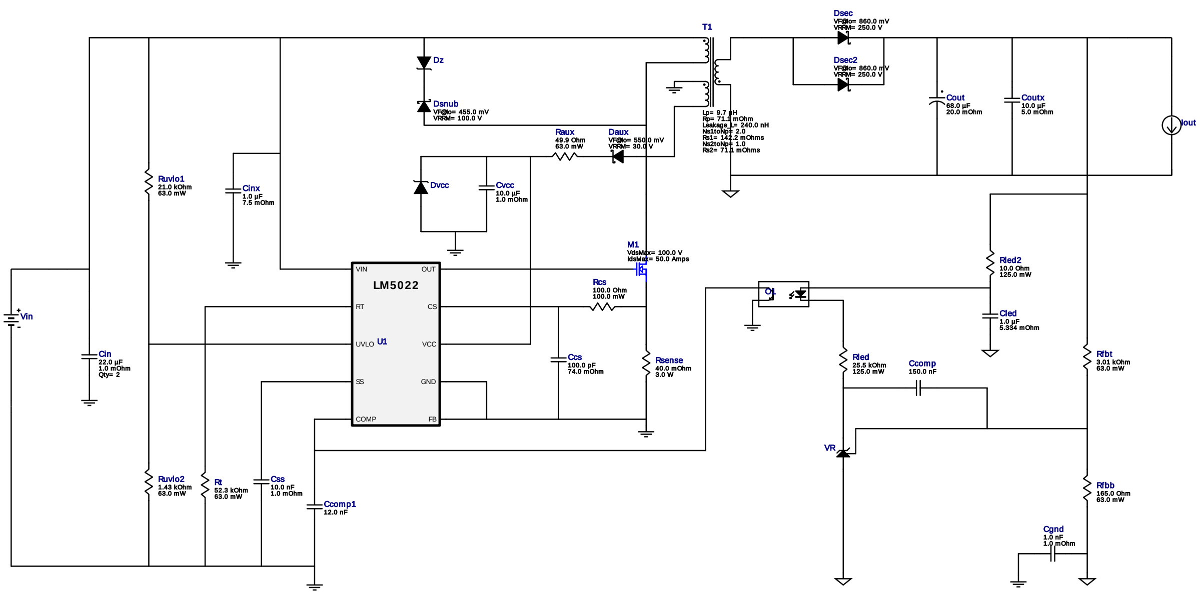
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 20.0V
VinMax = 30.0V
Vout = 24.0V
Iout = 2.0A

Device = LM5022MM/NOPB
Topology = Flyback
Created = 2020-07-22 06:53:18.077
BOM Cost = $16.88
BOM Count = 33
Total Pd = 5.22W

