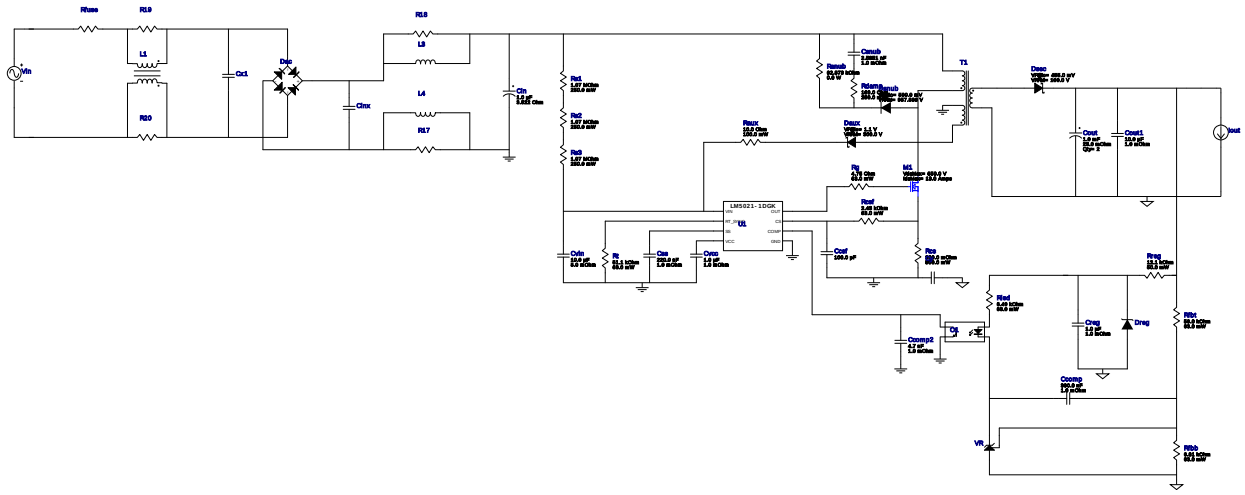
WEBENCH® Design Report

VinMin = 240.0V
VinMax = 340.0V
Vout = 24.0V
Iout = 2.0A

Device = LM5021NA-1/NOPB
Topology = Flyback
Created = 2021-01-08 01:56:28.358
BOM Cost = NA
BOM Count = 35
Total Pd = 6.76W

Design : 40 LM5021NA-1/NOPB
LM5021NA-1/NOPB 240V-340V to 24.00V @ 2A

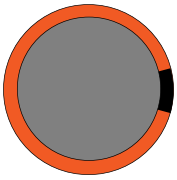


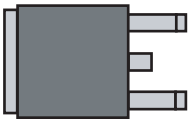
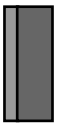
2. Click on the transformer symbol and select 'Design Transformer' to design using specific transformer cores and bobbin

Design Alerts

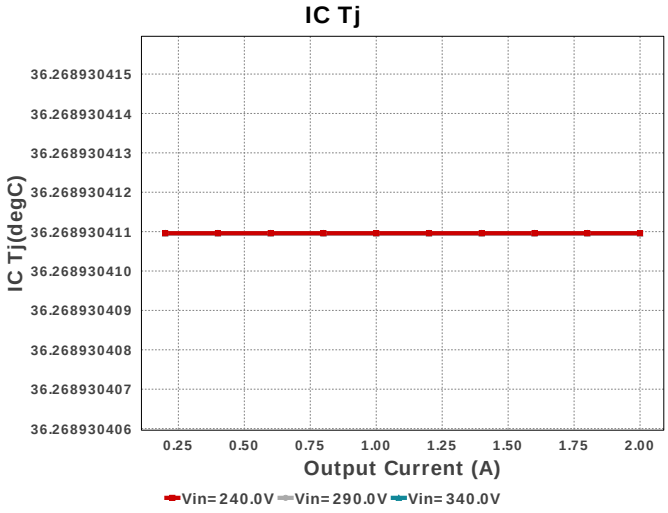
Component Selection Information
Click on the transformer symbol in the schematic and select "Explore Transformer Core/Bobbin Selection" to design using specific transformer cores and bobbin.

