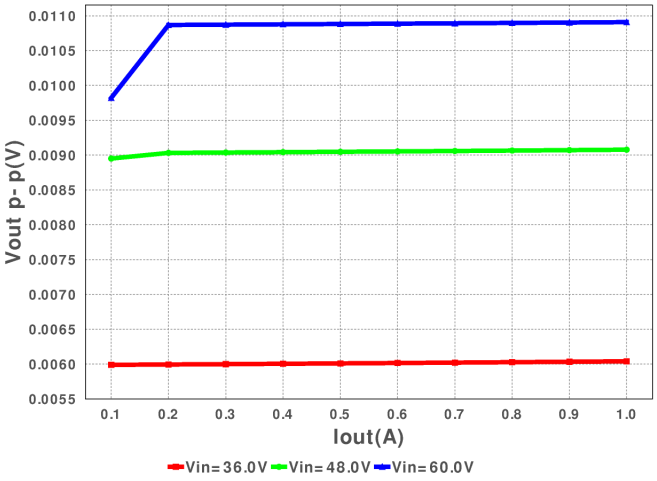
D1 Tj



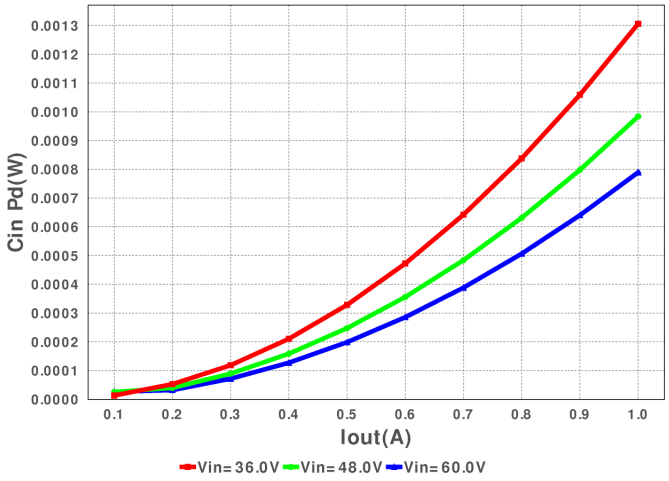
Efficiency



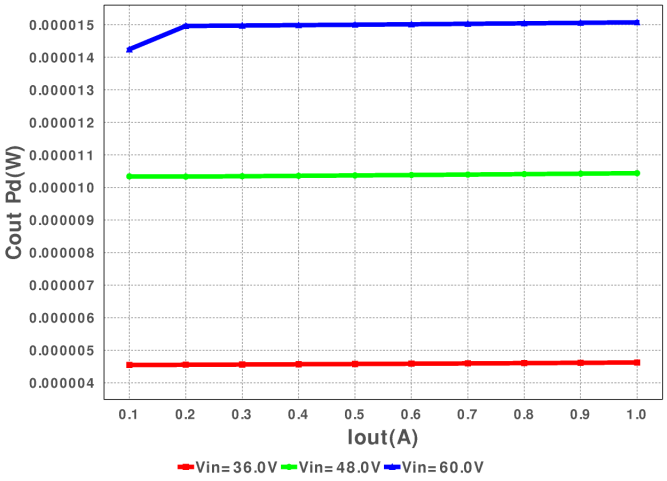
Vout p- p

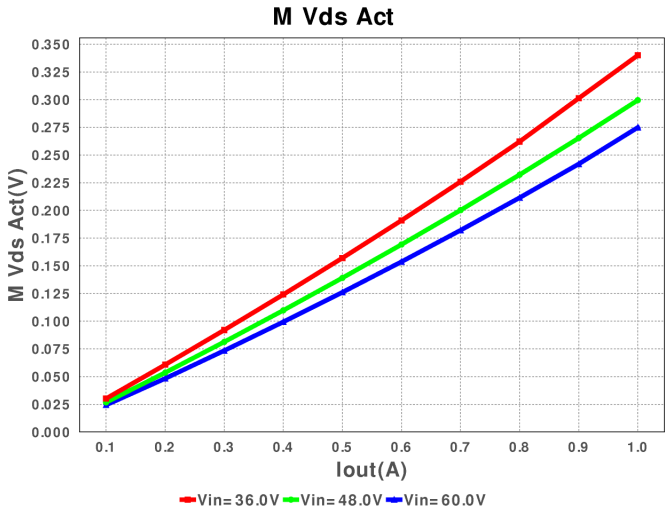


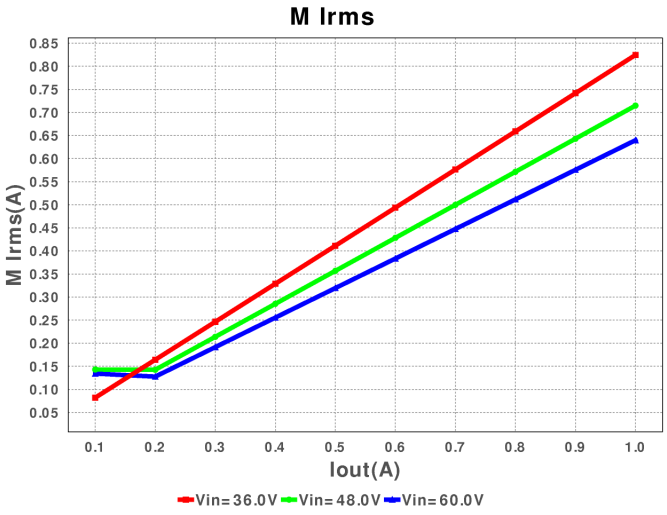
Cin Pd

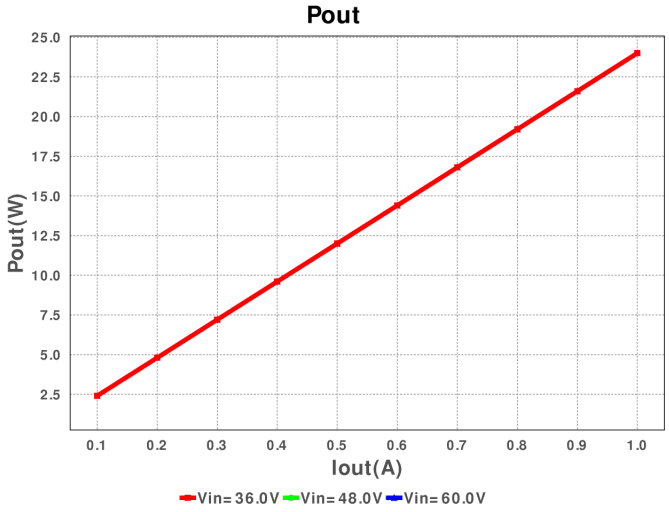


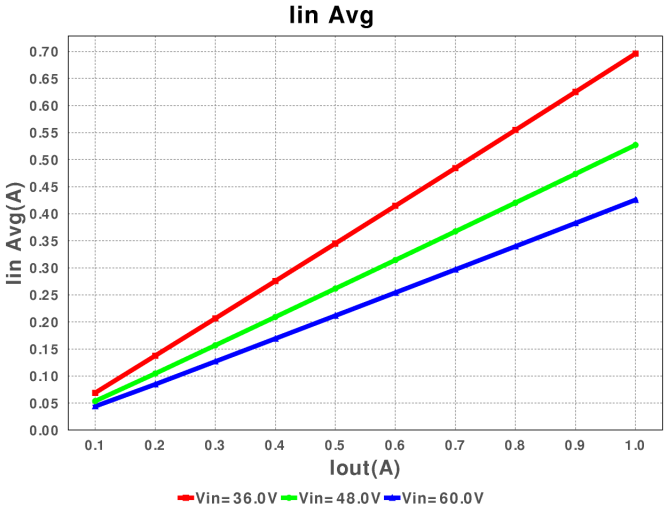
Cout Pd

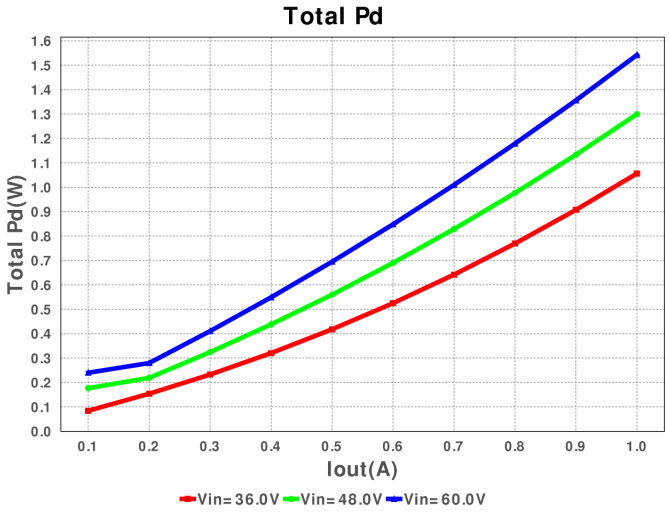


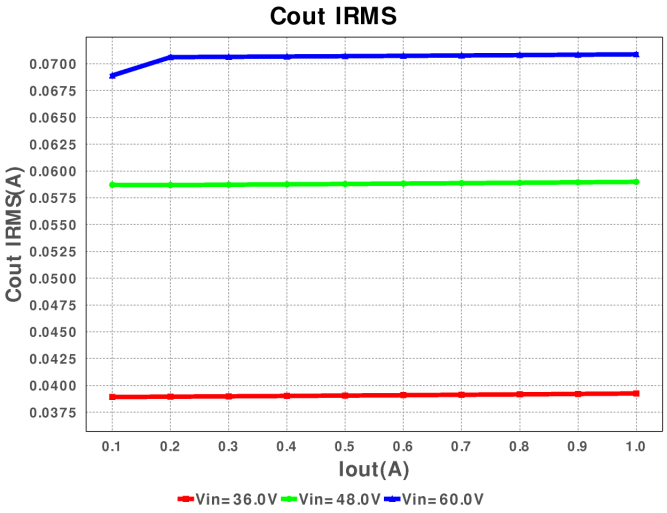


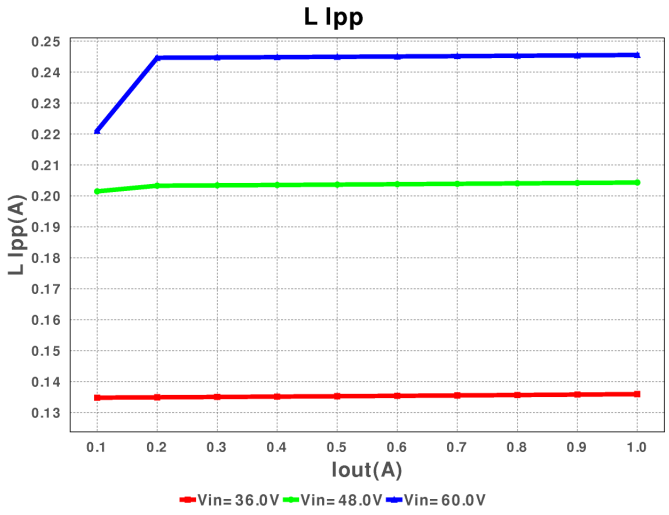


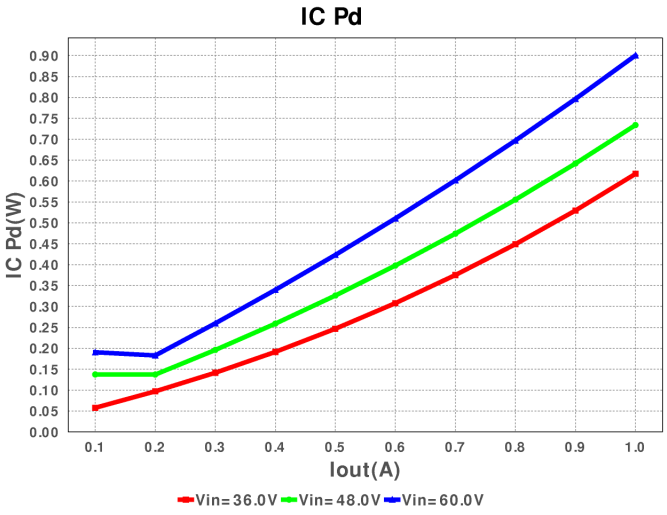


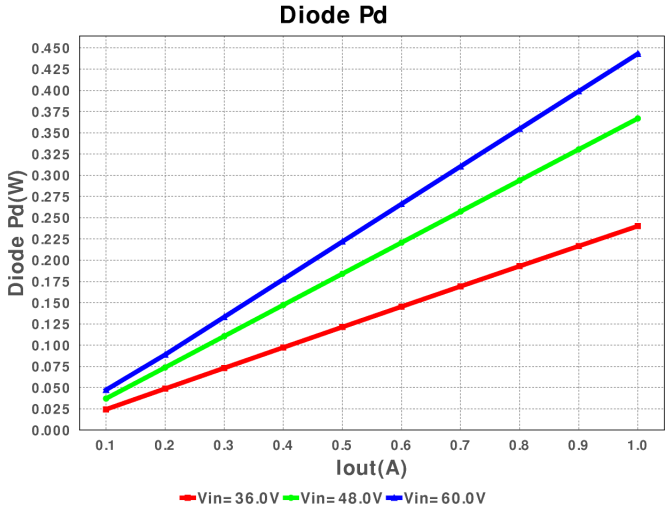












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	362.783 mA	Current	Input capacitor RMS ripple current
2.	Cout IRMS	80.999 mA	Current	Output capacitor RMS ripple current
3.	IC Ipk	1.14 A	Current	Peak switch current in IC
4.	Iin Avg	424.18 mA	Current	Average input current
5.	L Ipp	280.59 mA	Current	Peak-to-peak inductor ripple current
6.	M1 Irms	639.682 mA	Current	Q Iavg
7.	BOM Count	14	General	Total Design BOM count
8.	FootPrint	384.0 mm2	General	Total Foot Print Area of BOM components
9.	Frequency	525.0 kHz	General	Switching frequency
10.	IC Tolerance	50.0 mV	General	IC Feedback Tolerance
11.	M Vds Act	265.161 mV	General	Voltage drop across the MosFET
12.	Pout	24.0 W	General	Total output power
13.	Total BOM	$2.48	General	Total BOM Cost
