

Transformer Designer for Isolated High-Voltage Power Design

Create a complete isolated high-voltage power design including the design of a transformer

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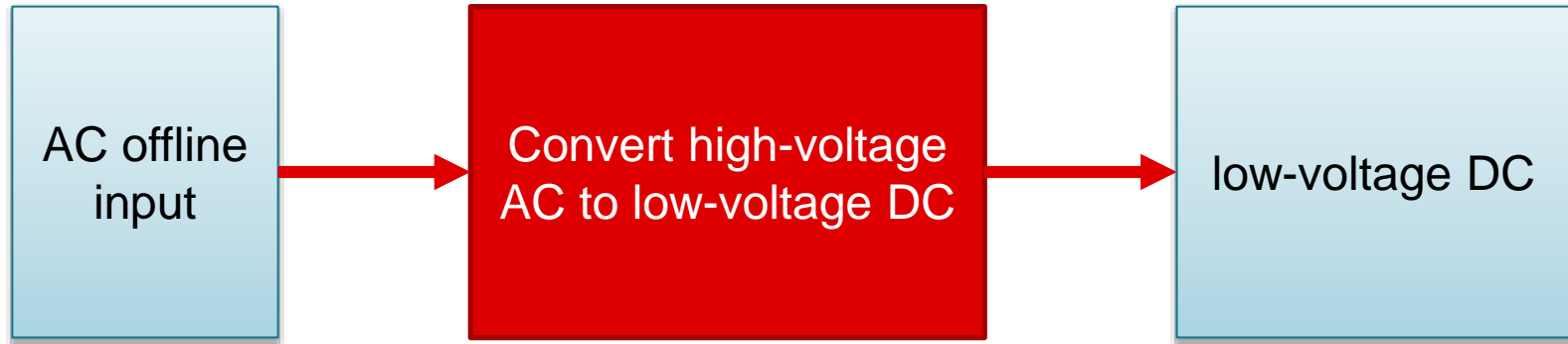
Convert from what we have to what we want



Convert high-voltage
AC to low-voltage DC



Convert from what we have to what we want— from high-voltage AC generate low-voltage DC



Key Requirements:

- Provide electrical **isolation**
- Regulate to desired DC level
- Balance efficiency, footprint and cost

Isolation

- **What is it?**

- No direct conduction path between input and output (galvanic or electrical isolation)
- Dangerous electrical shorts cannot pass through to either side in the event of component failure or fault

- **Why it is needed?**

- Protect the primary side from faults and components failures on the secondary side
- Protect the secondary side from line-level events, e.g. surges, lightning strikes, noise
- Protect the human operator and the equipment
- Secondary ground can be configured either positive or negative for negative outputs
- Regulatory standards require isolation

- **How is it implemented?**

- Power transferred through a transformer.
- Secondary-to-primary signal sensing through an opto-coupler & independent grounds

Flyback topology

Flyback is the most popular topology for low-power (~75 W) AC/DC conversion applications:

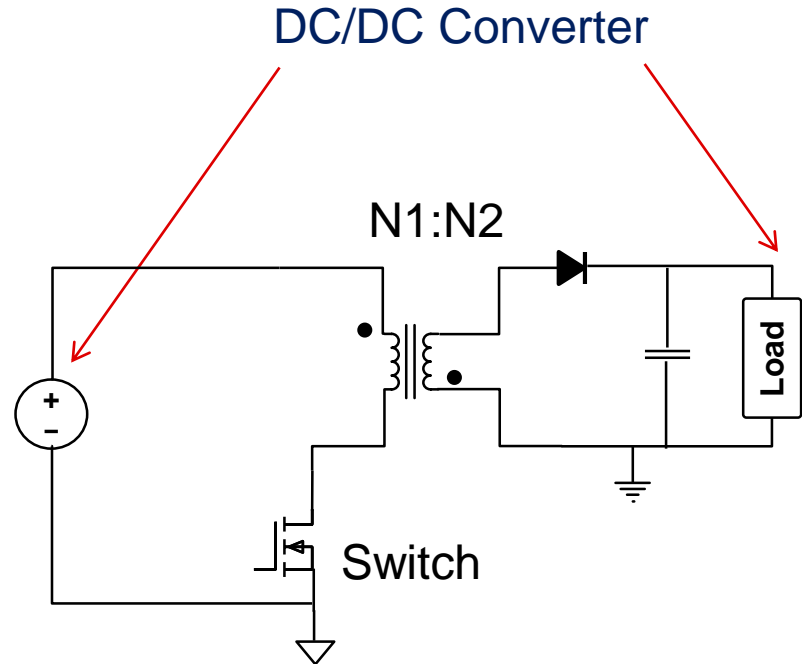
- A Flyback transformer combines the actions of an isolating transformer and an output inductor into a single element ^[1] hence, no separate inductor is needed.
- A Flyback transformer provides galvanic (electrical) isolation up to ~5 kV DC, reduces noise ^[2], and can provide multiple and/or negative outputs.
- Simple design requires just one semiconductor switch (MOSFET) and one freewheeling diode.
- Reference:
 - [1] J. Picard, Under the hood of Flyback SMPS design. <https://www.ti.com/seclit/ml/slup261/slup261.pdf>
 - [2] G. Jones, Miniature solutions for voltage isolation. www.ti.com/lit/an/slyt211/slyt211.pdf

Flyback Converter Operation

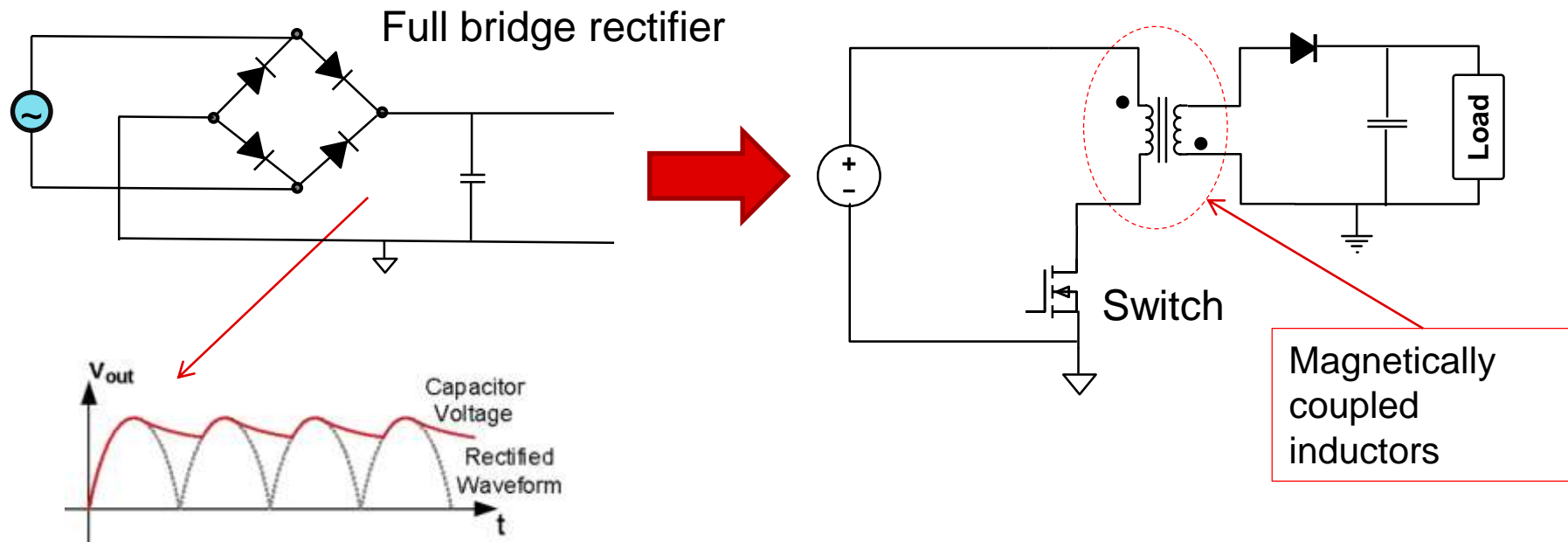


Flyback Topology

- Basic circuit:
 - Primary winding and switch
 - Secondary winding and rectifier
 - Bias winding and rectifier
 - Control circuit
- Note the transformer polarity
- Primary and secondary windings conduct alternately
- Primary winding stores energy in air-gap
- Secondary winding transfers air-gap energy to the output



AC/DC Flyback: Operation



Convert AC voltage to DC using a full-bridge diode rectifier

Flyback operation: Stage 1

- The MOSFET switch is on → transformer primary winding gets connected to the DC source (V_s) → linear increase of current in primary
- The magnetic flux in the transformer windings and core is entirely due to the primary winding current
- Diode is in reverse biased mode due to the induced voltage in the secondary
- Output load receives power from the output capacitor due to the previously stored charge