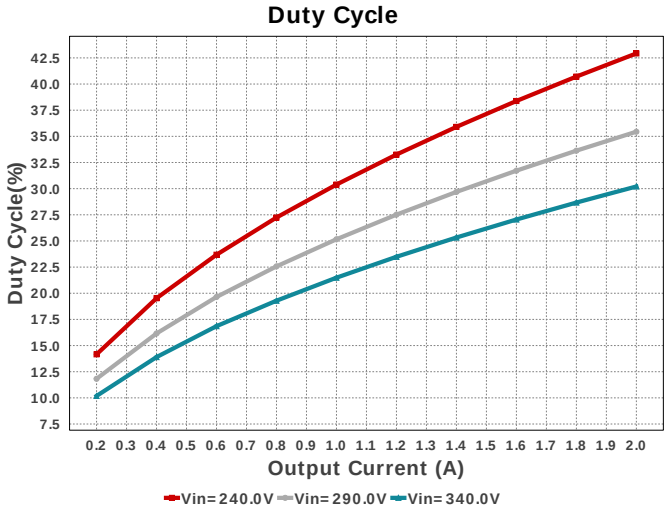
Electrical BOM

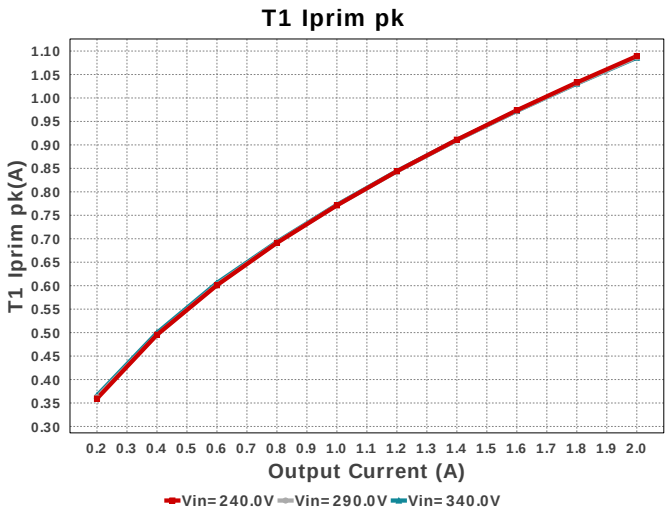
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Ccomp	MuRata	GRM155R61A394KE15D Series= X5R	Cap= 390.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 6.0 A	1	$0.03	0402 3 mm^2
Ccomp2	MuRata	GRM033R71A472KA01D Series= X7R	Cap= 4.7 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
Ccsf	Samsung Electro-Mechanics	CL21C101JBANNNC Series= C0G/NP0	Cap= 100.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cin	CUSTOM	CUSTOM Series= ?	Cap= 1.0 uF ESR= 3.8225 Ohm VDC= 408.0 V IRMS= 428.57 mA	1	NA	CUSTOM 0 mm^2
Cout	TDK	B41896C6108M000 Series= 2355	Cap= 1.0 mF ESR= 23.0 mOhm VDC= 50.0 V IRMS= 3.16 A	2	$1.03	 B41896_1600x3150 324 mm^2
Cout1	TDK	C3216X5R1H106K160AB Series= X5R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 4.9 A	1	$0.26	1206_180 11 mm^2

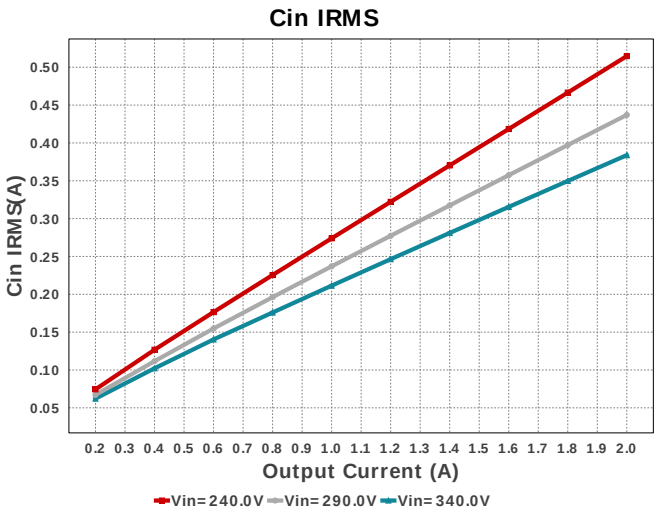
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Creg	Kemet	C0603C105K8PACTU Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	 0603 5 mm²
Csnub	CUSTOM	CUSTOM Series= ?	Cap= 2.5651 nF ESR= 1.0 mOhm VDC= 549.84 V IRMS= 86.343 mA	1	NA	CUSTOM 0 mm²
Css	Kemet	C0603C224Z4VACTU Series= Y5V	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	 0603 5 mm²
Cvcc	Taiyo Yuden	EMK107B7105KA-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.02	 0603 5 mm²
Cvin	Samsung Electro-Mechanics	CL32B106KBJNNWE Series= X7R	Cap= 10.0 uF ESR= 5.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.17	 1210_270 15 mm²
Daux	SMC Diode Solutions	ST1300ATR	VF@Io= 1.1 V VRRM= 300.0 V	1	$0.07	 SMA 37 mm²
Dreg	Diodes Inc.	SMBJ5.0A-13-F	Zener	1	$0.09	 SMB 44 mm²
Dsec	STMicroelectronics	STPS20M100SG-TR	VF@Io= 455.0 mV VRRM= 100.0 V	1	$1.33	 DDPAK 210 mm²
Dsnub	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 957.836 V	1	NA	CUSTOM 0 mm²
M1	Infineon Technologies	IPP65R190C7	VdsMax= 650.0 V IdsMax= 13.0 Amps	1	$1.43	 TO-220AB 79 mm²
O1	Fairchild Semiconductor	FOD817A	Optocoupler	1	$0.11	 DIP-4 71 mm²
Raux	Vishay-Dale	CRCW060310R0FKEA Series= CRCW..e3	Res= 10.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	 0603 5 mm²
Rcs	Rohm	MCR25JZHFLR390 Series= MCR25	Res= 390.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.03	 1210 15 mm²
Rcsf	Vishay-Dale	CRCW04022K43FKED Series= CRCW..e3	Res= 2.43 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
Rdamp	Vishay-Dale	CMF50169R00FHEB Series= CMF50	Res= 169.0 Ohm Power= 250.0 mW Tolerance= 1.0%	1	$0.20	 CMF50 46 mm²
Rfbb	Vishay-Dale	CRCW04026K81FKED Series= CRCW..e3	Res= 6.81 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
Rfbt	Vishay-Dale	CRCW040259K0FKED Series= CRCW..e3	Res= 59.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
Rg	Vishay-Dale	CRCW04024R75FKED Series= CRCW..e3	Res= 4.75 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²