Design : 55 LM5022MM/NOPB
LM5022MM/NOPB 20V-30V to 24.00V @ 2A

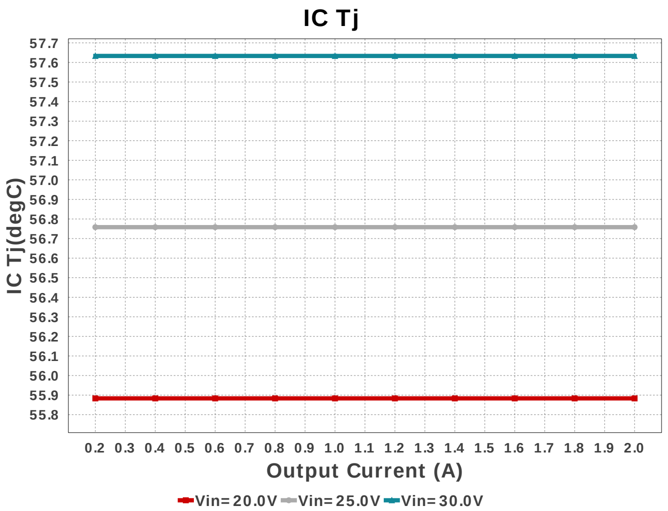


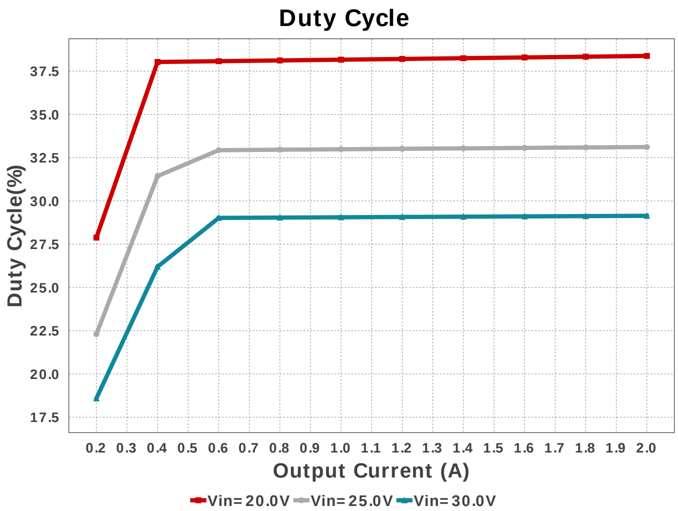
Electrical BOM

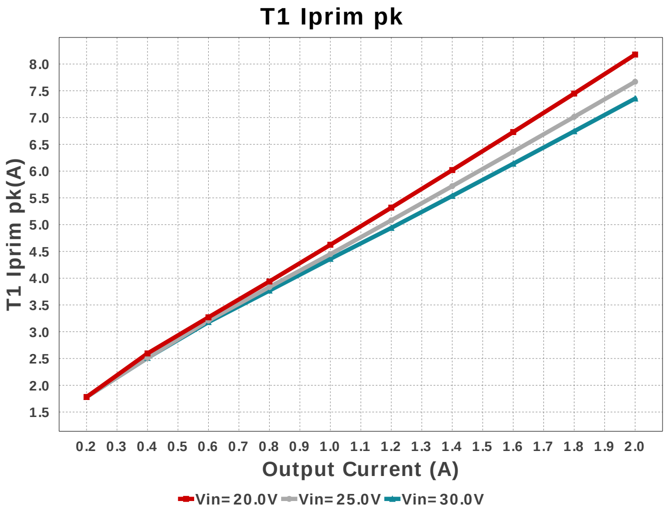
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Ccomp	Panasonic	ECPU1C154MA5 Series= ECPU(A)	Cap= 150.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.17	1206 11 mm^2
Ccomp1	Kemet	C0603C123J3GACTU Series= C0G/NP0	Cap= 12.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.11	0603 5 mm^2
Ccs	Kemet	C0805C101K5GACTU Series= C0G/NP0	Cap= 100.0 pF ESR= 74.0 mOhm VDC= 50.0 V IRMS= 524.0 mA	1	$0.01	0805 7 mm^2
Cgnd	MuRata	GRM21AR72E102KW01D Series= X7R	Cap= 1.0 nF ESR= 1.0 mOhm VDC= 250.0 V IRMS= 0.0 A	1	$0.07	0805 7 mm^2
Cin	TDK	CKG57NX7S2A226M500JH Series= X7S	Cap= 22.0 uF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	2	$2.36	CKG57N 56 mm^2
Cinx	TDK	C3216X7R2A105M160AA Series= X7R	Cap= 1.0 uF ESR= 7.5 mOhm VDC= 100.0 V IRMS= 5.9235 A	1	$0.12	1206 11 mm^2

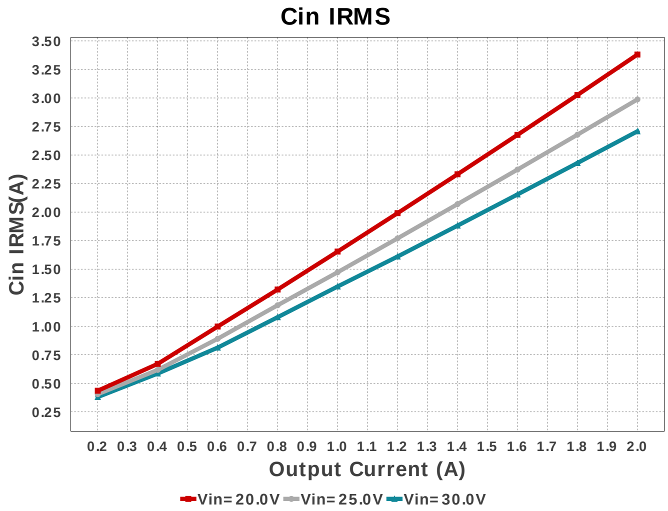
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cled	MuRata	GRM31CR72A105KA01L Series= X7R	Cap= 1.0 uF ESR= 5.334 mOhm VDC= 100.0 V IRMS= 1.55432 A	1	$0.24	1206_190 11 mm^2
Cout	Panasonic	50SVPF68M Series= SVPF	Cap= 68.0 uF ESR= 20.0 mOhm VDC= 50.0 V IRMS= 4.3 A	1	$0.95	CAPSMT_62_F12 151 mm^2
Coutx	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 mm^2
Css	MuRata	GRM155R71E103KA01D Series= X7R	Cap= 10.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cvcc	MuRata	GRT31CR61H106KE01L Series= X5R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.21	1206_180 11 mm^2
Daux	Panasonic	DB2S31600L	VF@Io= 550.0 mV VRRM= 30.0 V	1	$0.03	SOD-523 5 mm^2
Dsec	ON Semiconductor	MBRB40250TG	VF@Io= 860.0 mV VRRM= 250.0 V	1	$0.94	DDPAK 210 mm^2
Dsec2	ON Semiconductor	MBRB40250TG	VF@Io= 860.0 mV VRRM= 250.0 V	1	$0.94	DDPAK 210 mm^2
Dsnub	STMicroelectronics	STPS20M100SG-TR	VF@Io= 455.0 mV VRRM= 100.0 V	1	$1.33	DDPAK 210 mm^2
Dvcc	Diodes Inc.	DFLZ12-7	Zener	1	$0.13	PowerDI123 13 mm^2
Dz	Diodes Inc.	SMBJ24A-13-F	Zener	1	$0.09	SMB 44 mm^2
M1	Texas Instruments	CSD19537Q3	VdsMax= 100.0 V IdsMax= 50.0 Amps	1	$0.38	DQG0008A 18 mm^2
O1	California Eastern Laboratories	PS2501L-1-A	Optocoupler	1	$0.32	PS2501L 77 mm^2
Raux	Vishay-Dale	CRCW040249R9FKED Series= CRCW..e3	Res= 49.9 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcs	Vishay-Dale	CRCW0603100RFKEA Series= CRCW..e3	Res= 100.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbb	Vishay-Dale	CRCW0402165RFKED Series= CRCW..e3	Res= 165.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