14.	D1 Tj	96.466 degC	Op_Point	D1 junction temperature
15.	Vout OP	24.0 V	Op_Point	Operational Output Voltage
16.	Duty Cycle	40.919 %	Op_point	Duty cycle
17.	Efficiency	94.3 %	Op_point	Steady state efficiency
18.	IC Tj	62.353 degC	Op_point	IC junction temperature
19.	ICThetaJA	40.0 degC/W	Op_point	IC junction-to-ambient thermal resistance
20.	IOUT_OP	1.0 A	Op_point	Iout operating point
21.	VIN_OP	60.0 V	Op_point	Vin operating point
22.	Vout p-p	14.239 mV	Op_point	Peak-to-peak output ripple voltage
23.	Cin Pd	789.668 µW	Power	Input capacitor power dissipation
24.	Cout Pd	19.683 µW	Power	Output capacitor power dissipation
25.	Diode Pd	443.105 mW	Power	Diode power dissipation
26.	IC Pd	808.824 mW	Power	IC power dissipation
27.	L Pd	198.0 mW	Power	Inductor power dissipation
28.	Total Pd	1.451 W	Power	Total Power Dissipation

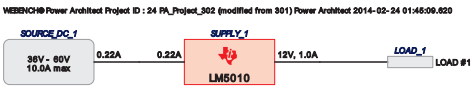
Design Inputs

#	Name	Value	Description
1.	Iout	1.0 A	Maximum Output Current
2.	Iout1	1.0 Amps	Output Current #1
3.	VinMax	60.0 V	Maximum input voltage
4.	VinMin	36.0 V	Minimum input voltage
5.	Vout	24.0 V	Output Voltage
6.	Vout1	24.0 Volt	Output Voltage #1
7.	base_pn	LM5010	Base Product Number
8.	source	DC	Input Source Type
9.	Ta	30.0 degC	Ambient temperature

Design Assistance

