Flyback Converter Design

Webinar June 26 2025 10:00 am PDT

Dr. Ray Ridley Ridley Engineering

Ridley Engineering

Our Organizers Today

Arthur Nace – Retired aerospace engineer and programmer who automated LTspice models for us. Our longest user of RidleyWorks.

John Beecroft – Course instructor with Ridley Engineering for 20 years.

Denise Ridley – The marketing and business brains behind Ridley Engineering. Denise made our workshops happen 25 years ago.

OBITUARY

Lloyd Henry Dixon Jr.

MAY 18, 1928 – MAY 23, 2025

Lloyd Henry Dixon Jr., age 97, of Naples, Florida passed away on Friday, May 23, 2025.

Download Lloyd Dixon's Magnetics Handbook

Flyback Design Choices

CCM or DCM – not a binary choice

Quasi-Resonant

RHP Zeros

RCD clamp

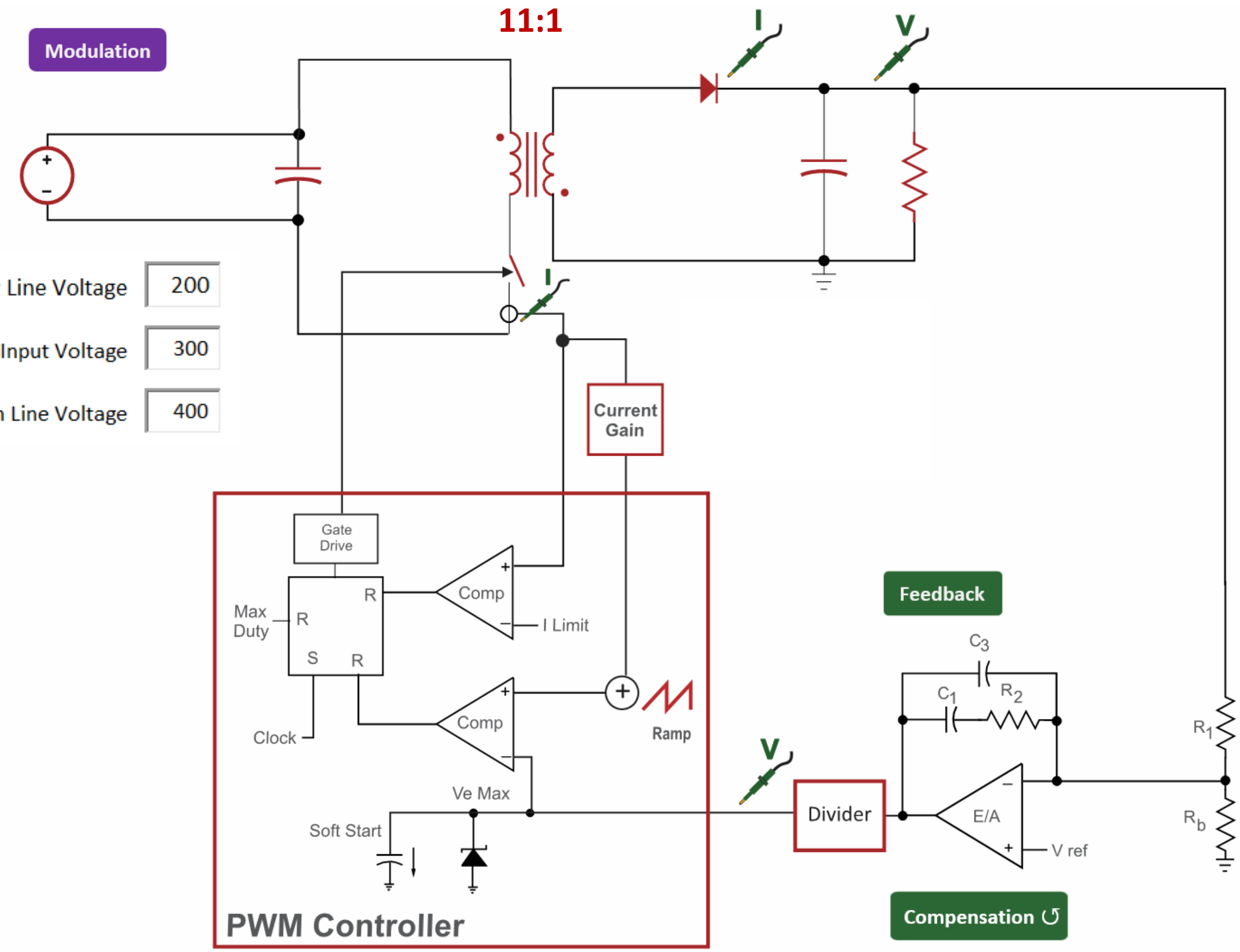
Isolated Feedback TL431

Cross Regulation

Snubbers

Active clamp

Converter Specifications



Low Line Voltage 200

Nominal Input Voltage 300

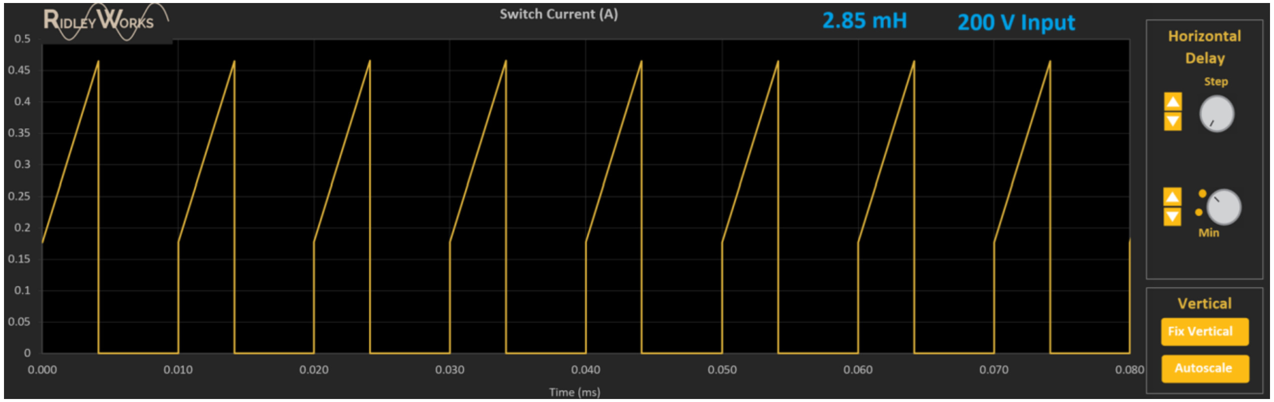
High Line Voltage 400

	Main
Output Voltage	12
Output Current	2

Switching Frequency 100 kHz

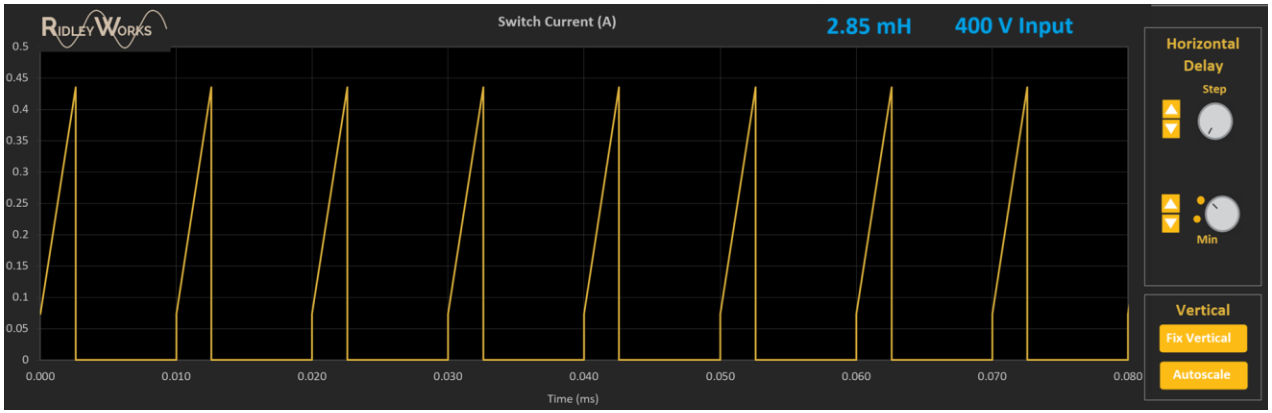
Ridley Engineering

DCM or CCM?