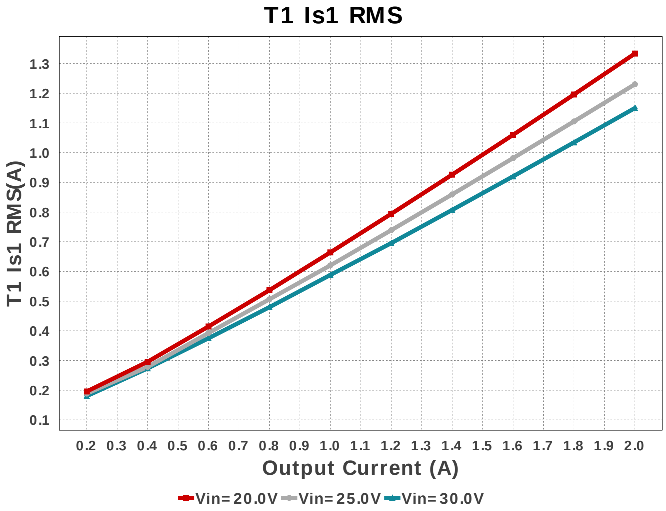
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rfbt	Vishay-Dale	CRCW04023K01FKED Series= CRCW..e3	Res= 3.01 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rled	Vishay-Dale	CRCW080525K5FKEA Series= CRCW..e3	Res= 25.5 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rled2	Vishay-Dale	CRCW080510R0FKEA Series= CRCW..e3	Res= 10.0 Ohm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rsense	Bourns	CRA2512-FZ-R040ELF Series= ?	Res= 40.0 mOhm Power= 3.0 W Tolerance= 1.0%	1	$0.13	2512 43 mm^2
Rt	Vishay-Dale	CRCW040252K3FKED Series= CRCW..e3	Res= 52.3 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruvlo1	Vishay-Dale	CRCW040221K0FKED Series= CRCW..e3	Res= 21.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruvlo2	Vishay-Dale	CRCW04021K43FKED Series= CRCW..e3	Res= 1.43 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
T1	Wurth Elektronik	749196531	Lp= 9.7 µH Rp= 71.1 mOhm Leakage_L= 240.0 nH Ns1toNp= 2.0 Rs1= 142.2 mOhms Ns2toNp= 1.0 Rs2= 71.1 mOhms	1	$4.71	EFD20 724 mm^2
U1	Texas Instruments	LM5022MM/NOPB	Switcher	1	$0.87	MUB10A 24 mm^2
VR	Texas Instruments	LMV431CM5/NOPB	Voltage References	1	$0.14	R-PDSO-G3 16 mm^2