1. For a Constant On Time device to be stable, we need to provide a ripple at the feedback comparator. There are various methods to implement the ripple. Depending on the circuit complexity vs. the allowable ripple, we have three options to choose from. The simplest option, 'Low Complexity', would require only a high ESR cap at the output. This means that the BOM count will be small, but the output voltage ripple will be quite large. The 'Optimal Solution' would require a feed-forward cap in parallel with the upper feedback resistor to AC couple the ripple to the feedback node. This increases the BOM count slightly, but now we have more control over the output voltage ripple. If the output voltage requirement is very tight, then the best option is to go for the 'Low Output Ripple' solution. In this option we can go with very low ESR output caps and have very good control over the output voltage ripple.

2. **LM5010** Product Folder : http://www.ti.com/product/lm5010 : contains the data sheet and other resources.



WEBENCH® Power Architect

Project Report

Project : 3930701/24 : PA_Project_302 (modified from 301)
Created : 2014-02-24 01:45:09.620
Optimize project optFactor=3

Project Summary

1.	Total System Efficiency	89.902 %
2.	Total System BOM Count	14.0
3.	Total System Footprint	382.0 mm2
4.	Total System BOM Cost	$2.47
5.	Total System Power Dissipation	1.348 W

--> Launch WEBENCH Power Architect.