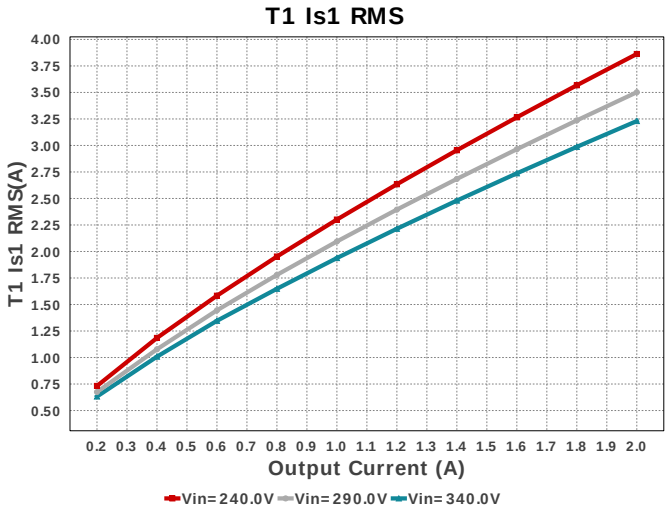
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rled	Vishay-Dale	CRCW04026K49FKED Series= CRCW..e3	Res= 6.49 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rreg	Yageo	RC0201FR-0712K1L Series= ?	Res= 12.1 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rs1	Vishay-Dale	CRCW12061M07FKEA Series= CRCW..e3	Res= 1.07 MOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²
Rs2	Vishay-Dale	CRCW12061M07FKEA Series= CRCW..e3	Res= 1.07 MOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²
Rs3	Vishay-Dale	CRCW12061M07FKEA Series= CRCW..e3	Res= 1.07 MOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²
Rsnub	CUSTOM	CUSTOM Series= ?	Res= 62.878 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rt	Vishay-Dale	CRCW040251K1FKED Series= CRCW..e3	Res= 51.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
T1	Core=TDK , CoilFormer=TDK	Core=B66317G0000X187 , CoilFormer=B66208X1110T001	Lp= 729.0 µH Turns Ratio(Nas)= 5:8 Turns Ratio(Nps)= 75:8 Npri= 75.0 Naux= 5.0 Nsec= 8.0	1	$0.22	TDK_B66305 569 mm²
U1	Texas Instruments	LM5021NA-1/NOPB	Switcher	1	$0.58	DGK0008A 24 mm²
VR	Texas Instruments	TL431IDBVR	Voltage References	1	$0.06	R-PDSO-G3 16 mm²