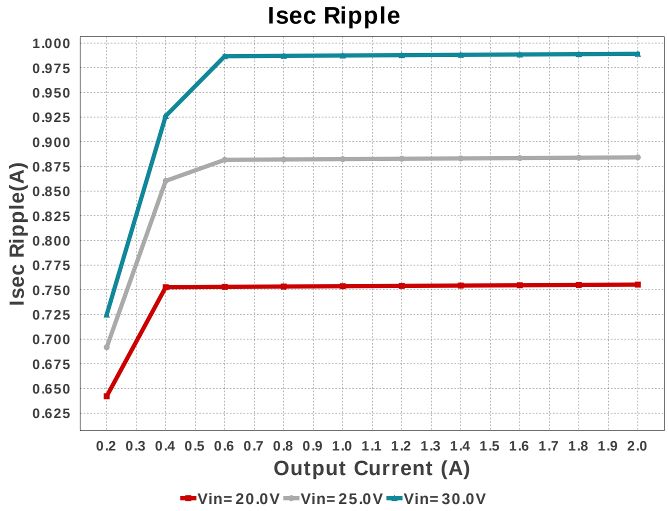


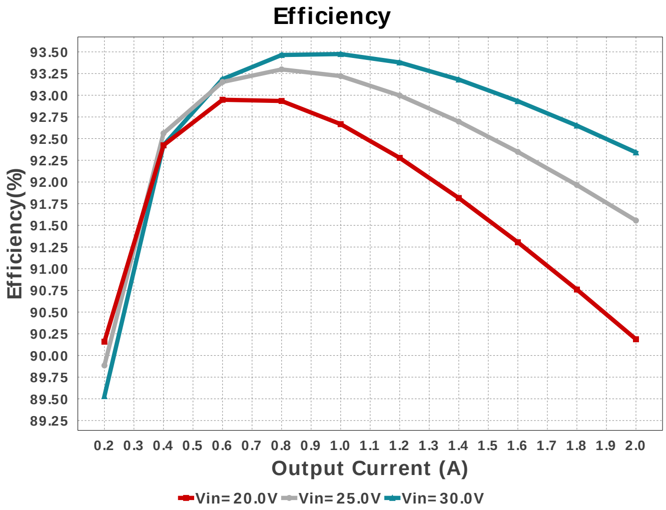


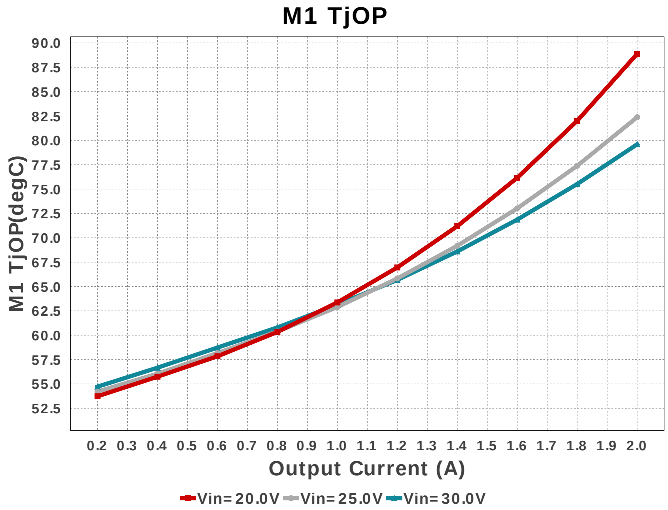

T1 Iprim pk
T1 Iprim pk(A)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V

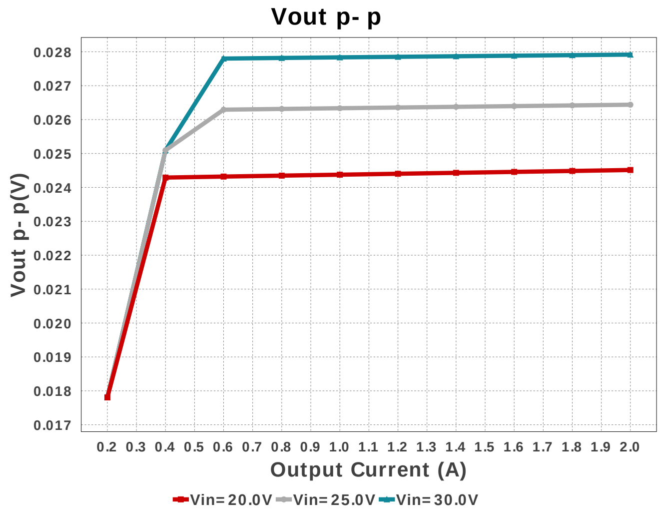

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V

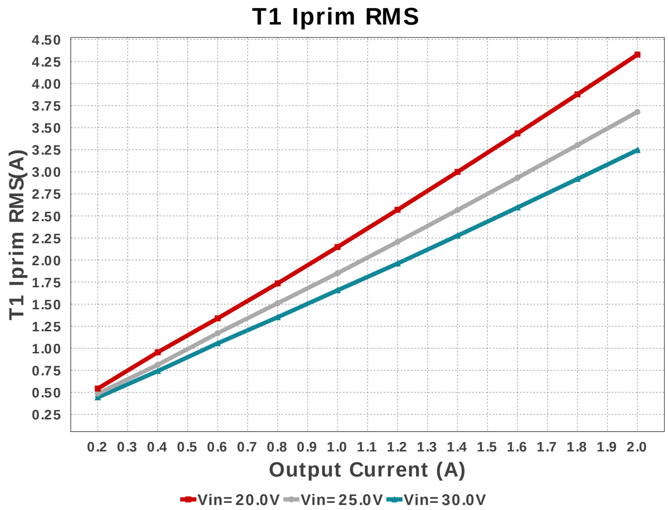

T1 Is1 RMS
T1 Is1 RMS(A)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V

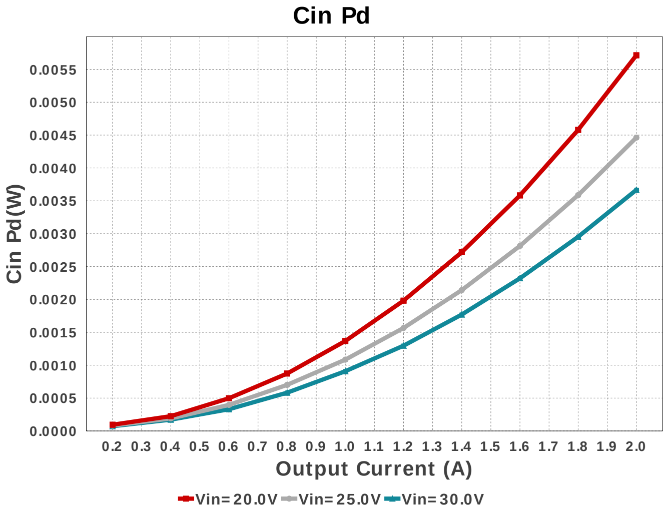

Isec Ripple
Isec Ripple(A)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V

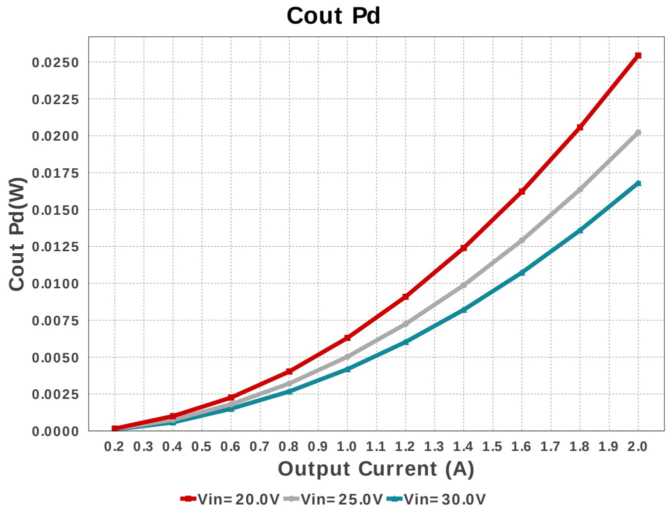

Efficiency
Efficiency(%)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V

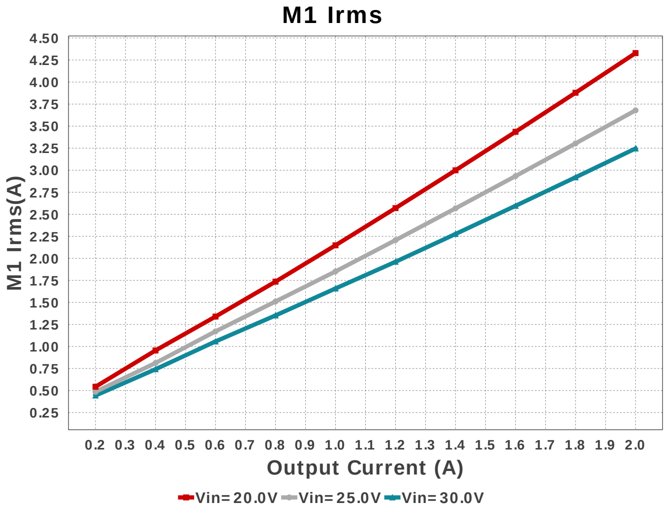

M1 TjOP
M1 TjOP(degC)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V

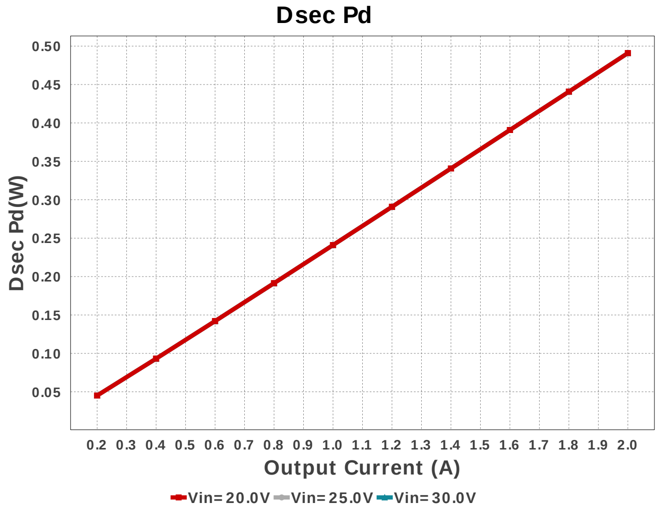

Vout p- p
Vout p- p(V)
Output Current (A)
Vin= 20.0V
Vin= 25.0V
Vin= 30.0V

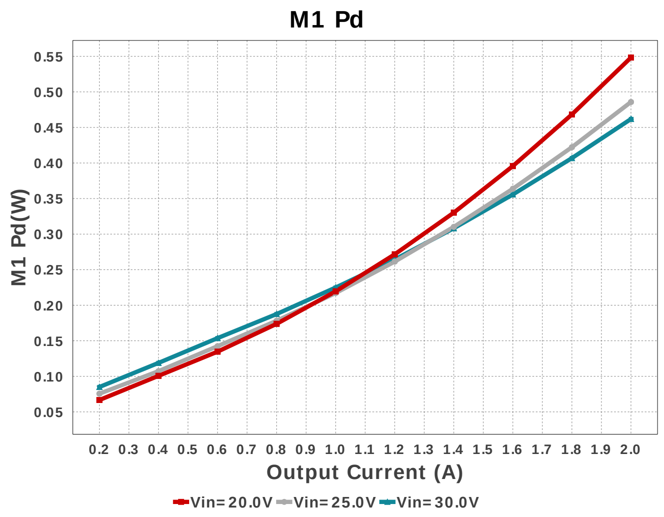

T1 Iprim RMS
T1 Iprim RMS(A)
Output Current (A)
Vin= 20.0V
Vin= 25.0V
Vin= 30.0V

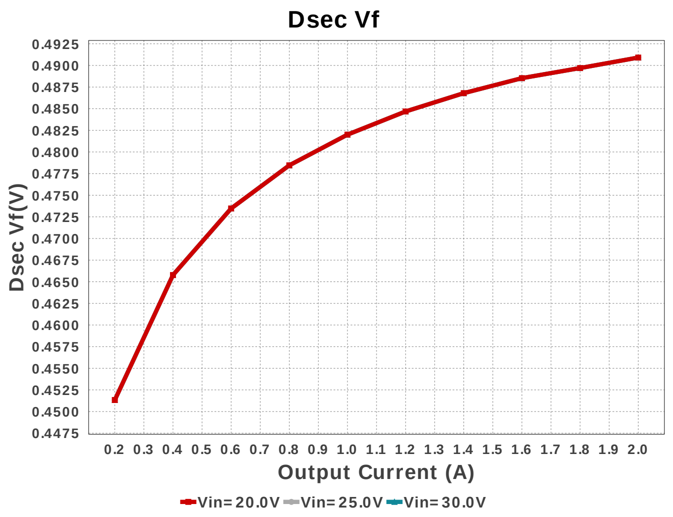

Cin Pd
Cin Pd(W)
Output Current (A)
Vin= 20.0V
Vin= 25.0V
Vin= 30.0V

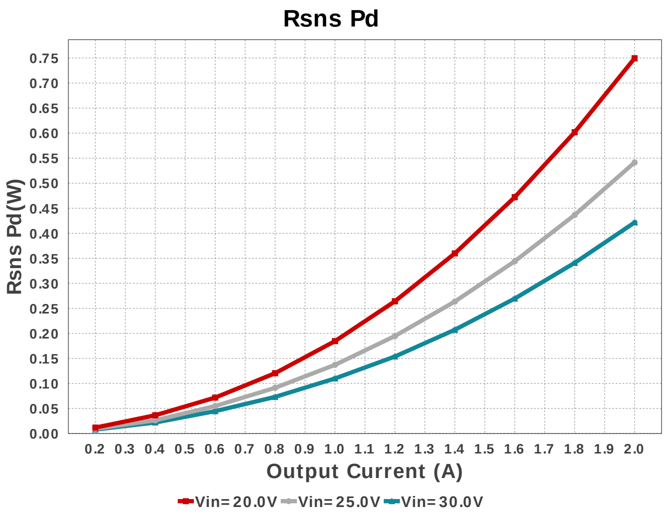