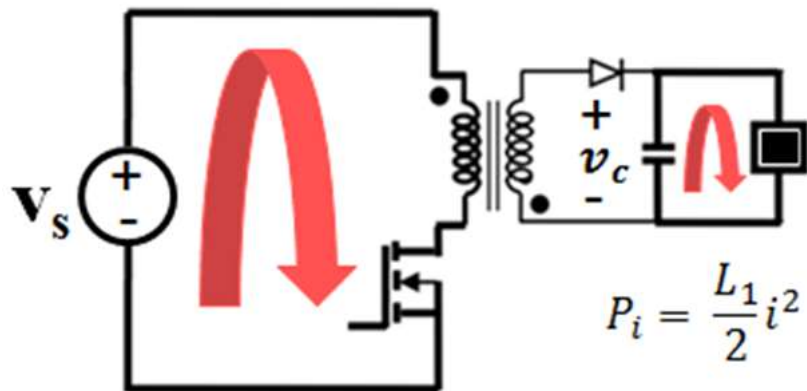


Fig. 2 (a): Current flow during Stage 1

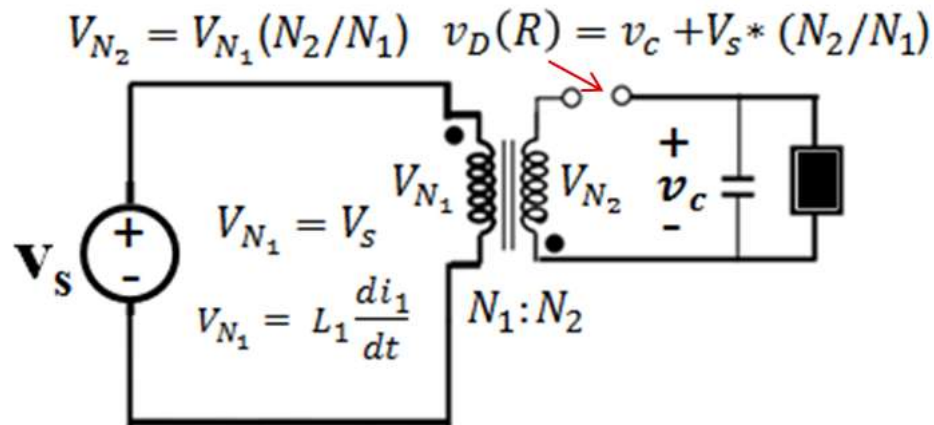


Fig. 2 (b): Equivalent circuit schematic in Stage 1

Flyback operation: Stage 2

- MOSFET switch turned off → the primary winding path is disconnected → the voltage polarities across the windings reverses
- Primary winding current is interrupted → secondary winding immediately begins to conduct → the magneto motive force (MMF) produced by the windings do not change suddenly → this will ensure no interruption in the magnetic field energy ($E = B^2/2\mu$)
- Diode in the secondary circuit becomes forward biased due to this polarity reversal
- **Capacitor voltage magnitude will stabilize if during each switching cycle, the energy output by the secondary winding equals the energy delivered to the load.**

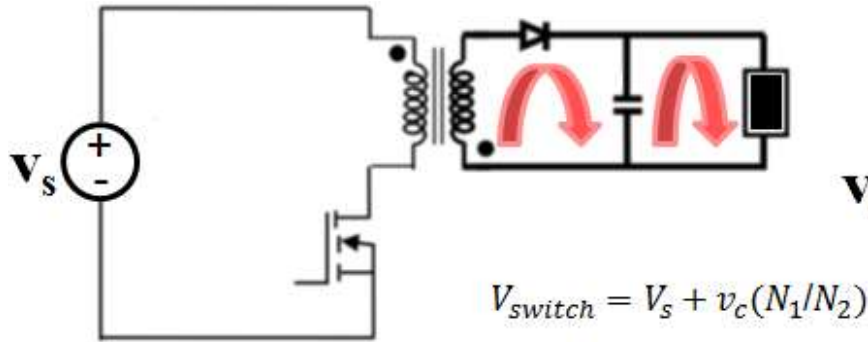


Fig. 3 (a): Current flow during Stage 2

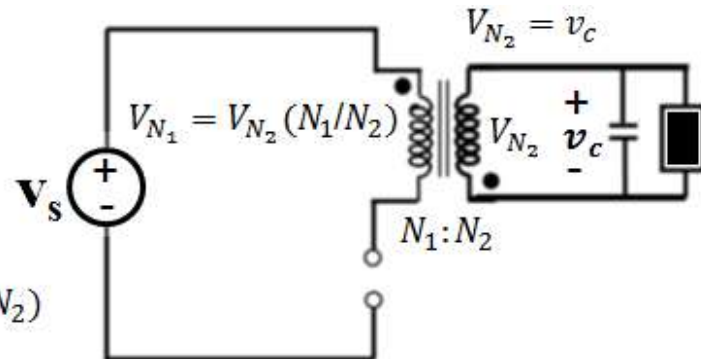


Fig. 3 (b): Equivalent circuit schematic in Stage 2

Flyback operation: Stage 3

- Considering a lengthy period for the off time → the secondary current decay to zero and magnetic field energy is completely discharged → output capacitor continues providing power to the load (discontinuous mode) → complete transfer of the magnetic field energy to the output → the secondary winding EMF as well as current decay to zero → the rectifying diode in secondary winding stops conducting
- Uninterrupted supply voltage to the load if output capacitor is large enough...
- End of Stage 3 → circuit resumes operation from Stage 1

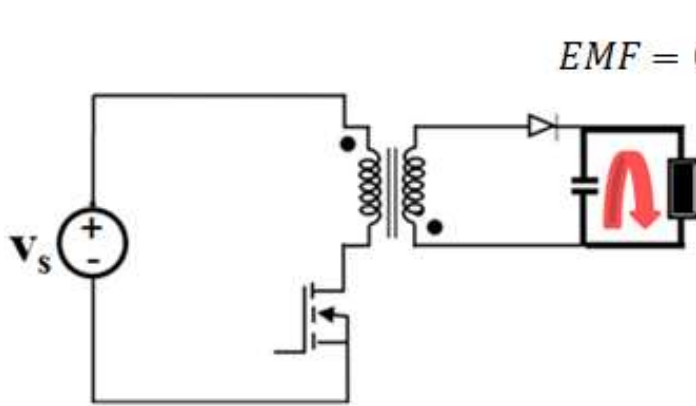


Fig. 4 (a): Current flow during Stage 3

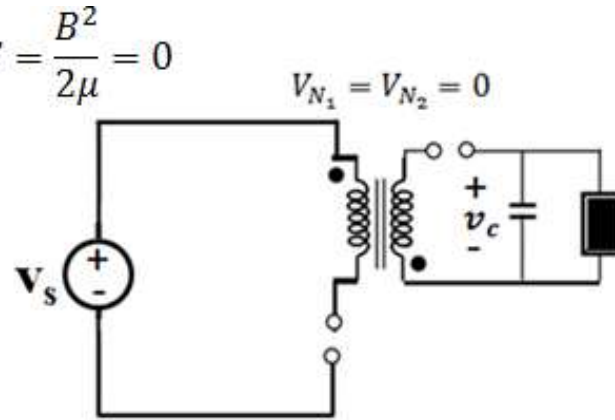
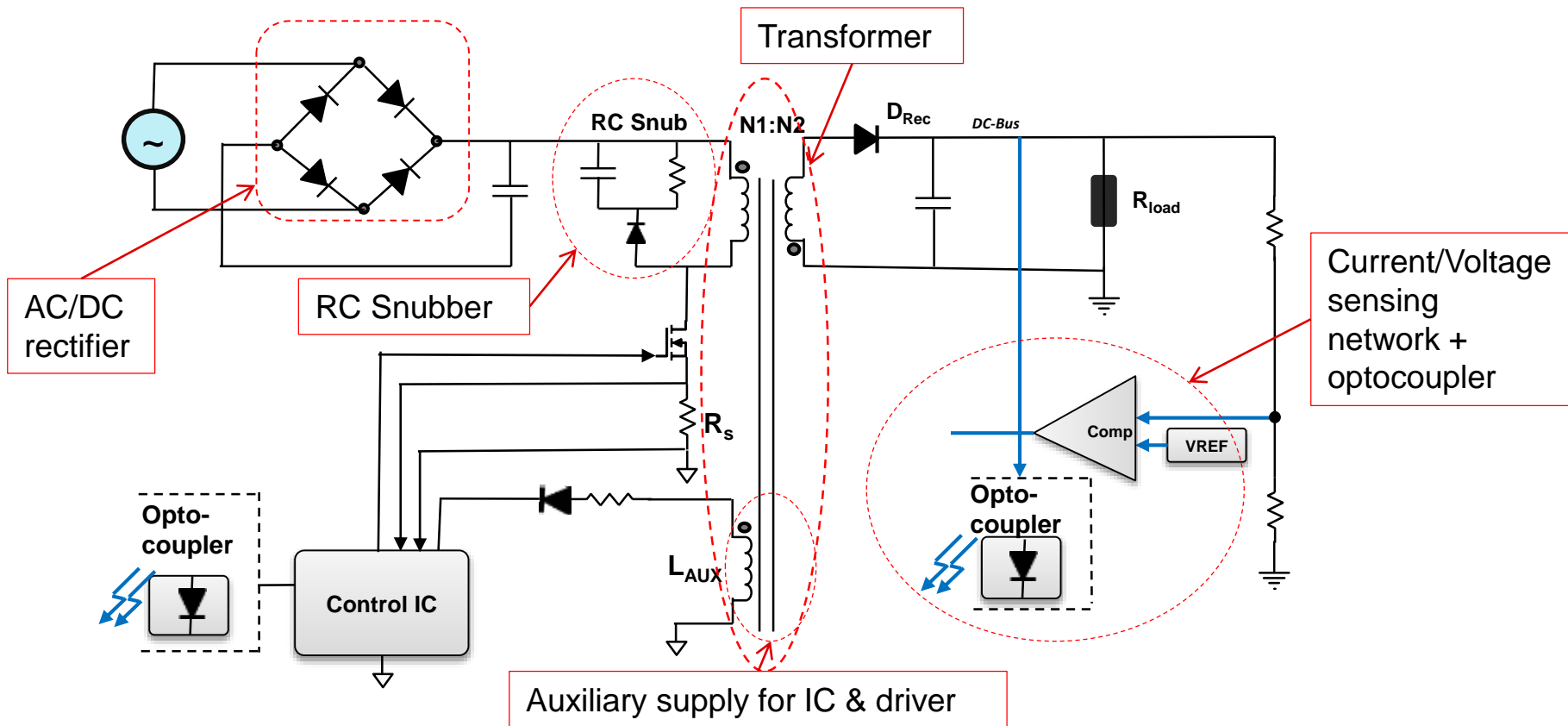