Power Supplies

#	Name	NSID	Description	Vout	Iout	Efficiency	Foot-print	Cost	Design	Page
1.	SUPPLY_1	LM5010	Switcher : 75V 1.0A Step Down Regulator	12 V	1.0 A	89.9%	382	$2.47	27	4

Power Loads

#	Name	VLoad	ILoad	Description
1.	LOAD #1	12 V	1 A	VoutRipple=10%

Project Diagram

Electrical Procurement BOM

Manufacturer	Part Number	Description	Quantity	Budgetary Price	Footprint (mm^2)
Vishay-Semiconductor	BYS12-90-E3/TR	SMA	1	$0.08	37
Kemet	C0805C472K5RACTU	0805	1	$0.01	7
Kemet	C1206C182K5RACTU	1206	1	$0.06	11
TDK	C2012X7R2A104K	0805	1	$0.03	7
TDK	C3216X7R2A105M	1206	1	$0.11	11
Vishay-Dale	CRCW0402154KFKED	0402	1	$0.01	3
Vishay-Dale	CRCW04021K50FKED	0402	1	$0.01	3
Vishay-Dale	CRCW04025K76FKED	0402	1	$0.01	3
Taiyo Yuden	EMK212B7474KD-T	0805	1	$0.02	7
MuRata	GRM155R61C223KA01D	0402	1	$0.01	3
MuRata	GRM21BR61C475KA88L	0805	1	$0.04	7
Texas Instruments	LM5010SD/NOPB	MXA14A	1	$1.43	59
Rohm	PMR25HZPFV1L00	1210	1	$0.24	15
Bourns	SRR1260-101M	SRR1260	1	$0.41	210
Total			**14**	**$2.47**	**382**

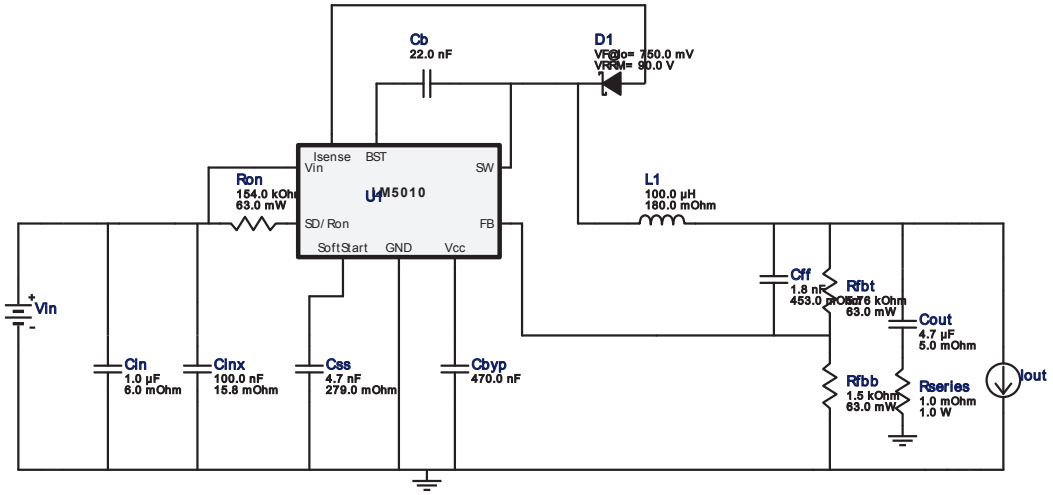
TEXAS INSTRUMENTS

WEBENCH® Design Report

VinMin = 36.0V
VinMax = 60.0V
Vout = 12.0V
Iout = 1.0A

Device = LM5010SD/NOPB
Topology = Buck
Created = 2/24/14 1:45:08 AM
BOM Cost = $2.47
Total Pd = 1.35W
Footprint = 382.0mm2
BOM Count = 14

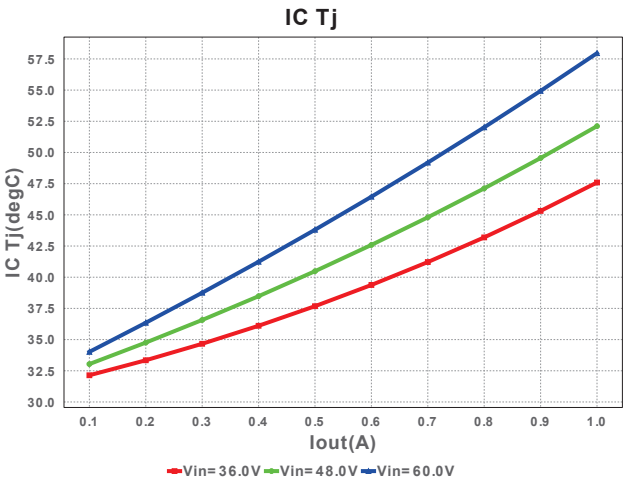
Design : 3930701/27 LM5010SD/NOPB
LM5010SD/NOPB 36.0V-60.0V to 12.0V @ 1.0A