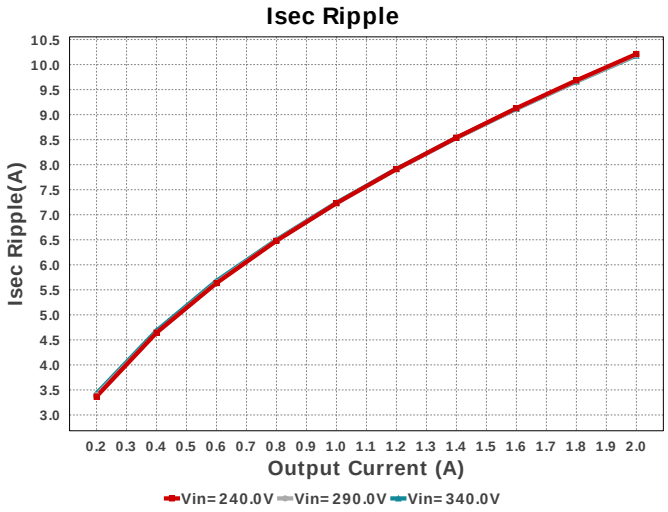


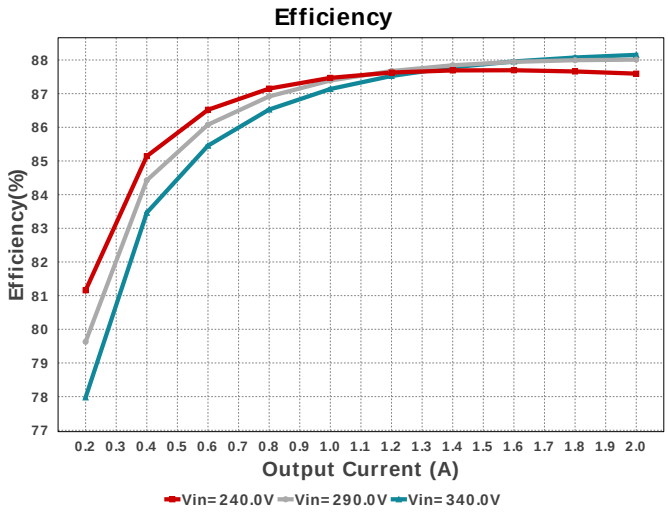


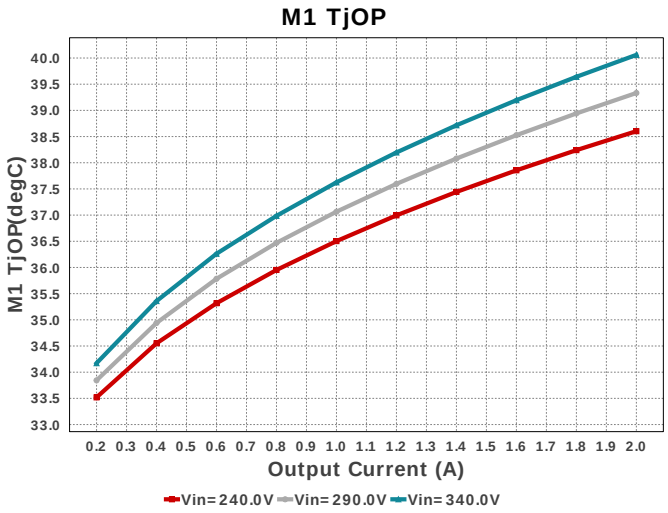


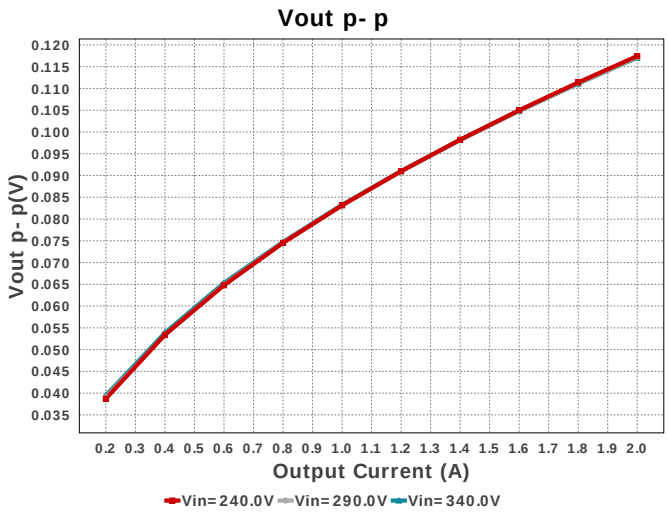


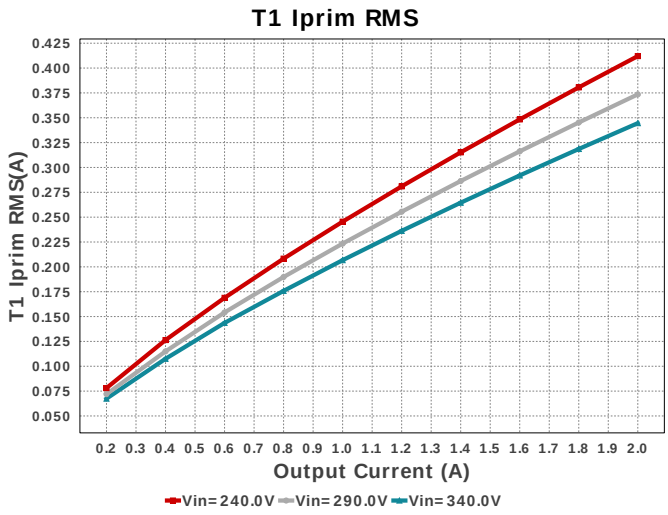


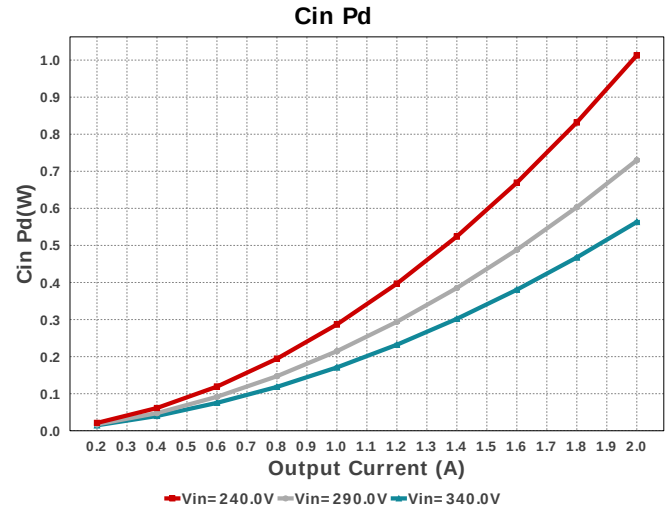


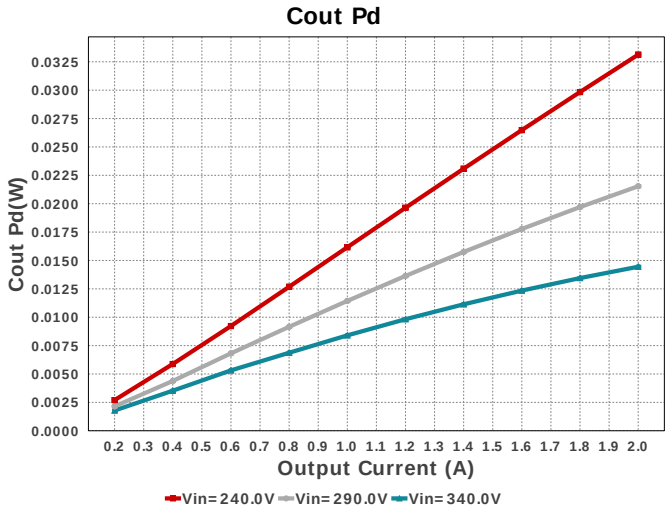


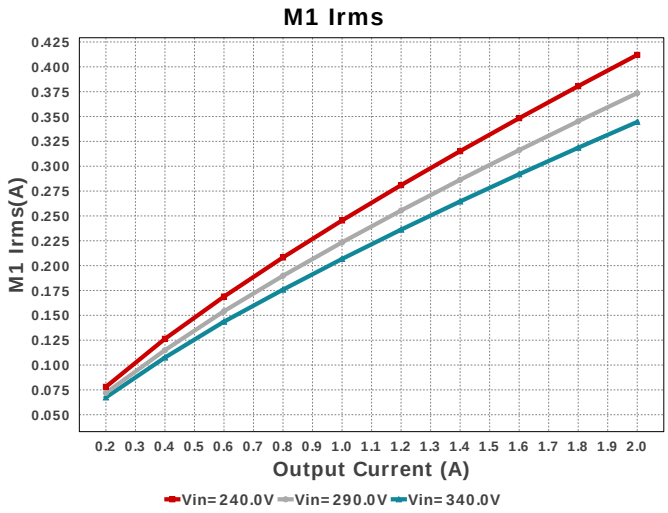


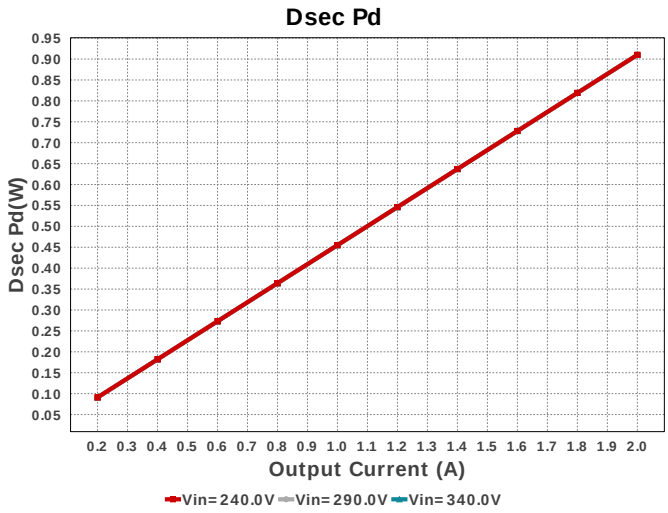


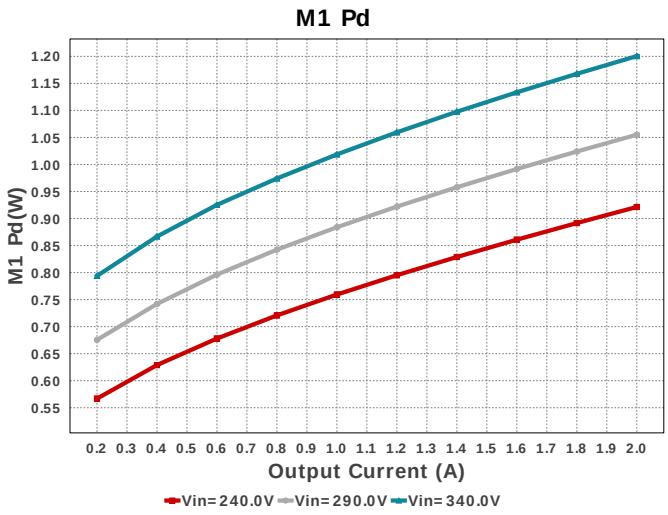


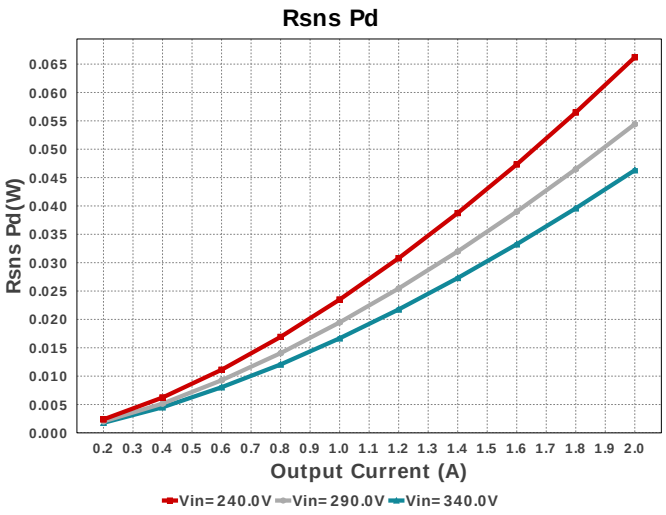


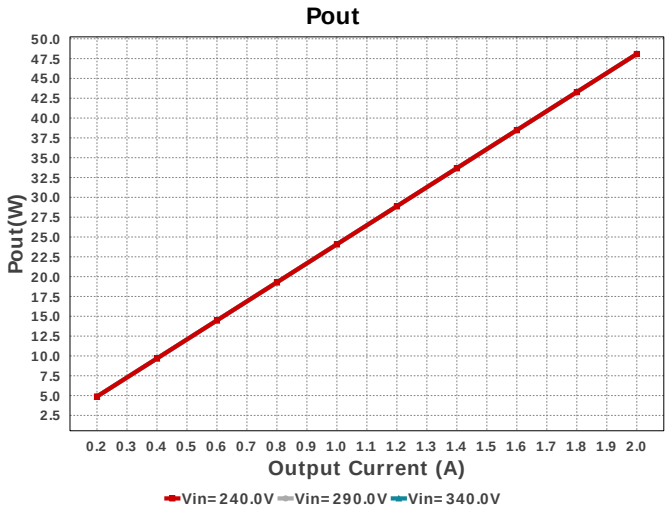


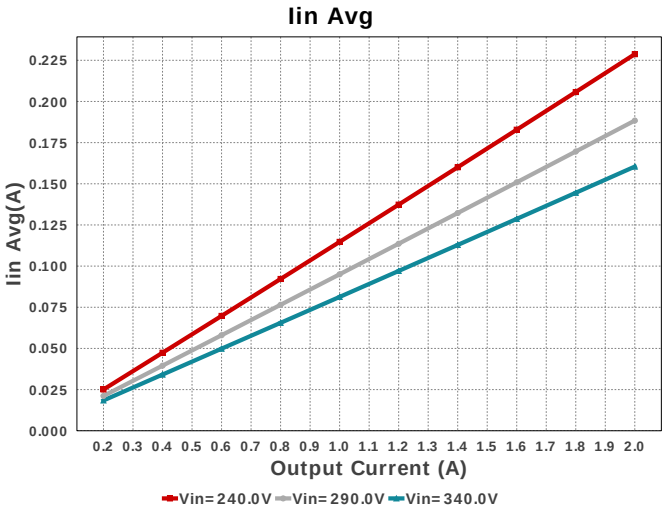


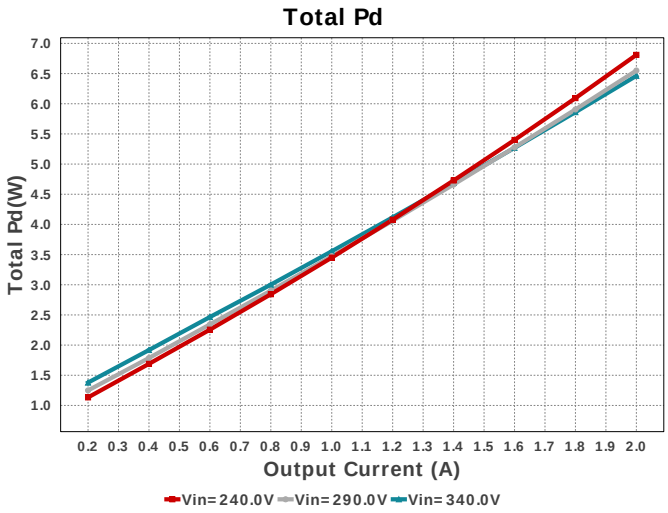


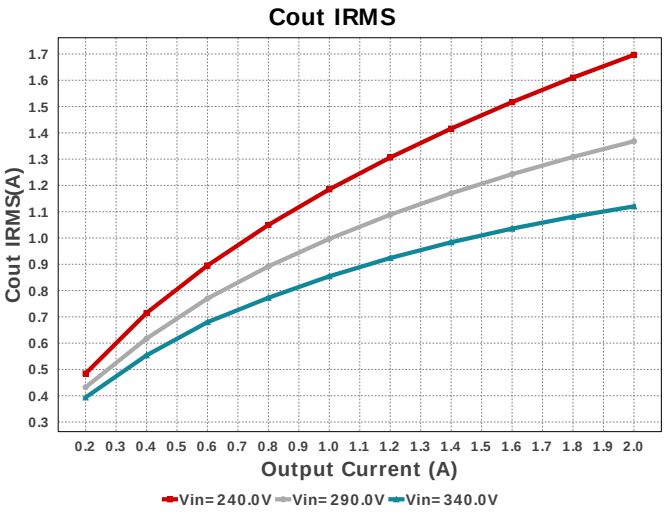


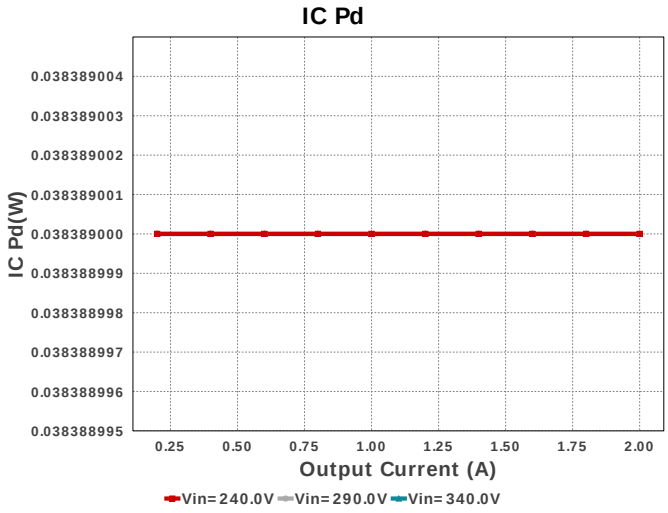


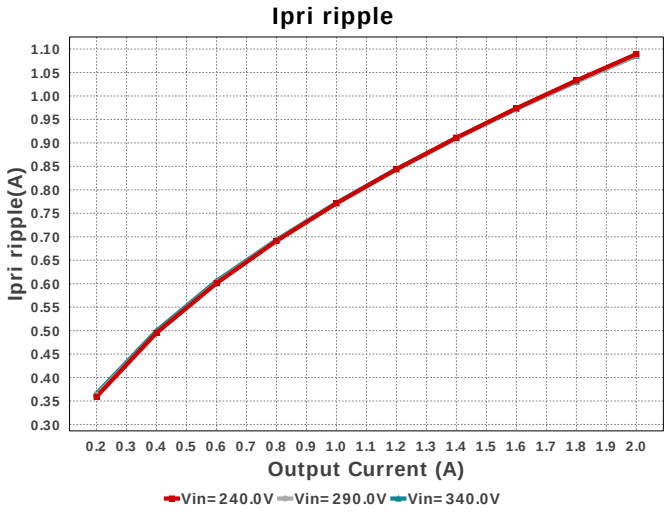


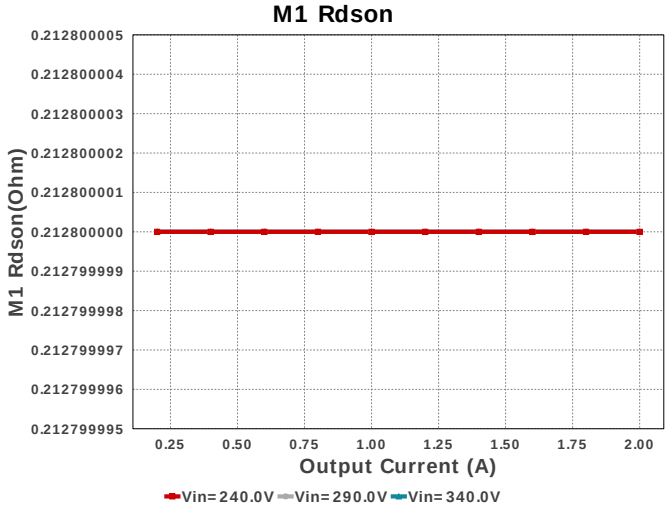


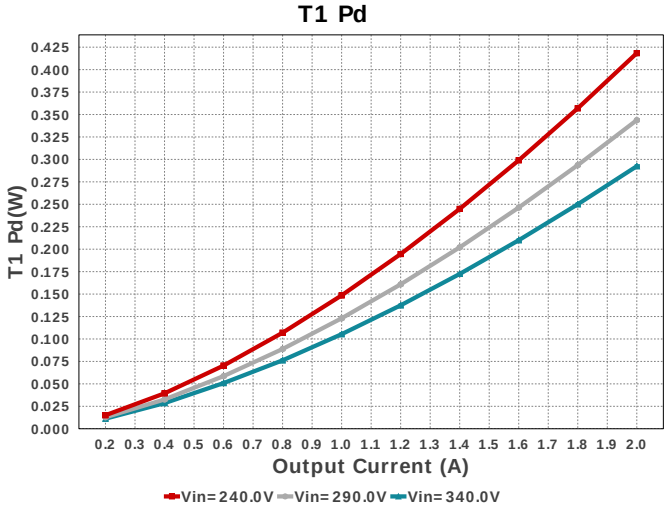


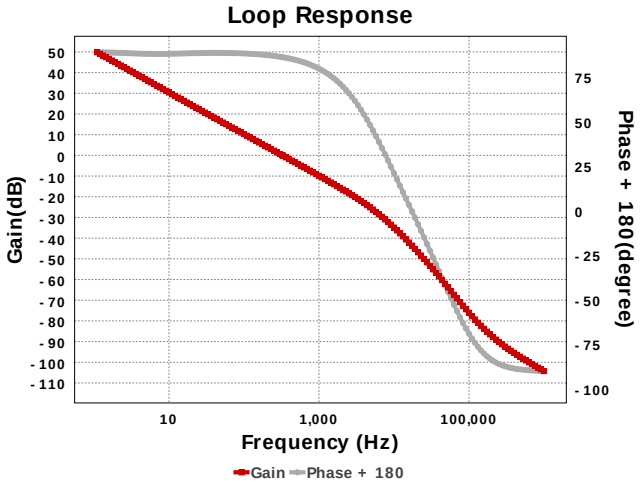