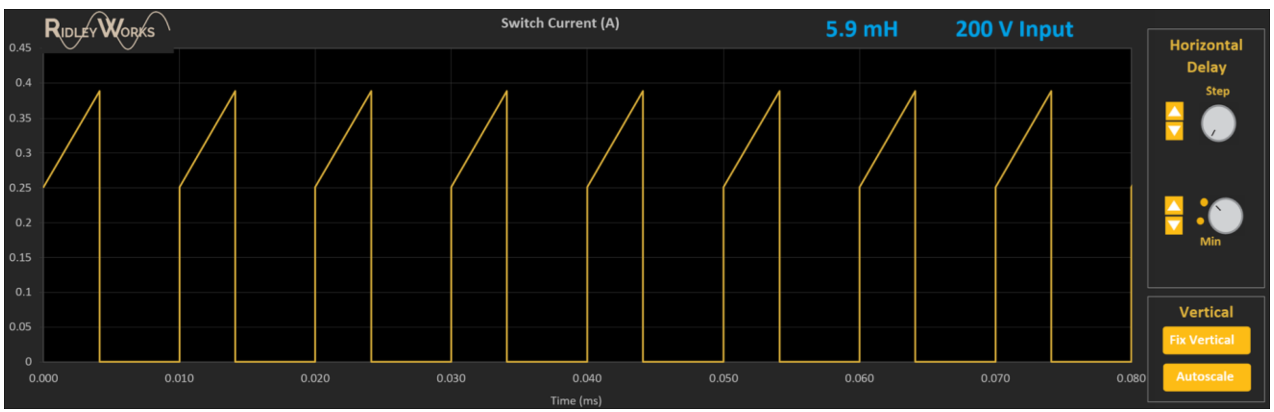


Low Line

Default Design > 10W
CCM Operation

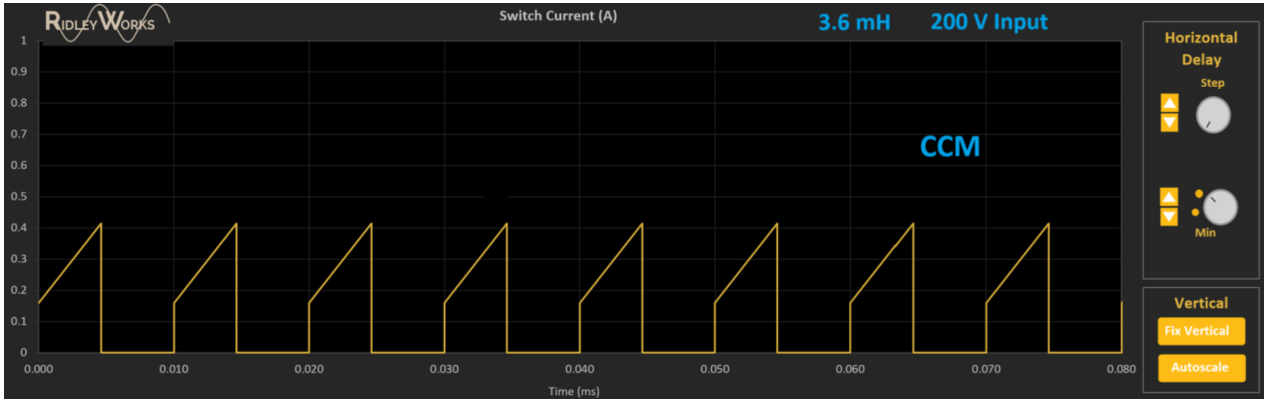


High Line

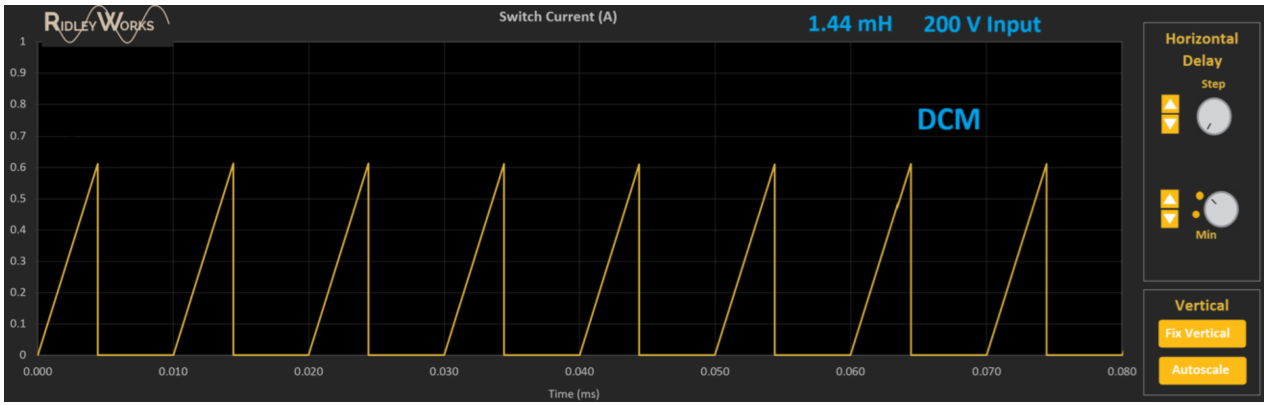


Deeper CCM