Cout Pd
Cout Pd(W)
Output Current (A)
Vin= 20.0V
Vin= 25.0V
Vin= 30.0V

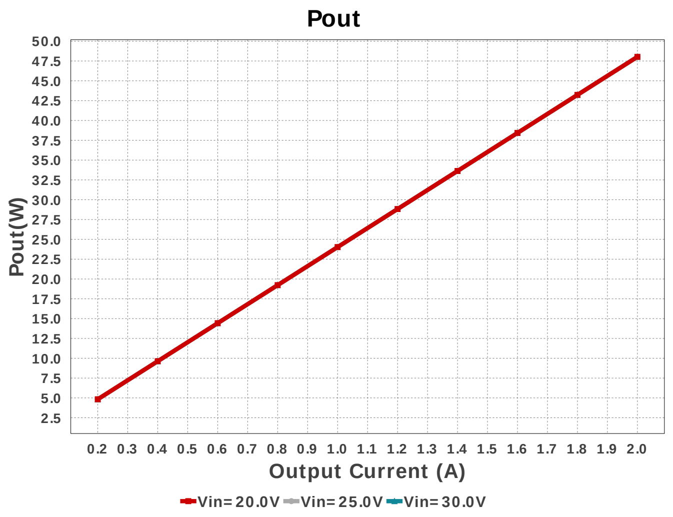

M1 Irms
M1 Irms(A)
Output Current (A)
Vin= 20.0V
Vin= 25.0V
Vin= 30.0V

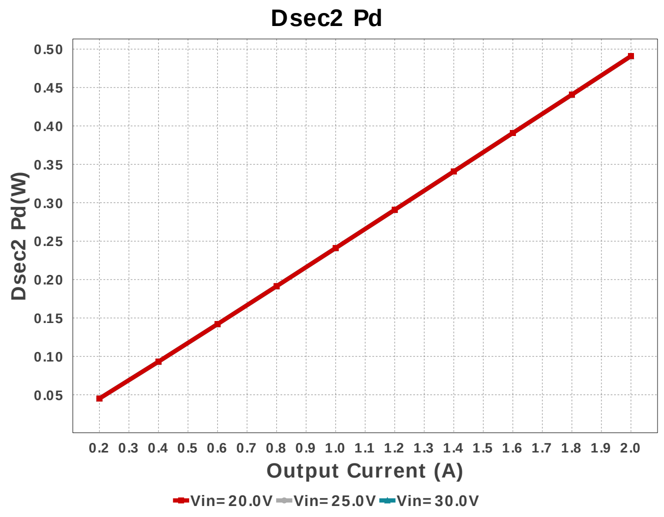

Dsec Pd
Dsec Pd(W)
Output Current (A)
Vin= 20.0V
Vin= 25.0V
Vin= 30.0V

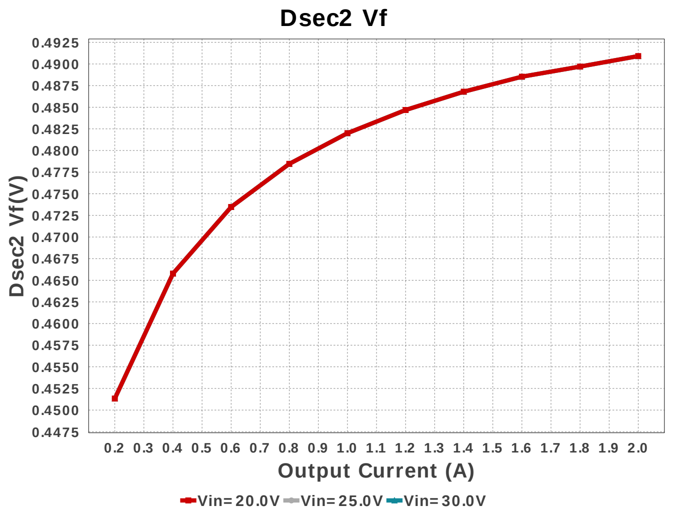

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V


Dsec Vf
Dsec Vf(V)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V

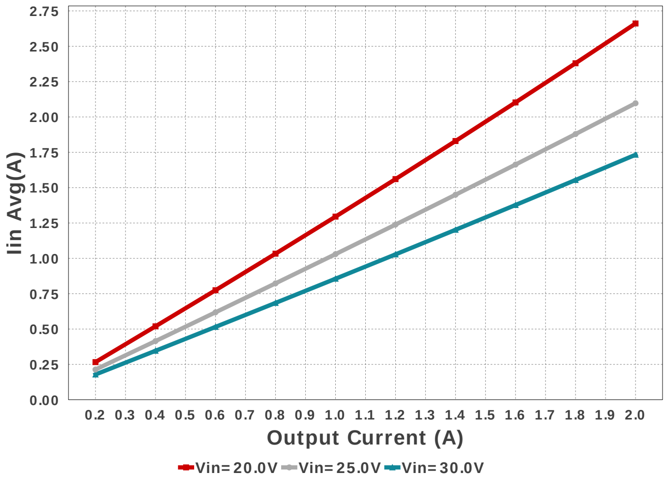

Rsns Pd
Rsns Pd(W)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V


Pout
Pout(W)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V

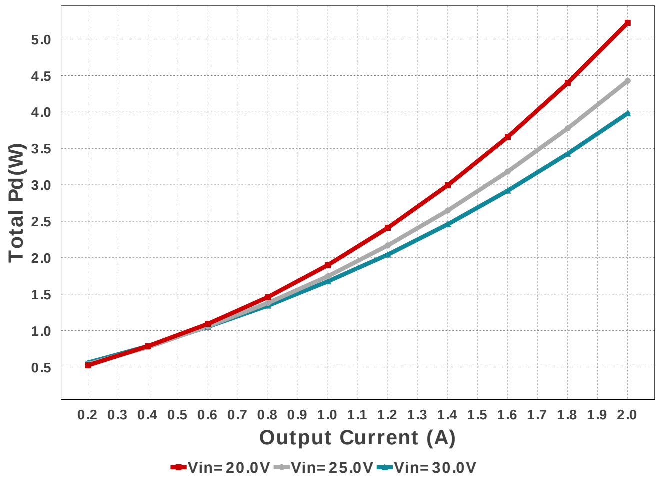

Dsec2 Pd
Dsec2 Pd(W)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V


Dsec2 Vf
Dsec2 Vf(V)
Output Current (A)
Vin=20.0V Vin=25.0V Vin=30.0V

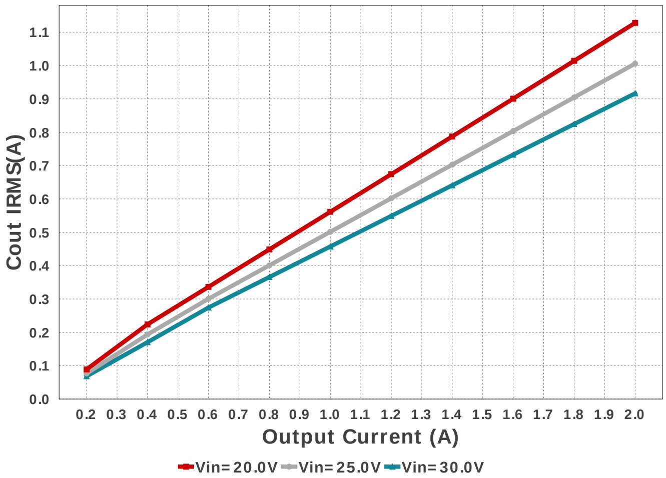
Iin Avg



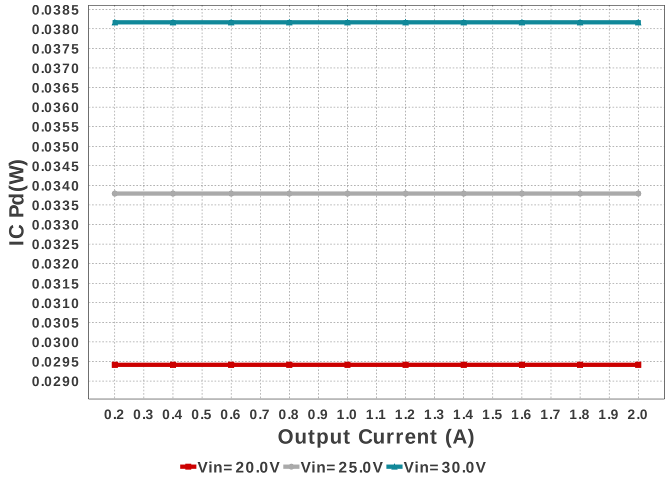
Total Pd



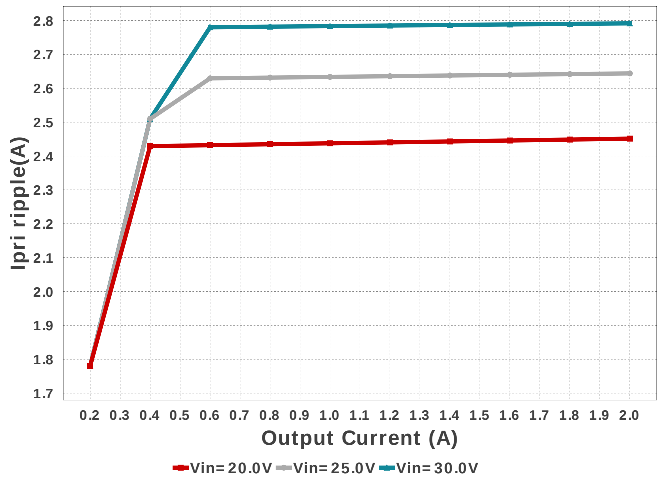
Cout IRMS



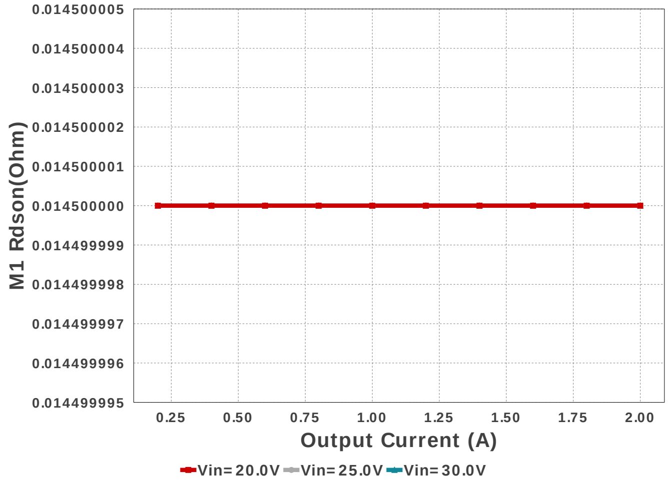
IC Pd

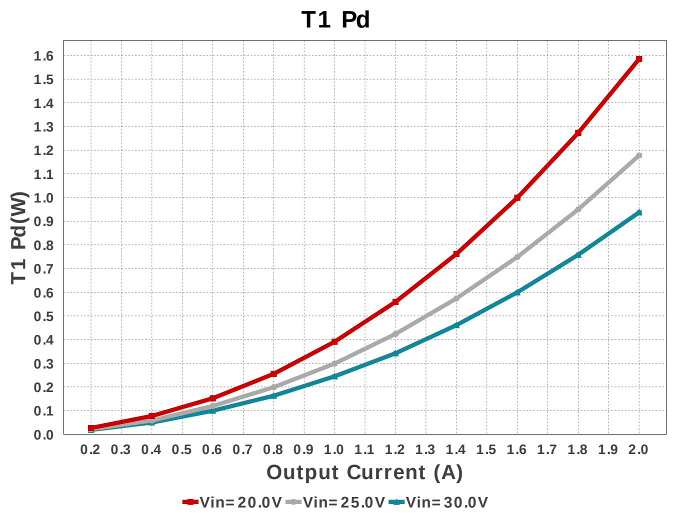


Ipri ripple



M1 Rdson