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	514.032 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.01 W	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	1.693 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	32.979 mW	Capacitor	Output capacitor power dissipation
5.	Dsec Pd	874.28 mW	Diode	Secondary Diode Power Dissipation
6.	IC Pd	38.389 mW	IC	IC power dissipation
7.	IC Tj	36.269 degC	IC	IC junction temperature
8.	ICThetaJA	163.3 degC/W	IC	IC junction-to-ambient thermal resistance
9.	Iin Avg	228.53 mA	IC	Average input current
10.	M1 Irms	411.576 mA	Mosfet	Q Iavg
11.	M1 Pd	920.5 mW	Mosfet	MOSFET power dissipation

#	Name	Value	Category	Description
12.	M1 Rdson	212.8 mOhm	Mosfet	Drain-Source On-resistance
13.	M1 TjOP	88.665 degC	Mosfet	M1 MOSFET junction temperature
14.	Cin Pd	1.01 W	Power	Input capacitor power dissipation
15.	Cout Pd	32.979 mW	Power	Output capacitor power dissipation
16.	Dsec Pd	874.28 mW	Power	Secondary Diode Power Dissipation
17.	IC Pd	38.389 mW	Power	IC power dissipation
18.	M1 Pd	920.5 mW	Power	MOSFET power dissipation
19.	Rsns Pd	66.064 mW	Power	Current Limit Sense Resistor Power Dissipation