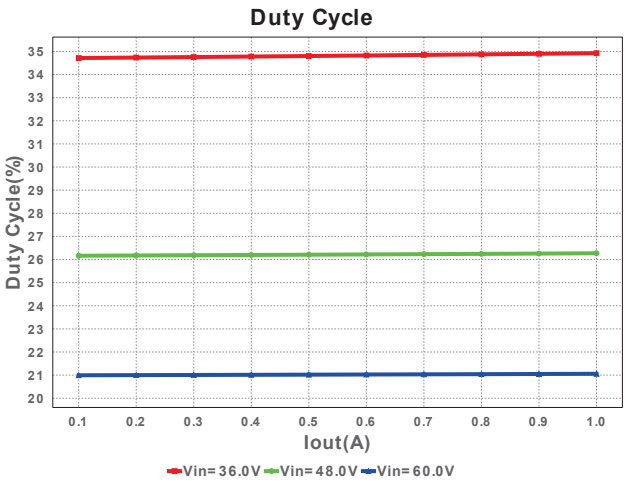


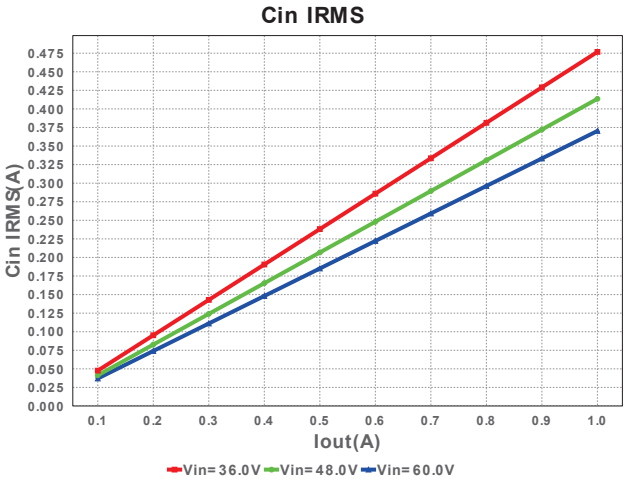
Electrical BOM

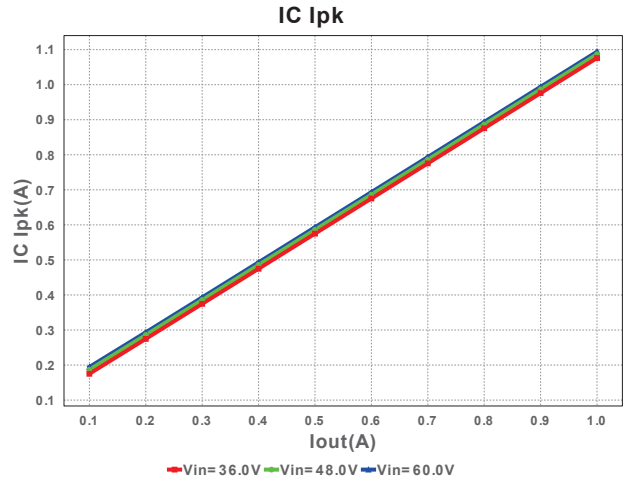
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Cb	MuRata	GRM155R61C223KA01D Series= X5R	Cap= 22.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3mm2
2.	Cbyp	Taiyo Yuden	EMK212B7474KD-T Series= X7R	Cap= 470.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0805 7mm2
3.	Cff	Kemet	C1206C182K5RACTU Series= X7R	Cap= 1.8 nF ESR= 453.0 mOhm VDC= 50.0 V IRMS= 190.0 mA	1	$0.06	1206 11mm2
4.	Cin	TDK	C3216X7R2A105M Series= 285	Cap= 1.0 µF ESR= 6.0 mOhm VDC= 100.0 V IRMS= 4.5 A	1	$0.11	1206 11mm2
5.	Cinx	TDK	C2012X7R2A104K Series= X7R	Cap= 100.0 nF ESR= 15.8 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.03	0805 7mm2
6.	Cout	MuRata	GRM21BR61C475KA88L Series= X5R	Cap= 4.7 µF ESR= 5.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.04	0805 7mm2
7.	Css	Kemet	C0805C472K5RACTU Series= X7R	Cap= 4.7 nF ESR= 279.0 mOhm VDC= 50.0 V IRMS= 321.0 mA	1	$0.01	0805 7mm2
8.	D1	Vishay-Semiconductor	BYS12-90-E3/TR	VF@Io= 750.0 mV VRRM= 90.0 V	1	$0.08	SMA 37mm2

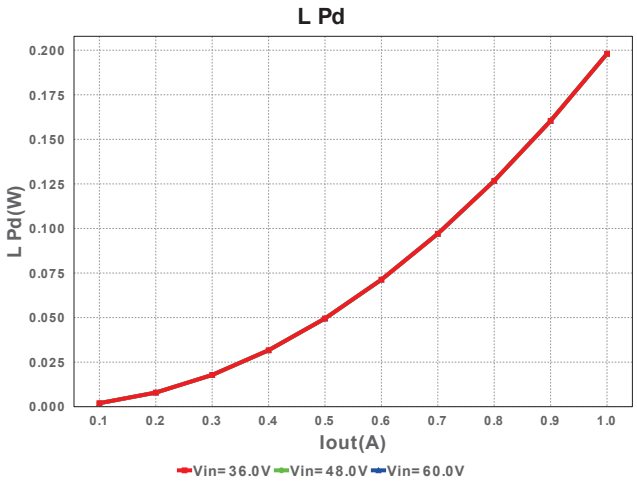
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
9.	L1	Bourns	SRR1260-101M	L= 100.0 µH DCR= 180.0 mOhm	1	$0.41	 SRR1260 210mm2
10.	Rfbb	Vishay-Dale	CRCW04021K50FKED Series= CRCW..e3	Res= 1.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3mm2
11.	Rfbt	Vishay-Dale	CRCW04025K76FKED Series= CRCW..e3	Res= 5.76 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3mm2
12.	Ron	Vishay-Dale	CRCW0402154KFKED Series= CRCW..e3	Res= 154.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3mm2
13.	Rseries	Rohm	PMR25HZPFV1L00 Series= 313	Res= 1.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.24	 1210 15mm2
14.	U1	Texas Instruments	LM5010SD/NOPB	Switcher	1	$1.43	 MXA14A 59mm2