Fig. 4 (b): Equivalent circuit schematic in Stage 3

Typical AC/DC Flyback converter schematic



Flyback Transformers

- **Conventional transformers store minimal energy**
 - E.g. Forward converter, Push-Pull converter etc.
 - Primary and secondary currents flow simultaneously.
 - Energy is transferred by the simultaneous flow of current.
- **Flyback “transformers” are really coupled-inductors**
 - Primary and secondary windings do not conduct simultaneously → they can be seen as two magnetically coupled inductors → often called inductor-transformer
 - Current flows in primary while secondary diode is reverse-biased
 - Primary current stores energy in air-gap
 - When primary current stops, secondary winding reverses polarity → forward-biases output diode → secondary current flows
 - Air-gap energy is transferred to the secondary load:
 - **DCM** => all stored energy is delivered to the load, followed by an interval of zero current flow in both windings
 - **CCM** => only some of the stored energy is delivered to the load, primary current starts before secondary current has decayed to zero

Challenges of Flyback design

Overall Design

- Balance cost, footprint and performance
- Design decisions on modes of operation (CCM, DCM, CRM/TM)
- Effective component selection – MOSFET, diodes should withstand the stress
- Design RC or RCD snubber to suppress ringing
- More complex design process compared to non-isolated topologies

Transformer Design

- Customize for the specific power design specifications
- Optimize selection of transformer based on efficiency, cost, footprint
- Select appropriate core, considering loss and magnetic saturation
- Select bobbin based on physical fit
- Select wires gauge based on skin effect & current carrying capability
- Design the winding strategy

Core and bobbin selection

- **Core**

- Huge variety of standard cores of different shapes, sizes and material
- Shapes
 - E-core, Pot core, RM core, PQ core
- Material
 - 3F3/N87, 3C90/N87, 3C95/N95/PC95, 3C96/N97/PC44
- Different sizes and combinations of A_e , A_w , V_e and l_e

- **Bobbin**

- Vertical or horizontal
- Lateral or low profile



Transformer design process constraints

- **Electrical Targets / Constraints**

- Electrically required turns ratio for functionality
- Primary inductance for target ripple current
- Wire size designed for skin depth and current capacity

- **Power dissipation**

- Minimize power losses
- Balance transformer size with power dissipation

- **Magnetic Constraints**

- Operating magnetic flux density does not go into saturation region

- **Physical Constrains**

- Winding physically fits in the core and bobbin window
- Core geometry factor (K_g) greater than what is required by the design

Constraint 1: Electrical

L_{prim} = Primary inductance, based on ripple

A_c = Core cross-section area

n = Number of turns

μ_0 = Permeability of free space

l_g = Air gap length

$$L_{prim} = \frac{n^2 A_c \mu_0}{l_g} = \frac{n A_c B_{max}}{I_{max}}$$

Constraint 2: Magnetic saturation

B_{max} = Maximum magnetic flux density
= 0.25–0.3 T for typical soft ferrite core

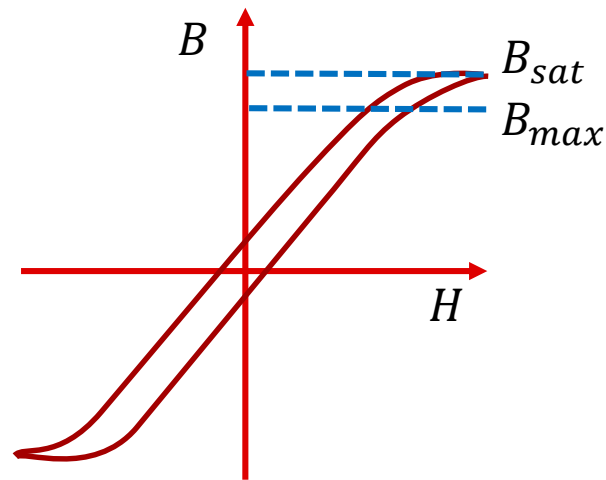
I_{max} = Maximum current

n = Number of turns

μ_0 = Permeability of free space

l_g = Air gap length

$$nI_{max} = B_{max} \frac{l_g}{\mu_0}$$



Constraint 3: Copper loss

Copper Wire DC resistance:

$$R_w = \rho \cdot \frac{n(MLT)}{A_w}$$

Where MLT = mean length of wire per turn

Copper loss based on DC resistance is targeted to be < 1-2 % of P_{out} sets the target R_w

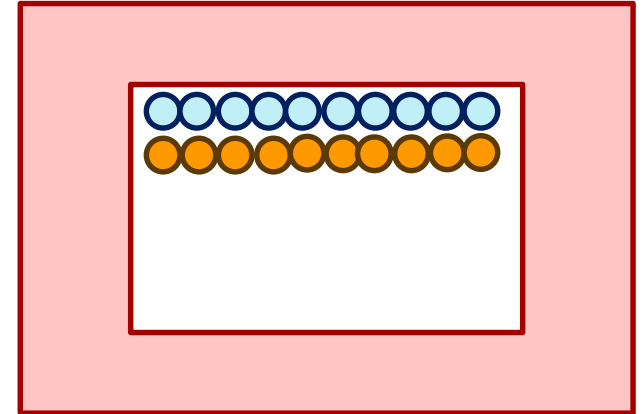
Constraint 4: Physical

A_w = wire cross-section area

W_A = Core window area

n = Number of turns

K_u = Fill factor, typically $\sim 0.5-0.9$



$$K_u W_A \geq n A_w$$

Aim is to utilize the core window fully, but space lost due to wire shape and insulation

Combining the constraints

Eliminating the unknowns n, l_g, A_w expresses the requirements of core in terms of the core geometrical constant, K_g

$$K_g = \frac{A_C^2 \cdot W_A}{(MLT)} \geq \rho \cdot \frac{L_{prim}^2 \cdot I_{max}^2}{R_w K_u B_{max}^2}$$

Property of
the core only Property of
the design

Select cores whose geometric constant is higher than that required by the design

Now design the rest of the transformer

- Determine the number of turns in the primary

$$n = \frac{L_{prim} I_{max}}{A_C B_{max}}$$

- Based on turns ratio, set number of turns in secondary and auxiliary
- Specify the inductance factor

$$A_L = \frac{L_{prim}}{n^2} = \frac{A_C \mu_0}{l_g}$$

WEBENCH[®] design examples



90+ High Voltage Products (> 70V) in WEBENCH® Tools

GPN	Comments
UCC28C40/1/2/3/4/5/UCC28C41-Q1 UCC38C40/1/2/3/4/5	Secondary Side Regulated Flyback using Optocoupler Feedback
UC1842/3/4/5 UC2842/3/4/5/UC2843A-Q1 UC1842A/3A/4A/5A UC2842A/3A/4A/5A UC3842/3/4/5 UC3842A/3A/4A/5A	Secondary Side Regulated Flyback using Optocoupler Feedback
UCC28910/1	Primary Side Regulated (PSR) Flyback
TL2842/3/4/5/42B/43B/44B/45B/43B-Q1 TL3842/3/4/5/42B/43B/44B/45B	Secondary Side Regulated Flyback using Optocoupler Feedback
UCC28704	PSR CV/CC Flyback controller
UCC28700/701/2/3/710/711/720/722	PSR CV/CC Flyback controller
UCC28740	CV/CC Flyback using Optocoupler Feedback
UCC28880/1	Non-isolated HV AC/DC HS Buck
LM5023	Quasi-Resonant Mode PWM
UCC28740 + UCC24636	Synchronous Rectifier Controller for USB Type C PD Applications
UCC2800/1800/3800/2800-Q1/UCC2813-0/3813-0 UCC2801/1801/3801/2801-Q1/UCC2813-1/3813-1 UCC2802/1802/3802/2802-Q1/UCC2813-2/3813-2 UCC2803/1803/3803/2803-Q1/UCC2813-3/3813-3 UCC2804/1804/3804/2804-Q1/UCC2813-4/3813-4 UCC2805/1805/3805/2805-Q1/UCC2813-5/3813-5	Low Power Current Mode PWM
UCC28880/1	Flyback Topology



Design example (UCC28C42):

WEBENCH®
design panel

TI Home > Semiconductors > Power Management > Off-line and Isolated DC/DC Controllers and Converters > PWM and

UCC28C42 (ACTIVE)

BiCMOS Low Current 8 Pin PWM Current Mode Controller

UCCx8C4x BiCMOS Low-Power Current-Mode PWM Controller (Rev. G)

Online datasheet | Technical documents | Tools & software | Order Now | Compare | Quality & packaging

Features

- Enhanced Replacement for UCx84x and UCx84xA Family V Pin Compatibility
- 1-MHz Operation
- 50- μ A Standby Current, 100- μ A Maximum
- Low Operating Current of 2.3 mA at 52 kHz

Parameter	Min	Max	Range
VinRMS	85	265	V 20.00 to 480.00V
Vout		12	V 3.3 to 50.0V
Iout		2	A \leq 20.0A
Ambient Temp		30	$^{\circ}$ C -40 to 105 $^{\circ}$ C

Open Design

WEBENCH® Design

Pop up alerts user of core/bobbin selection for the design

The screenshot displays the WEBENCH Design software interface. The main window shows a transformer schematic, a graph of efficiency vs. load current, and a table of component selections. A red arrow points to a pop-up dialog box titled 'Component Selection Information' which contains the following text:

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

Below the dialog box, there is a 'WEBENCH Disclaimer' section with a checkbox labeled 'Do not display this message again' and a 'Yes' button.