20.	T1 Pd	417.44 mW	Power	Estimated Losses in Transformer
21.	Total Pd	6.764 W	Power	Total Power Dissipation
22.	Rsns Pd	66.064 mW	Resistor	Current Limit Sense Resistor Power Dissipation
23.	BOM Count	35	System Information	Total Design BOM count
24.	Cross Freq	325.685 Hz	System Information	Bode plot crossover frequency
25.	Duty Cycle	42.895 %	System Information	Duty cycle
26.	Efficiency	87.667 %	System Information	Steady state efficiency
27.	FootPrint	1.917 k mm^2	System Information	Total Foot Print Area of BOM components
28.	Frequency	129.746 kHz	System Information	Switching frequency
29.	Gain Marg	-42.462 dB	System Information	Bode Plot Gain Margin
30.	Iout	2.0 A	System Information	Iout operating point
31.	Low Freq Gain	49.86 dB	System Information	Gain at 1Hz
32.	Mode	DCM	System Information	Conduction Mode
33.	Phase Marg	86.704 deg	System Information	Bode Plot Phase Margin
34.	Pout	48.082 W	System Information	Total output power
35.	Total BOM	NA	System Information	Total BOM Cost
36.	Vin	240.0 V	System Information	Vin operating point
37.	Vout	24.0 V	System Information	Operational Output Voltage
38.	Vout Actual	24.111 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	1.811 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	117.348 mV	System Information	Peak-to-peak output ripple voltage
41.	Ipri ripple	1.088 A	Transformer	Ripple Current in the Primary Winding
42.	Isec Ripple	10.204 A	Transformer	Ripple Current in the Secondary Winding
43.	T1 Iprim RMS	411.576 mA	Transformer	Transformer Primary RMS Current
44.	T1 Iprim pk	1.088 A	Transformer	Transformer Primary Peak Current
45.	T1 Is1 RMS	3.859 A	Transformer	Transformer Secondary1 RMS Current
46.	T1 Pd	417.44 mW	Transformer	Estimated Losses in Transformer

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	340.0	Maximum input voltage
VinMin	240.0	Minimum input voltage
Vout	24.0	Output Voltage
acFrequency	60.0	AC Frequency
base_pn	LM5021-1	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