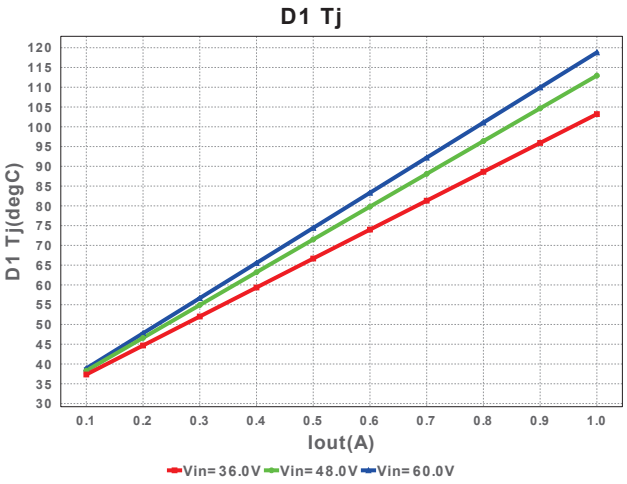


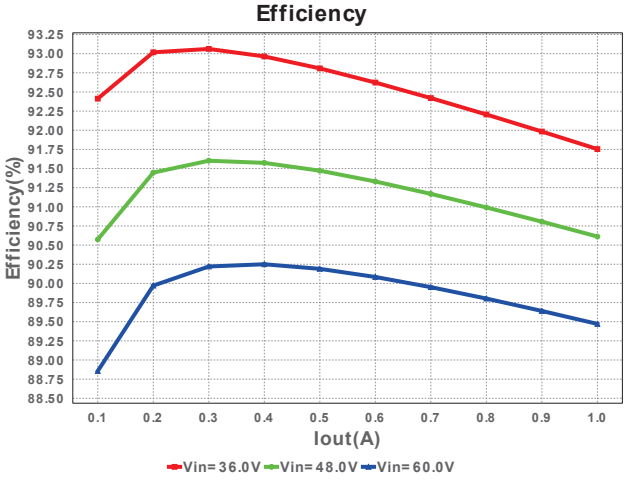


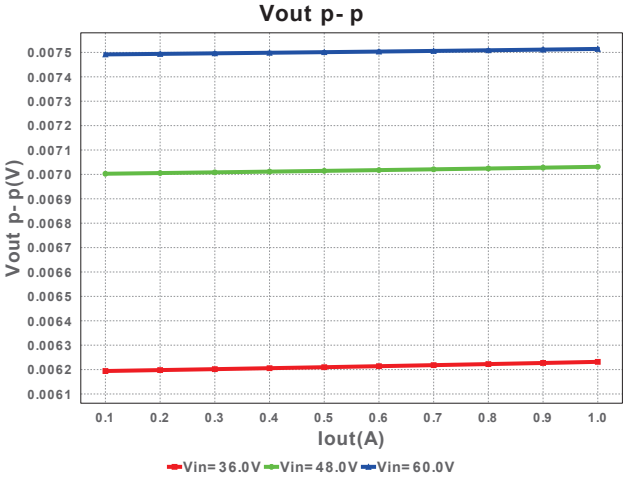


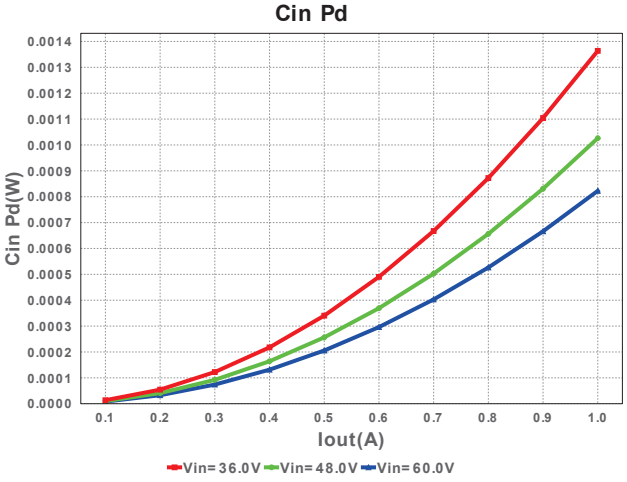


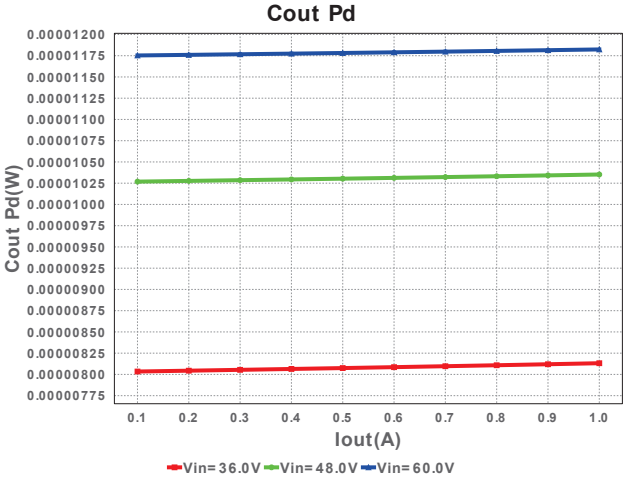


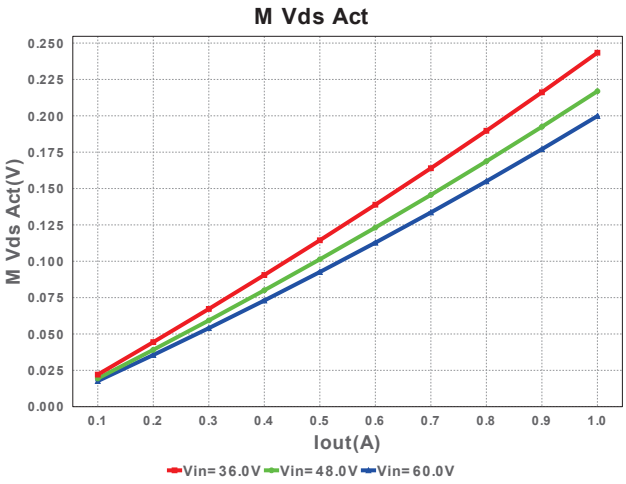


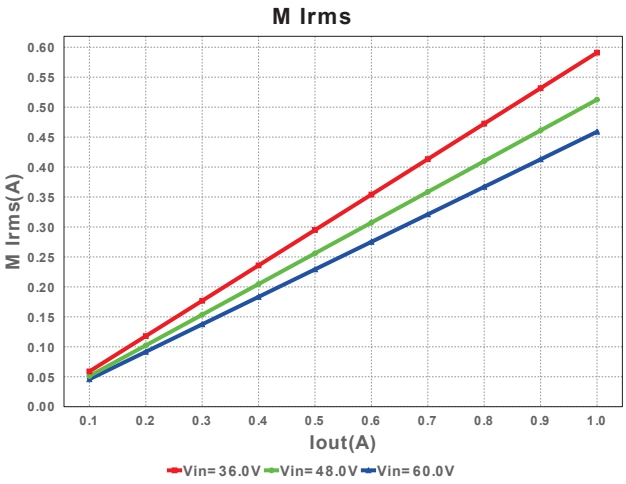


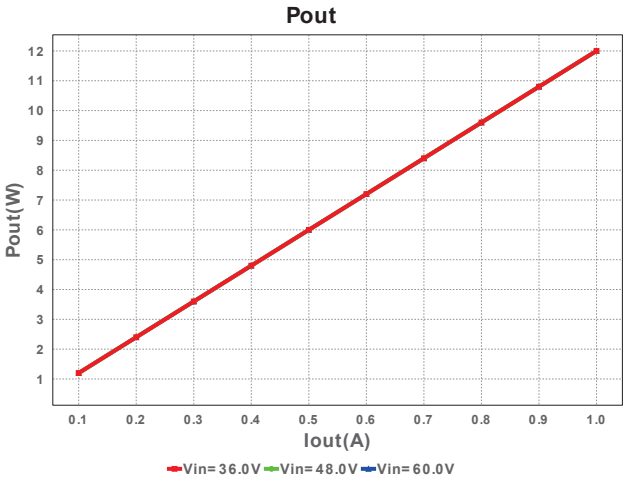


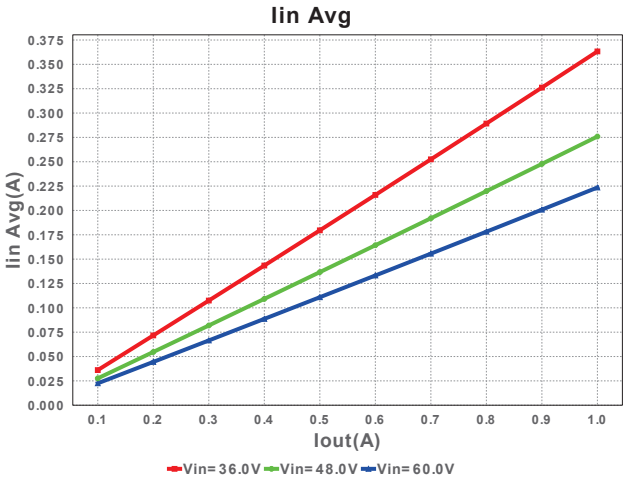


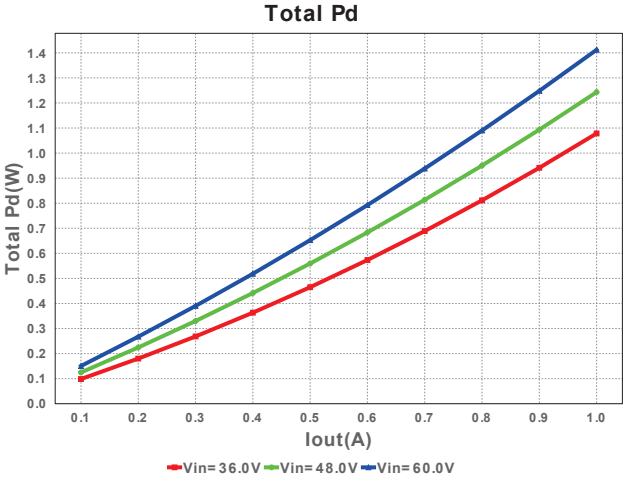


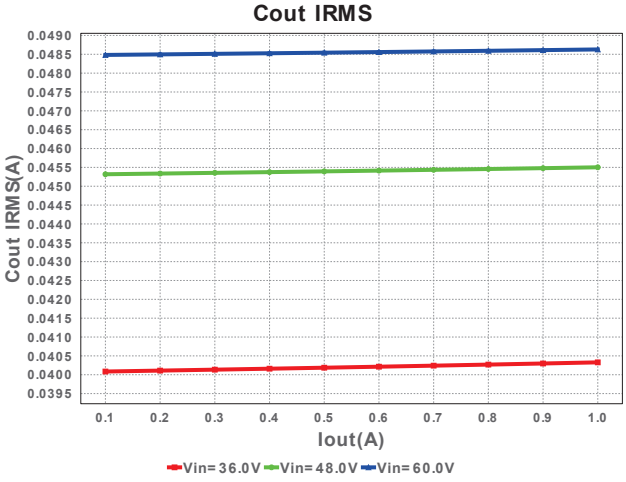


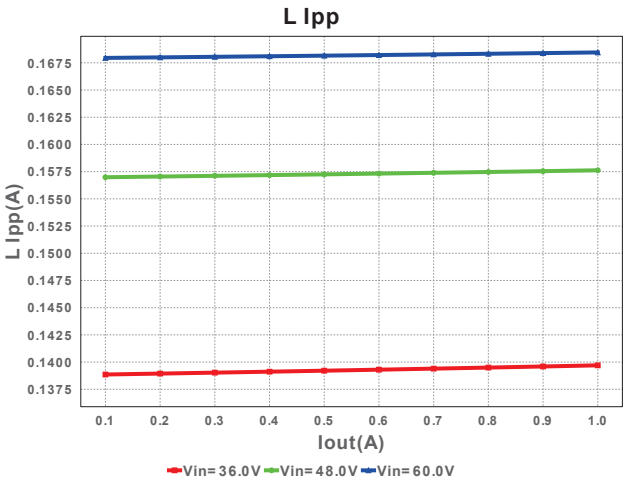


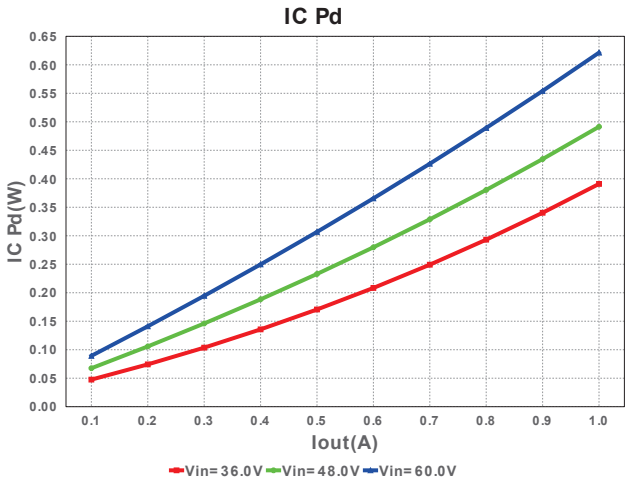


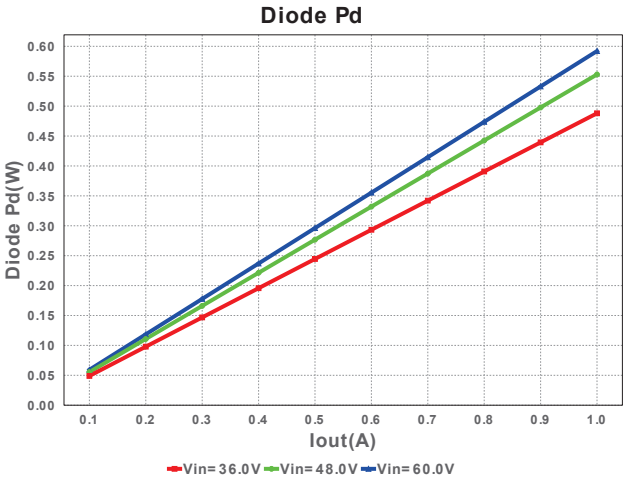












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	370.289 mA	Current	Input capacitor RMS ripple current
2.	Cout IRMS	55.57 mA	Current	Output capacitor RMS ripple current
3.	IC Ipk	1.096 A	Current	Peak switch current in IC
4.	Iin Avg	222.46 mA	Current	Average input current
5.	L Ipp	192.501 mA	Current	Peak-to-peak inductor ripple current
6.	M1 Irms	458.855 mA	Current	Q Iavg
7.	BOM Count	14	General	Total Design BOM count
8.	FootPrint	382.0 mm2	General	Total Foot Print Area of BOM components
9.	Frequency	525.0 kHz	General	Switching frequency
10.	IC Tolerance	50.0 mV	General	IC Feedback Tolerance