Category	Item	QTY	Comments	Description
Core	33-2000	1		33-2000
Core	33-2000	1		33-2000
Core	33-2000	1		33-2000
Core	33-2000	1		33-2000
Core	33-2000	1		33-2000
Core	33-2000	1		33-2000
Core	33-2000	1		33-2000
Core	33-2000	1		33-2000
Core	33-2000	1		33-2000
Core	33-2000	1		33-2000

WEBENCH® design summary

The screenshot displays the WEBENCH Designer interface with several key sections highlighted by red boxes and arrows:

- Optimization Tuning:** A control panel with a slider for balancing 'Lowest BOM Cost' (2378) and 'Highest Efficiency' (91). It also shows 'Footprint' (2378) and 'BOM Cost' (\$18.15).
- Charts:** A graph titled 'Efficiency' showing efficiency curves for different operating points. An arrow labeled 'OpVals' points to the 'Operating Values' table below it.
- Schematic:** A circuit schematic diagram of a power converter, highlighted with a red box and labeled 'Circuit Schematic'.
- Advanced Options:** A panel for 'Design Inputs' including 'User Preferred Frequency', 'Frequency' (25kHz to 870kHz), and 'Max Current Ripple%' (90% to 150%). It shows 'Current Design: #13408' and 'IC: UCC28C42'.
- BOM of Materials:** A table listing components, quantities, and prices, highlighted with a red box and labeled 'BOM Information'.
- WEBENCH® Optimizer:** A section with a 'Click here to Start Design Optimization' button and a 'Your Complete Design' summary.

Design Inputs

OpVals

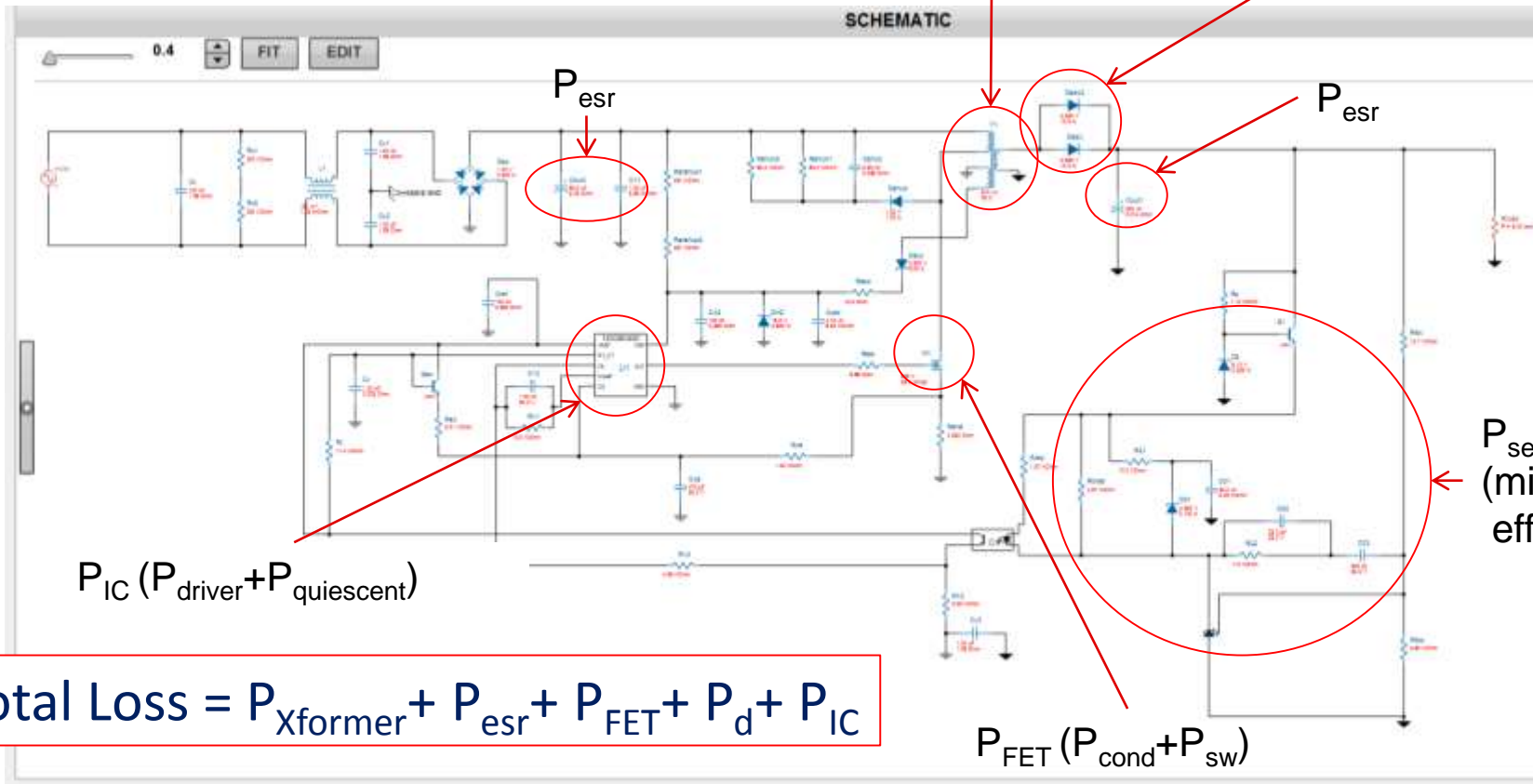
Circuit Schematic

BOM Information

Power loss contributions

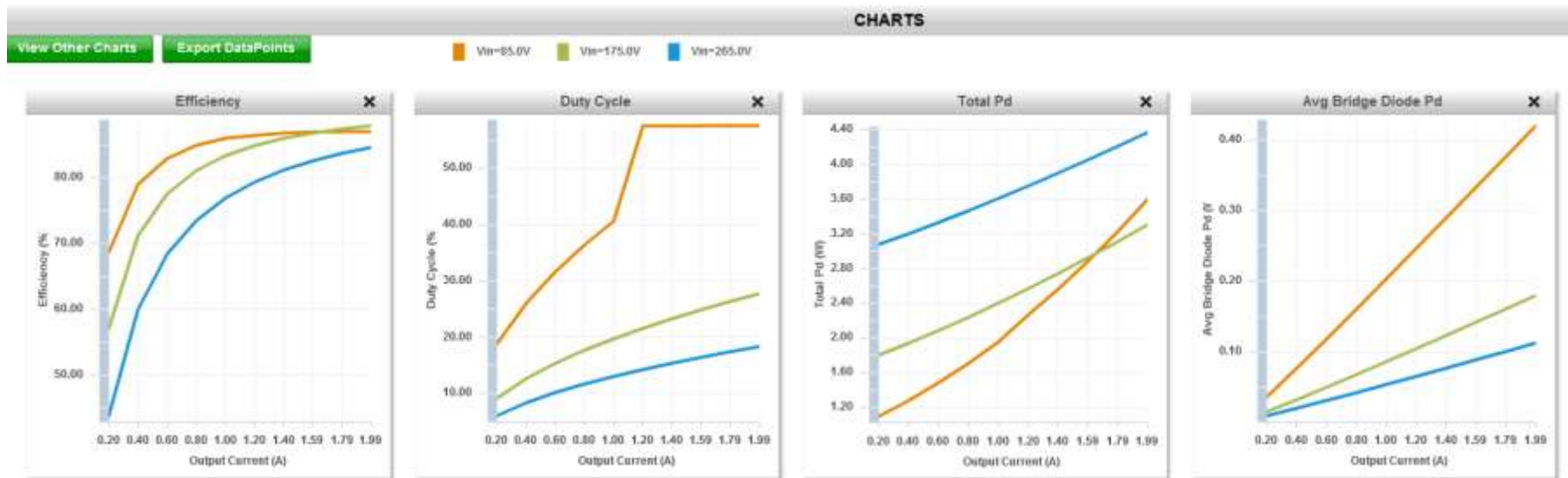
$$P_{X\text{former}} (P_{\text{dcr}} + P_{\text{core}})$$

$$P_{\text{diode}} (P_{\text{cond}} + P_{\text{rr}})$$



$$\text{Total Loss} = P_{X\text{former}} + P_{\text{esr}} + P_{\text{FET}} + P_{\text{d}} + P_{\text{IC}}$$

Operating charts



Operating values

Operating Values

Modify Operating Point

Vin (V): Iout (A):

Search

Categories	Name ▲	Value	Cat
<input type="radio"/> Current	Duty Cycle	57.6%	Op_
<input type="radio"/> General	Efficiency	86.97%	Op_
<input checked="" type="radio"/> Op_Point	IC Tj	35.8degC	Op_
<input type="radio"/> Power	ICThetaJA	50degC/W	Op_
<input type="radio"/> Unknown	IOUT_OP	2.000A	Op_
<input type="radio"/> All	M1 TJOP	44.4degC	Op_
	Peak Rectified Vin	120.207V	Op_
	Vin_OP_RMS	85.000V	Op_
	Vout OP	12.000V	Op_
	Vout p-p	0.080V	Op_

BOM

Export to: Excel BOM Cost: \$18.13 *Footprint is component footprint plus trim per side.