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	3.38 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	5.714 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	1.129 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	25.487 mW	Capacitor	Output capacitor power dissipation
5.	Dsec Pd	490.91 mW	Diode	Secondary Diode Power Dissipation
6.	Dsec Vf	490.91 mV	Diode	Effective Forward Voltage Drop at the Operating Current
7.	Dsec2 Pd	490.91 mW	Diode	Secondary Diode Power Dissipation
8.	Dsec2 Vf	490.91 mV	Diode	Effective Forward Voltage Drop at the Operating Current
9.	IC Pd	29.416 mW	IC	IC power dissipation
10.	IC Tj	55.883 degC	IC	IC junction temperature
11.	ICThetaJA	200.0 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	2.661 A	IC	Average input current
13.	M1 Irms	4.329 A	Mosfet	Q Iavg
14.	M1 Pd	548.28 mW	Mosfet	MOSFET power dissipation
15.	M1 Rdson	14.5 mOhm	Mosfet	Drain-Source On-resistance
16.	M1 TjOP	88.879 degC	Mosfet	M1 MOSFET junction temperature
17.	Cin Pd	5.714 mW	Power	Input capacitor power dissipation
18.	Cout Pd	25.487 mW	Power	Output capacitor power dissipation
19.	Dsec Pd	490.91 mW	Power	Secondary Diode Power Dissipation
20.	Dsec2 Pd	490.91 mW	Power	Secondary Diode Power Dissipation
21.	IC Pd	29.416 mW	Power	IC power dissipation