Bigger inductor Value

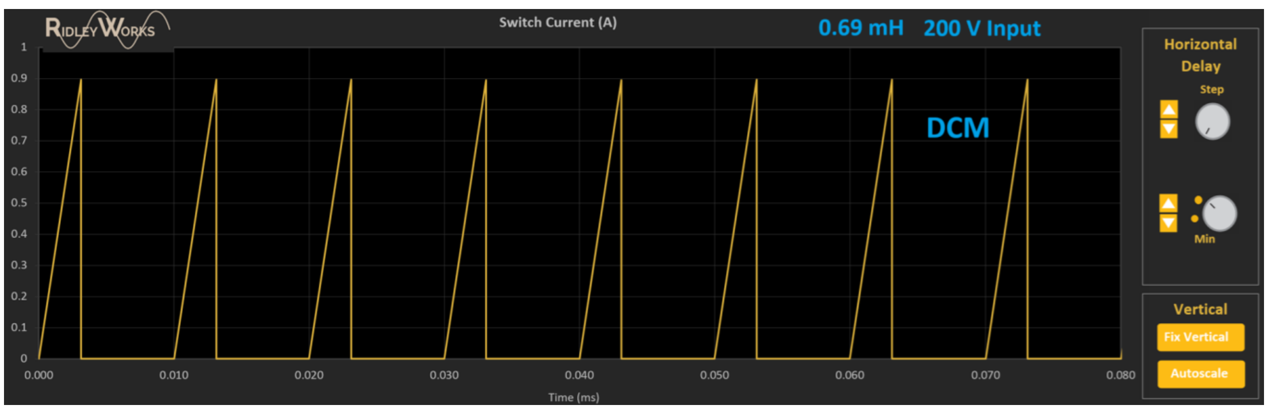
DCM or CCM?



Low Line CCM



Low Line DCM



Deeper DCM
Smaller Inductor Value

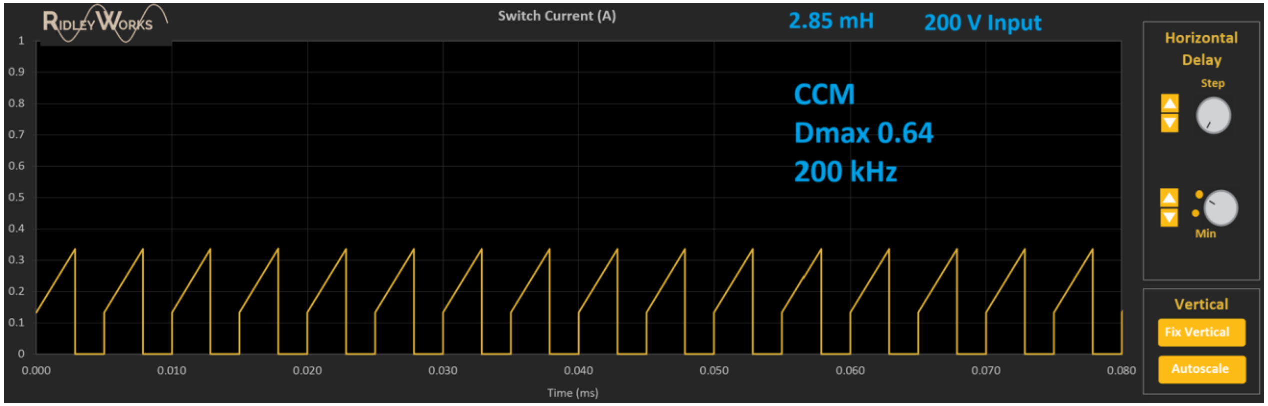
Quasi-Resonant? How Much?