Part	Manufacturer	Part Number	Quantity	Price	Attributes	Footprint	Top View	Edit
C11	TDK	C5750X522P105K	1	\$1.25	Cap-1uF, ESR-6.203mOhm	54		Select Alternate Part
C12	AVX	08053C104KAT2A	1	\$0.01	Cap-100nF, ESR-0.280Ohm	7		Select Alternate Part
C13	Samsung Electro-Mechanica	CL21C103JBC189C	1	\$0.01	Cap-1uF, ESR-001m	7		Select Alternate Part
C21	TDK	C2012X5R1V226M125AC	1	\$0.33	Cap-22uF, ESR-2.05mOhm	7		Select Alternate Part
C22	Kemet	C0805C220K03ACTU	1	\$0.01	Cap-22pF, ESR-60fm	7		Select Alternate Part
C23	Samsung Electro-Mechanica	CL21C201JBA189C	1	\$0.01	Cap-200pF, ESR-001m	7		Select Alternate Part
Clmk	Neticon	LL53G2088LY	1	\$1.40	Cap-02uF, ESR-0.420Ohm	404		Select Alternate Part
Csa	Vague America	CC0805R027R00B471	1	\$0.01	Cap-075pF, ESR-80fm	7		Select Alternate Part
Cout1	Panasonic	255VPF330M	1	\$0.70	Cap-330uF, ESR-0.0140Ohm	151		Select Alternate Part
Cref	AVX	08053C104KAT2A	1	\$0.01	Cap-100nF, ESR-0.280Ohm	7		Select Alternate Part
Cres1b	TDK	C3216C42C302J	1	\$0.08	Cap-2.2uF, ESR-0.0200Ohm	11		Select Alternate Part
C1	Kemet	C0805C102J50ACTU	1	\$0.02	Cap-100F, ESR-0.0250Ohm	7		Select Alternate Part
Cvid	Murata	GRM319R01C475KA120	1	\$0.16	Cap-4.7uF, ESR-4.682mOhm	11		Select Alternate Part
Cx	Kemet	PH848R06100R0302	1	\$0.38	Cap-100uF, ESR-1.080Ohm	208		Select Alternate Part
Cy1	TDK	S01123C1102B	1	\$0.22	Cap-1uF, ESR-1.090Ohm	148		Select Alternate Part
Cy2	TDK	S01123C1102B	1	\$0.22	Cap-1uF, ESR-1.090Ohm	148		Select Alternate Part
Cy3	TDK	S01123C1102B	1	\$0.22	Cap-1uF, ESR-1.090Ohm	148		Select Alternate Part
D12	Diodes Inc.	MM525400E-7-T	1	\$0.04	Vf@Io=1V, DCWatts=0.5W, VRRM=40V	43		Select Alternate Part
D21	Panasonic	062531600L	1	\$0.04	Vf@Io=0.50V, Io=0.1A, VRRM=35V	6		Select Alternate Part
D6c	Diodes Inc.	RD06-T	1	\$0.13	Vf@Io=1V, Io=0.5A, VRRM=600V	42		Select Alternate Part
D6ax	SMC Diode Solutions	SK2204TR	1	\$0.05	Vf@Io=0.3V, Io=2A, VRRM=350V	37		Select Alternate Part
D6ax	SMC Diode Solutions	SBR110230TR	1	\$0.42	Vf@Io=0.30V, Io=10A, VRRM=200V	102		Select Alternate Part
D6ax2	SMC Diode Solutions	SBR110230TR	1	\$0.42	Vf@Io=0.30V, Io=10A, VRRM=200V	102		Select Alternate Part
D6ax3	Microsemi	VF5100JCT0813	1	\$0.71	Vf@Io=1.2V, Io=5A, VRRM=600V	42		Select Alternate Part

Print

Back New Searchbook Viewbook BOM Charts Schematics Options Up Data Build & List Print Share Design Help

SUMMARY

Click here to go

Please Select Your Report

Basic Design Report

Includes schematic, BOM and charts

Comments to add to your report:

Print Report Cancel



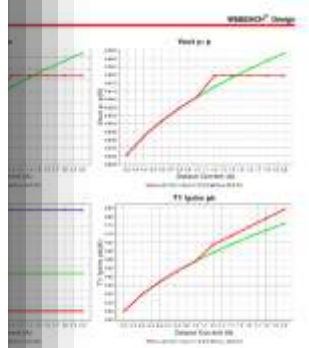
1. Pull in the mouse to zoom (horizontal scroll). The red cursor of mouse has the following color of a color for Report

My Comments

Item	Value	Unit	Min	Max	Target
1. 100	100	µF	100	100	100
2. 100	100	µF	100	100	100
3. 100	100	µF	100	100	100
4. 100	100	µF	100	100	100
5. 100	100	µF	100	100	100
6. 100	100	µF	100	100	100

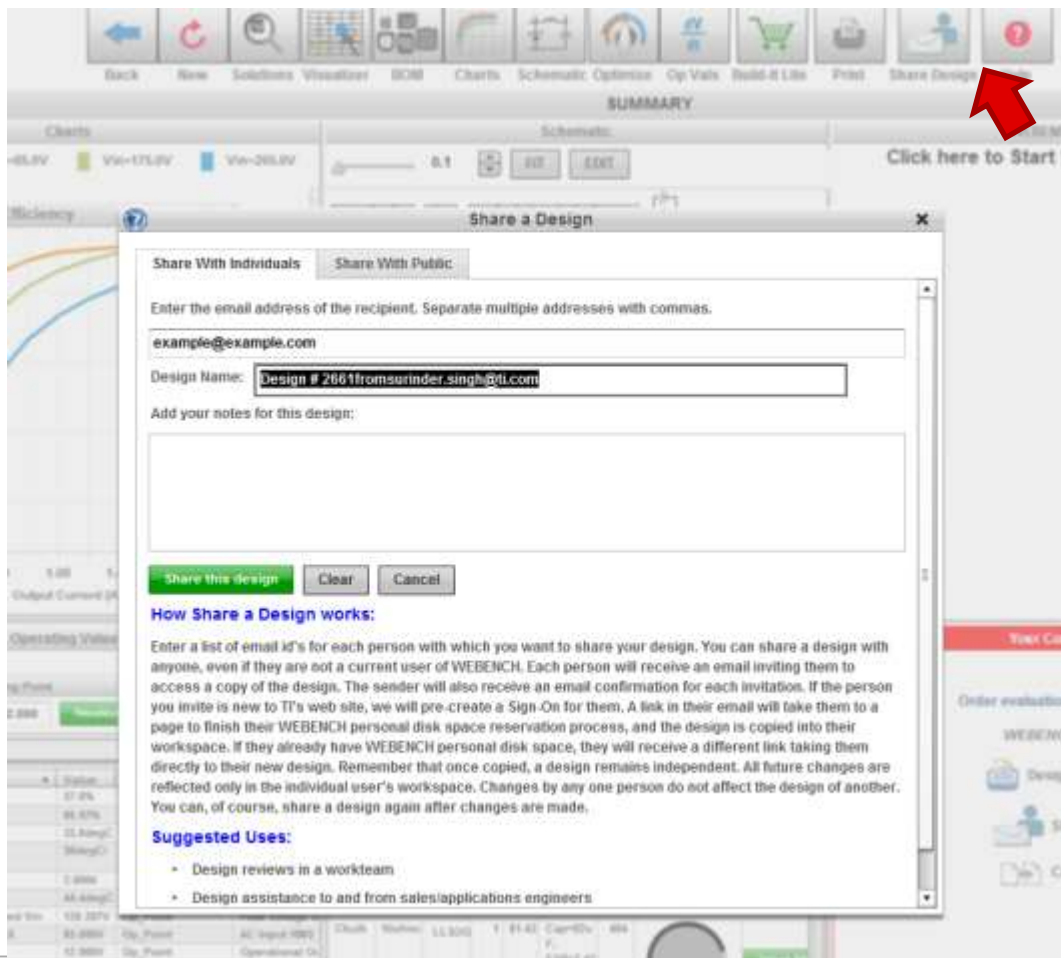
Design 0.001: Texas Instruments Incorporated

Item	Value	Unit	Min	Max	Target
1. 100	100	µF	100	100	100
2. 100	100	µF	100	100	100
3. 100	100	µF	100	100	100
4. 100	100	µF	100	100	100
5. 100	100	µF	100	100	100
6. 100	100	µF	100	100	100