22.	M1 Pd	548.28 mW	Power	MOSFET power dissipation
23.	Rsns Pd	749.47 mW	Power	Current Limit Sense Resistor Power Dissipation
24.	T1 Pd	1.585 W	Power	Estimated Losses in Transformer
25.	Total Pd	5.223 W	Power	Total Power Dissipation
26.	Rsns Pd	749.47 mW	Resistor	Current Limit Sense Resistor Power Dissipation
27.	BOM Count	33	System Information	Total Design BOM count
28.	Duty Cycle	38.38 %	System Information	Duty cycle
29.	Efficiency	90.187 %	System Information	Steady state efficiency
30.	FootPrint	1.973 k mm^2	System Information	Total Foot Print Area of BOM components
31.	Frequency	322.819 kHz	System Information	Switching frequency
32.	Iout	2.0 A	System Information	Iout operating point
33.	Mode	CCM	System Information	Conduction Mode
34.	Pout	48.027 W	System Information	Total output power
35.	Total BOM	$16.88	System Information	Total BOM Cost
36.	Vin	20.0 V	System Information	Vin operating point
37.	Vout	24.0 V	System Information	Operational Output Voltage
38.	Vout Actual	24.053 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	3.954 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable

#	Name	Value	Category	Description
40.	Vout p-p	24.513 mV	System Information	Peak-to-peak output ripple voltage