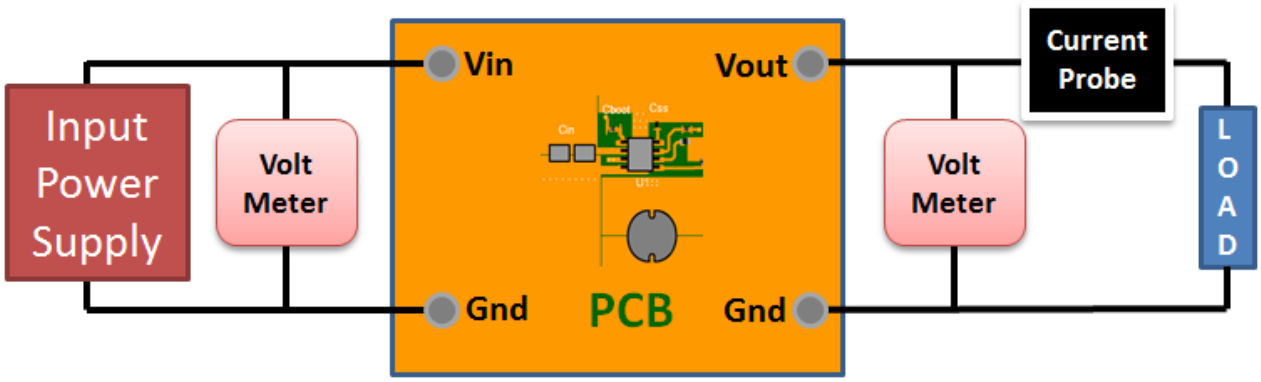
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 240.0V 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® Transformer Report

#	Name	Value
1.	Core Part Number	B66317G0000X187
2.	Core Manufacturer	TDK
3.	Coil Former Part Number	B66208X1110T001
4.	Coil Former Manufacturer	TDK

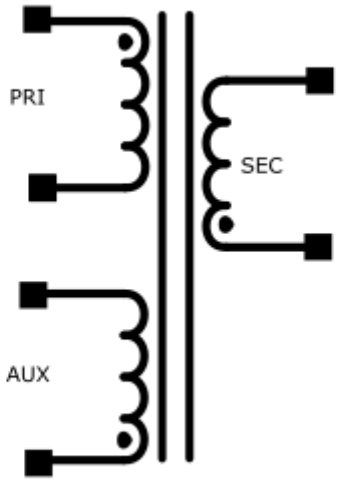
Transformer Electrical Diagram

Primary

Turns	75.0
AWG	28.0
Layers	4.0
Strands	2.0
Insulation Type	Heavy Insulated Magnet Wire

Auxiliary

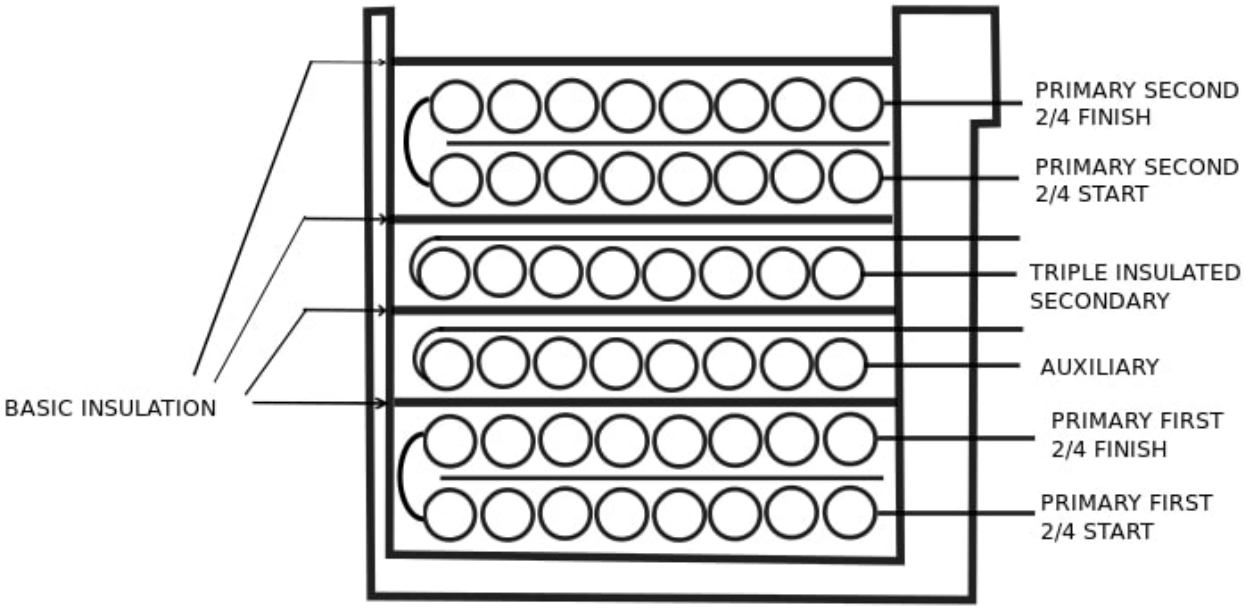
Turns	5.0
AWG	28.0
Layers	1.0
Strands	4.0
Insulation Type	Heavy Insulated Magnet Wire



Secondary

Turns	8.0
AWG	30.0
Layers	1.0
Strands	3.0
Insulation Type	Triple Insulated

Transformer Construction Diagram



Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 2/4.0	28.0	38	Clockwise
Auxiliary	28.0	5.0	Counter Clockwise
Triple Insulated Secondary	30.0	8.0	Counter Clockwise
Primary Second 2/4.0	28.0	37	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	7.29E-4H
2.	Inductance Factor(Al)	130.0nH
3.	Npri	75.0
4.	Nsec	8.0
5.	Naux	5.0
6.	Core Type	E25/13/7
7.	Core Material	N87
8.	Bmax	0.20T
9.	Switching Frequency	129.75kHz
10.	DMax	0.5
11.	Ipk(Primary)	1.08A
12.	Irms(Primary)	0.44A
13.	Ipk(Secondary)	10.2A
14.	Irms(Secondary)	4.15A

Design Assistance

1. Isolated feedback, DC-DC Flyback controller with wide Vin range
2. Master key : 3A81EC28EDE504E4[v1]
3. **LM5021-1** Product Folder : http://www.ti.com/product/LM5021 : contains the data sheet and other resources.