Item	Value	Unit	Min	Max	Target
1. 100	100	µF	100	100	100
2. 100	100	µF	100	100	100
3. 100	100	µF	100	100	100
4. 100	100	µF	100	100	100
5. 100	100	µF	100	100	100
6. 100	100	µF	100	100	100

Share



The screenshot shows the WEBENCH software interface. At the top, a toolbar contains various icons, including a red question mark icon labeled 'Share Design'. A red arrow points to this icon. Below the toolbar, the 'SUMMARY' section is visible. A 'Share a Design' dialog box is open, showing the 'Share With Public' tab. The dialog box contains the following text:

Share With Individuals Share With Public

Enter the email address of the recipient. Separate multiple addresses with commas.

example@example.com

Design Name: Design # 2661fromsurinder.singh@ti.com

Add your notes for this design:

How Share a Design works:

Enter a list of email ID's for each person with which you want to share your design. You can share a design with anyone, even if they are not a current user of WEBENCH. Each person will receive an email inviting them to access a copy of the design. The sender will also receive an email confirmation for each invitation. If the person you invite is new to TI's web site, we will pre-create a Sign-On for them. A link in their email will take them to a page to finish their WEBENCH personal disk space reservation process, and the design is copied into their workspace. If they already have WEBENCH personal disk space, they will receive a different link taking them directly to their new design. Remember that once copied, a design remains independent. All future changes are reflected only in the individual user's workspace. Changes by any one person do not affect the design of another. You can, of course, share a design again after changes are made.

Suggested Uses:

- Design reviews in a workteam
- Design assistance to and from sales/applications engineers

Schematic

T1 Component Properties X

Select Assembled Off the Shelf Transformer

Explore Transformer Core/Bobbin selection Download Transformer Details

Below is the current state of this component.
Click on the 'Select Assembled Off the Shelf Transformer' button to change it.

Property	Value
PartNumber	Core=B65807P0000R087 , CoilFormer=
Manufacture	Core=TDK , CoilFormer=TDK
Lp	914 uH
Aux AWG	30.0
Aux Dia	0.310 mm
Aux Insulation Type	Heavy Insulated Magnet Wire
Aux Layers	1.00
Aux Strands	2.00
Avg.Length of Turn	31.0 mm
Budget_Price	\$1.92
CoilFormer Manufacturer	TDK
CoilFormer PartNumber	B65821C1008T001
Core Area	17.5 mm ²

SCHEMATIC

The schematic diagram shows a transformer circuit with various components including resistors, capacitors, and inductors. A red arrow points to a component in the upper part of the circuit, likely a transformer or inductor.

View or change Flyback transformer

Property	Value
PartNumber	Core=B65807P0000R087 , CoilFormer=
Manufacture	Core=TDK , CoilFormer=TDK
Lp	914 uH
Aux AWG	30.0
Aux Dia	0.310 mm
Aux Insulation Type	Heavy Insulated Magnet Wire
Aux Layers	1.00
Aux Strands	2.00
Avg.Length of Turn	31.0 mm
Budget_Price	\$1.92
CoilFormer Manufacturer	TDK
CoilFormer PartNumber	B65821C1008T001
Core Area	17.5 mm ²

Selecting this will give the user any available off-the-shelf transformers

Selecting this will give the user all selected core/bobbins for the current design

Flyback transformer designer

TRANSFORMER DESIGNER

Recommended Transformer | See Details below: Core=B66807P0000R087 , CoilFormer=B66821C1008T001

Core 3D View

Bobbin 3D View

Transformer Electrical Diagram

Transformer Construction Diagram

Transformer Electrical Properties

Property	Value
Primary Inductance(mH)	64.8
Flux density(T)	0.22
Wdg depth(mm)	0.25
Core Area(mm ²)	100
Frequency(kHz)	100
I(Max)	2
Primary Peak Current(A)	1.9
Primary RMS Current(A)	1.3
Secondary Peak Current(A)	3
Secondary RMS Current(A)	2.1

Transformer Construction Details

Property	Value
Primary Turns	68
Secondary Turns	11
Auxiliary Turns	11

Note the Kg of the selected cores with the design condition 85-265Vin, 12 V @ 2A

Found 6 Transformers

Select	Transformer	Apply	Top View	Manufacturer	Orientation	Core Type	Core Material	Transformer Cost(\$)	Transformer Footprint(mm ²)	Transformer Height(mm)	Core Geometry Factor(Kg)	Wdg(T)	Number of Pins	Bobbin Solutions
<input checked="" type="checkbox"/>	Core=B66807P0000R087, CoilFormer=B66821C1008T001	Apply to Design Download Transformer PDF		Core=TDK, CoilFormer=TDK	II	RM6 LP	N67	\$1.82	290	7.300	734	0.300	8	1
<input type="checkbox"/>	Core=B66807P0000R087, CoilFormer=B66821C1008T001			Core=TDK, CoilFormer=TDK	II	RM6	N65	\$1.58	280	7.300	780	0.300	8	1
<input type="checkbox"/>	Core=B66807P0000R087, CoilFormer=B66821C1008T001			Core=TDK, CoilFormer=TDK	II	RM6	N65	\$2.17	280	7.300	734	0.400	8	1
<input type="checkbox"/>	Core=B66807P0000R087, CoilFormer=B66821C1008T001			Core=TDK, CoilFormer=TDK	II	RM6	N65	\$2.25	280	7.300	780	0.400	8	1

See the different list of Core/Bobbins selected for the design & their respective parameters (core type/material, Kg)

Let us change the design condition now...