11.	M Vds Act	193.639 mV	General	Voltage drop across the MosFET
12.	Pout	12.0 W	General	Total output power
13.	Total BOM	$2.47	General	Total BOM Cost
14.	D1 Tj	118.813 degC	Op_Point	D1 junction temperature
15.	Vout OP	12.0 V	Op_Point	Operational Output Voltage
16.	Duty Cycle	21.055 %	Op_point	Duty cycle
17.	Efficiency	89.902 %	Op_point	Steady state efficiency
18.	IC Tj	52.275 degC	Op_point	IC junction temperature
19.	ICThetaJA	40.0 degC/W	Op_point	IC junction-to-ambient thermal resistance
20.	IOUT_OP	1.0 A	Op_point	Iout operating point
21.	VIN_OP	60.0 V	Op_point	Vin operating point
22.	Vout p-p	9.799 mV	Op_point	Peak-to-peak output ripple voltage
23.	Cin Pd	822.681 µW	Power	Input capacitor power dissipation
24.	Cout Pd	15.44 µW	Power	Output capacitor power dissipation
25.	Diode Pd	592.089 mW	Power	Diode power dissipation
26.	IC Pd	556.873 mW	Power	IC power dissipation
27.	L Pd	198.0 mW	Power	Inductor power dissipation
28.	Total Pd	1.348 W	Power	Total Power Dissipation

Design Inputs

#	Name	Value	Description
1.	Iout	1.0 A	Maximum Output Current
2.	Iout1	1.0 Amps	Output Current #1
3.	VinMax	60.0 V	Maximum input voltage
4.	VinMin	36.0 V	Minimum input voltage
5.	Vout	12.0 V	Output Voltage
6.	Vout1	12.0 Volt	Output Voltage #1
7.	base_pn	LM5010	Base Product Number
8.	source	DC	Input Source Type
9.	Ta	30.0 degC	Ambient temperature

Design Assistance

1. For a Constant On Time device to be stable, we need to provide a ripple at the feedback comparator. There are various methods to implement the ripple. Depending on the circuit complexity vs. the allowable ripple, we have three options to choose from. The simplest option, 'Low Complexity', would require only a high ESR cap at the output. This means that the BOM count will be small, but the output voltage ripple will be quite large. The 'Optimal Solution' would require a feed-forward cap in parallel with the upper feedback resistor to AC couple the ripple to the feedback node. This increases the BOM count slightly, but now we have more control over the output voltage ripple. If the output voltage requirement is very tight, then the best option is to go for the 'Low Output Ripple' solution. In this option we can go with very low ESR output caps and have very good control over the output voltage ripple.

2. **LM5010** Product Folder : http://www.ti.com/product/lm5010 : contains the data sheet and other resources.