41.	Ipri ripple	2.451 A	Transformer	Ripple Current in the Primary Winding
42.	Isec Ripple	755.259 mA	Transformer	Ripple Current in the Secondary Winding
43.	T1 Iprim RMS	4.329 A	Transformer	Transformer Primary RMS Current
44.	T1 Iprim pk	8.177 A	Transformer	Transformer Primary Peak Current
45.	T1 Is1 RMS	1.334 A	Transformer	Transformer Secondary1 RMS Current
46.	T1 Pd	1.585 W	Transformer	Estimated Losses in Transformer

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	30.0	Maximum input voltage
VinMin	20.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	LM5022	Base Product Number
source	DC	Input Source Type
Ta	50.0	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

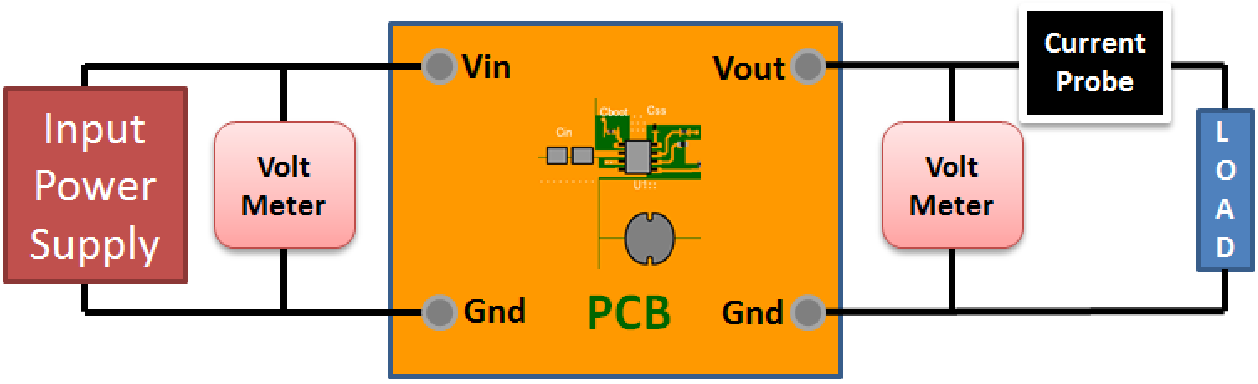
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 20.0V 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.



Design Assistance

1. Isolated feedback, DC-DC Flyback controller with wide Vin range

2. Master key : 89E09FD907EBCE6F[v1]

3. **LM5022** Product Folder : http://www.ti.com/product/LM5022 : contains the data sheet and other resources.

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