Change the inputs to the design

Click on “Change Design Inputs” button to see this window on the right

Optimization Tuning

Efficiency

Schematic

BOM of Materials

Part	Manufacturer	Part No.	Q	Pin	ADD/Notes	Pa	Top View	3D
C18	10K	C20K	1	01	Cap+Tol 82K±5%	0		
C19	10K	C20K	1	02	Cap+Tol 82K±5%	0		
C20	10K	C20K	1	03	Cap+Tol 82K±5%	0		
C21	10K	C20K	1	04	Cap+Tol 82K±5%	0		
C22	10K	C20K	1	05	Cap+Tol 82K±5%	0		
C23	10K	C20K	1	06	Cap+Tol 82K±5%	0		
C24	10K	C20K	1	07	Cap+Tol 82K±5%	0		
C25	10K	C20K	1	08	Cap+Tol 82K±5%	0		
C26	10K	C20K	1	09	Cap+Tol 82K±5%	0		
C27	10K	C20K	1	10	Cap+Tol 82K±5%	0		
C28	10K	C20K	1	11	Cap+Tol 82K±5%	0		
C29	10K	C20K	1	12	Cap+Tol 82K±5%	0		
C30	10K	C20K	1	13	Cap+Tol 82K±5%	0		
C31	10K	C20K	1	14	Cap+Tol 82K±5%	0		
C32	10K	C20K	1	15	Cap+Tol 82K±5%	0		
C33	10K	C20K	1	16	Cap+Tol 82K±5%	0		
C34	10K	C20K	1	17	Cap+Tol 82K±5%	0		
C35	10K	C20K	1	18	Cap+Tol 82K±5%	0		
C36	10K	C20K	1	19	Cap+Tol 82K±5%	0		
C37	10K	C20K	1	20	Cap+Tol 82K±5%	0		
C38	10K	C20K	1	21	Cap+Tol 82K±5%	0		
C39	10K	C20K	1	22	Cap+Tol 82K±5%	0		
C40	10K	C20K	1	23	Cap+Tol 82K±5%	0		
C41	10K	C20K	1	24	Cap+Tol 82K±5%	0		
C42	10K	C20K	1	25	Cap+Tol 82K±5%	0		
C43	10K	C20K	1	26	Cap+Tol 82K±5%	0		
C44	10K	C20K	1	27	Cap+Tol 82K±5%	0		
C45	10K	C20K	1	28	Cap+Tol 82K±5%	0		
C46	10K	C20K	1	29	Cap+Tol 82K±5%	0		
C47	10K	C20K	1	30	Cap+Tol 82K±5%	0		
C48	10K	C20K	1	31	Cap+Tol 82K±5%	0		
C49	10K	C20K	1	32	Cap+Tol 82K±5%	0		
C50	10K	C20K	1	33	Cap+Tol 82K±5%	0		
C51	10K	C20K	1	34	Cap+Tol 82K±5%	0		
C52	10K	C20K	1	35	Cap+Tol 82K±5%	0		
C53	10K	C20K	1	36	Cap+Tol 82K±5%	0		
C54	10K	C20K	1	37	Cap+Tol 82K±5%	0		
C55	10K	C20K	1	38	Cap+Tol 82K±5%	0		
C56	10K	C20K	1	39	Cap+Tol 82K±5%	0		
C57	10K	C20K	1	40	Cap+Tol 82K±5%	0		
C58	10K	C20K	1	41	Cap+Tol 82K±5%	0		
C59	10K	C20K	1	42	Cap+Tol 82K±5%	0		
C60	10K	C20K	1	43	Cap+Tol 82K±5%	0		
C61	10K	C20K	1	44	Cap+Tol 82K±5%	0		
C62	10K	C20K	1	45	Cap+Tol 82K±5%	0		
C63	10K	C20K	1	46	Cap+Tol 82K±5%	0		
C64	10K	C20K	1	47	Cap+Tol 82K±5%	0		
C65	10K	C20K	1	48	Cap+Tol 82K±5%	0		
C66	10K	C20K	1	49	Cap+Tol 82K±5%	0		
C67	10K	C20K	1	50	Cap+Tol 82K±5%	0		
C68	10K	C20K	1	51	Cap+Tol 82K±5%	0		
C69	10K	C20K	1	52	Cap+Tol 82K±5%	0		
C70	10K	C20K	1	53	Cap+Tol 82K±5%	0		
C71	10K	C20K	1	54	Cap+Tol 82K±5%	0		
C72	10K	C20K	1	55	Cap+Tol 82K±5%	0		
C73	10K	C20K	1	56	Cap+Tol 82K±5%	0		
C74	10K	C20K	1	57	Cap+Tol 82K±5%	0		
C75	10K	C20K	1	58	Cap+Tol 82K±5%	0		
C76	10K	C20K	1	59	Cap+Tol 82K±5%	0		
C77	10K	C20K	1	60	Cap+Tol 82K±5%	0		
C78	10K	C20K	1	61	Cap+Tol 82K±5%	0		
C79	10K	C20K	1	62	Cap+Tol 82K±5%	0		
C80	10K	C20K	1	63	Cap+Tol 82K±5%	0		
C81	10K	C20K	1	64	Cap+Tol 82K±5%	0		
C82	10K	C20K	1	65	Cap+Tol 82K±5%	0		
C83	10K	C20K	1	66	Cap+Tol 82K±5%	0		
C84	10K	C20K	1	67	Cap+Tol 82K±5%	0		
C85	10K	C20K	1	68	Cap+Tol 82K±5%	0		
C86	10K	C20K	1	69	Cap+Tol 82K±5%	0		
C87	10K	C20K	1	70	Cap+Tol 82K±5%	0		
C88	10K	C20K	1	71	Cap+Tol 82K±5%	0		
C89	10K	C20K	1	72	Cap+Tol 82K±5%	0		
C90	10K	C20K	1	73	Cap+Tol 82K±5%	0		
C91	10K	C20K	1	74	Cap+Tol 82K±5%	0		
C92	10K	C20K	1	75	Cap+Tol 82K±5%	0		
C93	10K	C20K	1	76	Cap+Tol 82K±5%	0		
C94	10K	C20K	1	77	Cap+Tol 82K±5%	0		
C95	10K	C20K	1	78	Cap+Tol 82K±5%	0		
C96	10K	C20K	1	79	Cap+Tol 82K±5%	0		
C97	10K	C20K	1	80	Cap+Tol 82K±5%	0		
C98	10K	C20K	1	81	Cap+Tol 82K±5%	0		
C99	10K	C20K	1	82	Cap+Tol 82K±5%	0		
C100	10K	C20K	1	83	Cap+Tol 82K±5%	0		
C101	10K	C20K	1	84	Cap+Tol 82K±5%	0		
C102	10K	C20K	1	85	Cap+Tol 82K±5%	0		
C103	10K	C20K	1	86	Cap+Tol 82K±5%	0		
C104	10K	C20K	1	87	Cap+Tol 82K±5%	0		
C105	10K	C20K	1	88	Cap+Tol 82K±5%	0		
C106	10K	C20K	1	89	Cap+Tol 82K±5%	0		
C107	10K	C20K	1	90	Cap+Tol 82K±5%	0		
C108	10K	C20K	1	91	Cap+Tol 82K±5%	0		
C109	10K	C20K	1	92	Cap+Tol 82K±5%	0		
C110	10K	C20K	1	93	Cap+Tol 82K±5%	0		
C111	10K	C20K	1	94	Cap+Tol 82K±5%	0		
C112	10K	C20K	1	95	Cap+Tol 82K±5%	0		
C113	10K	C20K	1	96	Cap+Tol 82K±5%	0		
C114	10K	C20K	1	97	Cap+Tol 82K±5%	0		
C115	10K	C20K	1	98	Cap+Tol 82K±5%	0		
C116	10K	C20K	1	99	Cap+Tol 82K±5%	0		
C117	10K	C20K	1	100	Cap+Tol 82K±5%	0		

Change Inputs

VinMin	20V	< 85	V < 480V
VinMax	20V	< 265	V < 480V
Vout	3.3V	< 12	V < 50V
Iout	6A	< 2	A < 20A
Ta	-40°C	< 39	°C < 105°C

Change Submit

Enter new output current

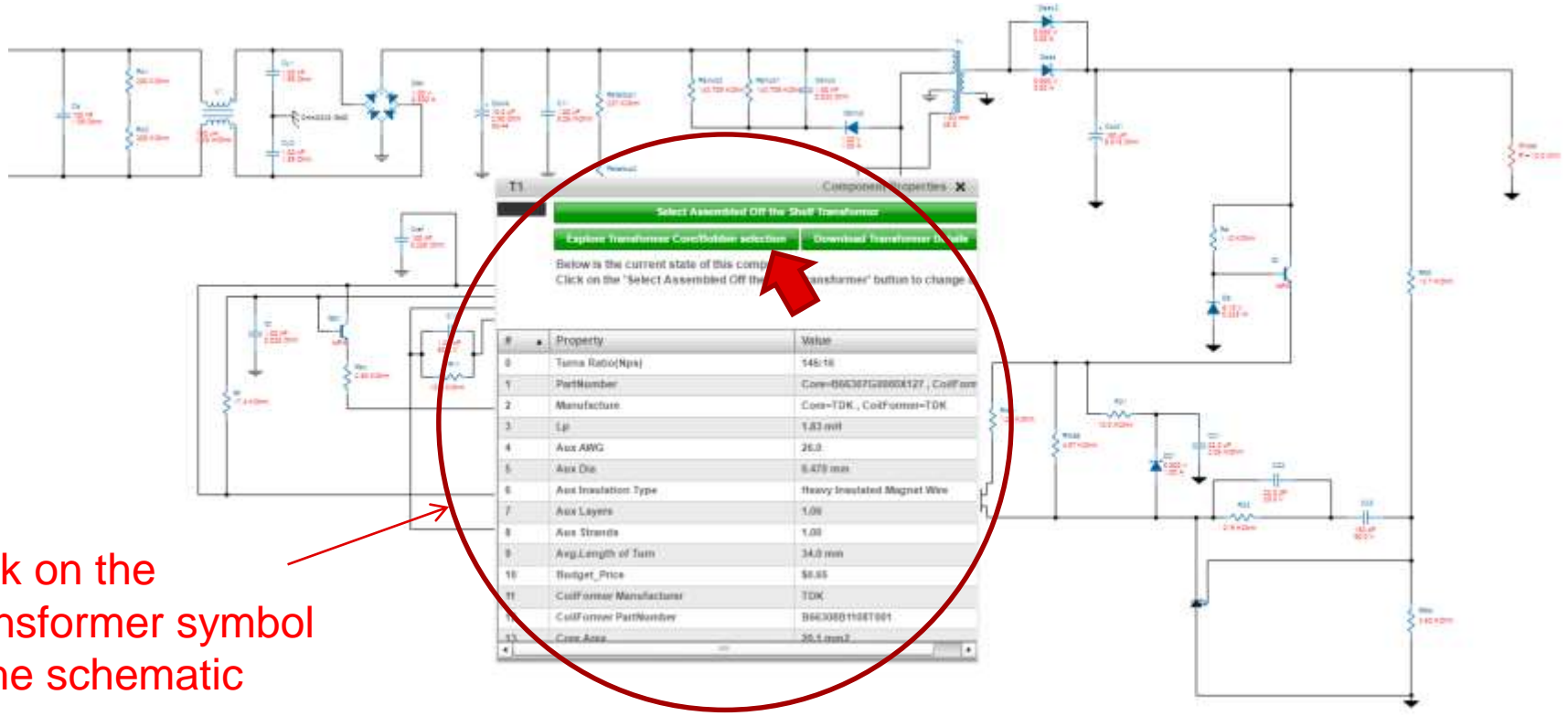
Lets decrease the output current to 1 A from 2 A and see how our core selection changes

Change Inputs

VinMin	20V	<	85	V < 480V
VinMax	20V	<	265	V < 480V
Vout	3.3V	<	12	V < 50V
Iout	0A	<	1	A < 20A
Ta	-40°C	<	30	°C < 105°C

Close Submit

View the Flyback transformer in the schematic




Click on the Transformer symbol in the schematic

Flyback transformer design


TRANSFORMER DESIGNER

Recommended Transformer (See Details below): Core=B66307G0000X127 , CoilFormer=B66308B1108T001

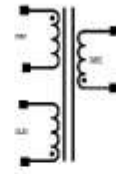
Core 3D View



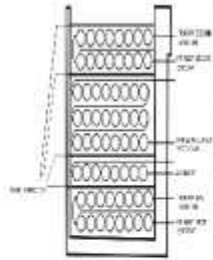
Bobbin 3D View



Transformer Electrical Diagram



Transformer Construction Diagram



Transformer Electrical Properties






Property	Value
Primary Inductance(mH)	103.2
Flux density(T)	
Skin depth(mm)	
Core Amplitude	
Frequency(KHz)	
Delta	
Primary Peak Current(A)	
Primary RMS Current(A)	
Secondary Peak Current(A)	1.85
Secondary RMS Current(A)	

Transformer Construction Details

Property	Value
Primary Turns	146
Primary Layers	4
Secondary Turns	3
Secondary Layers	3

Note the Kg of the selected cores with the design condition 85-265Vin, 12 V@ 1A. It is lesser than the previous design

Search: Found 5 Transformers

Select	Transformer	Apply	Top View	Manufacturer	Orientation	Core Type	Core Material	Transformer Cost(\$)	Transformer Footprint(mm ²)	Core Girth Factor(mm ²)	Transformer Height(mm)	Boat(T)	Number of Pins	Bobbin Sections
<input checked="" type="radio"/>	Core=B66307G0000X127 , CoilFormer=B66308B1108T001	Apply to Design Download Transformer PDF		Core-TDK , CoilFormer=TDK	H	E169G	N27	\$6.66	206	264	12,100	6,410	8	1
<input type="radio"/>	Core=B66307G0000X127 , CoilFormer=B66308W1108T001			Core-TDK , CoilFormer=TDK	V	E169G	N27	\$6.75	196	264	16,200	6,410	8	1
<input type="radio"/>	Core=B66307G0000X187 , CoilFormer=B66308B1108T001			Core-TDK , CoilFormer=TDK	H	E169G	N37	\$6.65	206	264	12,100	6,180	8	1
<input type="radio"/>	Core=B66307G0000X187 , CoilFormer=B66308W1108T001			Core-TDK , CoilFormer=TDK	V	E169G	N37	\$6.74	196	264	16,200	6,180	8	1
<input type="radio"/>	Core=B65907G0000X087 , CoilFormer=B65922F1108T001			Core-TDK , CoilFormer=TDK	H	RMS LP	N37	\$1.85	103	200	6,900	6,180	8	1

Differences in electrical specs

2-A design

Property	Value		Property	Value	
Primary Inductance(uH)	914.0	▲	Primary Turns	79	▲
Flux density(T)	0.25	▮	Primary AWG	30	▮
Skin depth(mm)	0.21		Primary Insulation	Heavy Insulated Magnet Wir	
Core Area(mm2)	37.5		Primary Layers	4	
Frequency(kHz)	98.85		Primary Strands	1	
DMax	0.6	▼	Secondary Turns	9	▼

1-A design results in larger primary inductance than the 2-A design due to lower ripple current

1-A design

Property	Value		Property	Value	
Primary Inductance(uH)	1831.0	▲	Primary Turns	146	▲
Flux density(T)	0.25	▮	Primary AWG	32	▮
Skin depth(mm)	0.21		Primary Insulation	Heavy Insulated Magnet W	
Core Area(mm2)	20.1		Primary Layers	4	
Frequency(kHz)	98.85		Primary Strands	1	
DMax	0.6		Secondary Turns	16	
Primary Peak Current(A)	0.40		Secondary AWG	30	
Primary RMS Current(A)	0.19	▼	Secondary Insulation	Triple Insulated	▼

Lower current design reduces cost, footprint, Kg

2-A design

Transformer Cost(\$)	Transformer Footprint(mm2)	Core Geometry Factor(mm5)
\$1.92	290	734
\$1.98	290	700
\$1.84	290	700
\$2.17	290	700
\$2.17	290	734
\$2.05	290	700

1-A design

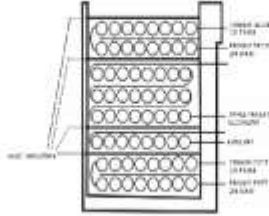
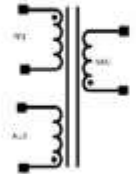


Transformer Cost(\$)	Transformer Footprint(mm2)	Core Geometry Factor(mm5)
\$0.66	200	264
\$0.75	198	264
\$0.65	200	264
\$0.74	198	264
\$1.90	103	266

Download the transformer design report

TRANSFORMER DESIGNER

Recommended Transformer (See Details below): Core=B65807P0000R087 , CoilFormer=B65821C1008T001





Core 3D View Bobbin 3D View Transformer Electrical Diagram Transformer Construction Diagram Transformer Electrical Properties Transformer Construction Details



Property	Value
Primary Inductance(uH)	914.0
Flux density(T)	0.25
Skin depth(mm)	0.21
Core Area(mm2)	37.5
Frequency(KHz)	98.85
DMax	0.6

Property	Value
Primary Turns	79
Primary AWG	30
Primary Insulation	Heavy Insulated Magnet
Primary Layers	4
Primary Strands	1
Secondary Turns	9

Search: Found 6 Transformers

Select	Transformer	Apply	Top View	Manufacturer	Orientation	Core Type	Core Material	Transformer Cost(\$)	Transfo Footprint
<input checked="" type="radio"/>	Core=B65807P0000R087 CoilFormer=B65821C1008T001	Apply to Design Download Transformer PDF		Core=TDK CoilFormer=TDK	H	RM6 LP	N87	\$1.82	290
<input type="radio"/>	Core=B65807J0000R041 CoilFormer=B65821C1008T001			Core=TDK CoilFormer=TDK	H	RM6	N41	\$1.98	290
<input type="radio"/>	Core=B65807J0000R087 CoilFormer=B65821C1008T001			Core=TDK CoilFormer=TDK	H	RM6	N87	\$1.84	290
<input type="radio"/>	Core=B65807J0000R097 CoilFormer=B65821C1008T001			Core=TDK CoilFormer=TDK	H	RM6	N87	\$2.17	290

Send the transformer report for fabrication



WEBENCH® Transformer Report

Design: T1802032861 UCC28CA2DR
 UCC28CA2DR: 2018-09-10 11:29:49

#	Name	Value
1.	Cole Part Number	B0507P000R057
2.	Cole Manufacturer	TDK
3.	Coil Former Part Number	B0582YC1008T301
4.	Coil Former Manufacturer	TDK

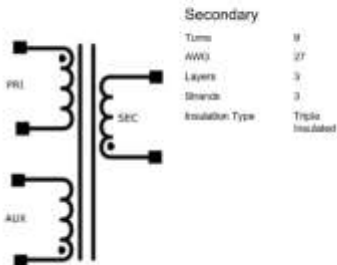
Transformer Electrical Diagram

Primary

Turns	79
AWG	30
Layers	4
Strands	1
Insulation Type	Heavy Insulated Magnet Wire

Auxiliary

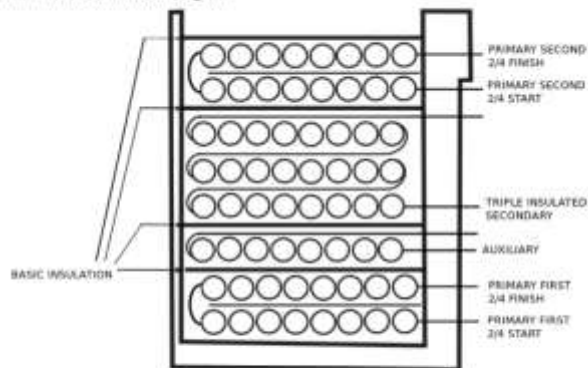
Turns	10
AWG	30
Layers	1
Strands	3
Insulation Type	Heavy Insulated Magnet Wire



Secondary

Turns	9
AWG	27
Layers	3
Strands	3
Insulation Type	Triple Insulated

Transformer Construction Diagram



Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 2/4	30	40	Clockwise
Auxiliary	30	10	Counter Clockwise
Triple Insulated Secondary	27	9	Counter Clockwise
Primary Second 2/4	30	39	Clockwise

Transformer Parameters

#	Name	Value
1.	L _{pri}	9.14E-4H
2.	Inductance Factor(K)	147m
3.	N _{pri}	79
4.	N _{aux}	9
5.	N _{sec}	10
6.	Core Type	RM LP
7.	Core Material	M67
8.	E _{max}	0.25T
9.	Switching Frequency	90.0kHz
10.	D _{max}	0.0
11.	I _{pk(Primary)}	0.8A
12.	I _{avg(Primary)}	0.29A
13.	I _{pk(Secondary)}	7.03A
14.	I _{avg(Secondary)}	2.75A

Explore WEBENCH transformer designer for your next isolated high-voltage design

WEBENCH® Designer MyDesigns

Power

Enter your power supply requirements:

DC AC

Frequency 50Hz 60Hz

Vin RMS Min 85 V Max 265 V

Output Vout 12 V Iout 2 A

Isolated Output

Multiple Loads **Power Architect**

Single Output **Start Design**

TEXAS INSTRUMENTS

WEBENCH® Transformer Report

Design: 11952032981_UCC39CAZDR
12/22/2016 09:09:00 AM CST (GMT-06:00)

#	Name	Value
1.	Cole Part Number	8600776009D07
2.	Cole Manufacturer	TDK
3.	Coil Former Part Number	865821C100ET381
4.	Coil Former Manufacturer	TDK

Transformer Electrical Diagram

Primary		Secondary	
Turns	78	Turns	8
AWG	30	AWG	27
Layers	4	Layers	3
Strands	1	Strands	3
Insulation Type	Heavy Insulated Magnet Wire	Insulation Type	Triple Insulated

Auxiliary

Turns	10
AWG	30
Layers	1
Strands	3
Insulation Type	Heavy Insulated Magnet Wire

Conclusion – high-voltage and transformer design

- Transformer design is critical for Flyback isolated designs
- WEBENCH tools can help you design your customized transformer
- Using the tool you can prototype and manufacture your transformer rapidly