Low Line DCM
30:1 Step Down (versus 11:1)

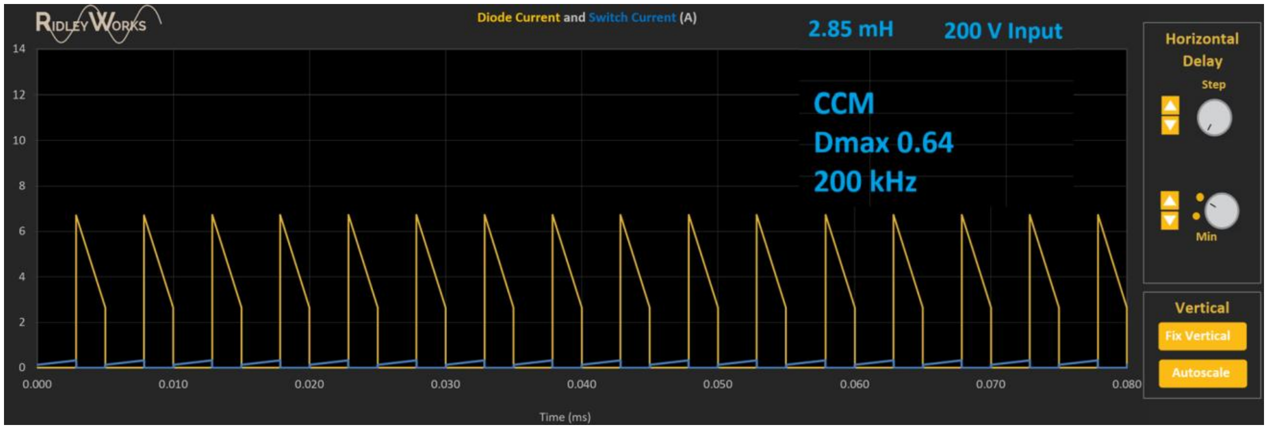
QR Mode
Change in frequency
Increase inductance to
lower the frequency
Peak Current Reduces

QR Mode
High Line QR Mode
290 kHz

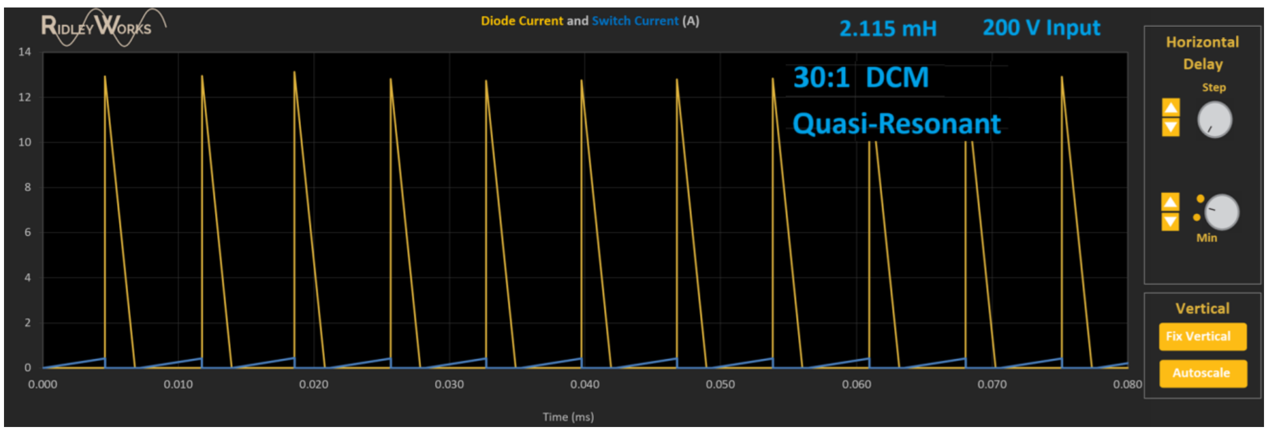
CCM vs Full Quasi-Resonant



Redesign CCM with 0.64 Dmax
200 kHz frequency



Secondary Current CCM



Secondary Current QR DCM

Ridley Engineering

Magnetics for the Flyback

RIDLEYIQ™

High level designer now in RidleyWorks

Real intelligence based on 40 years experience

Core selection

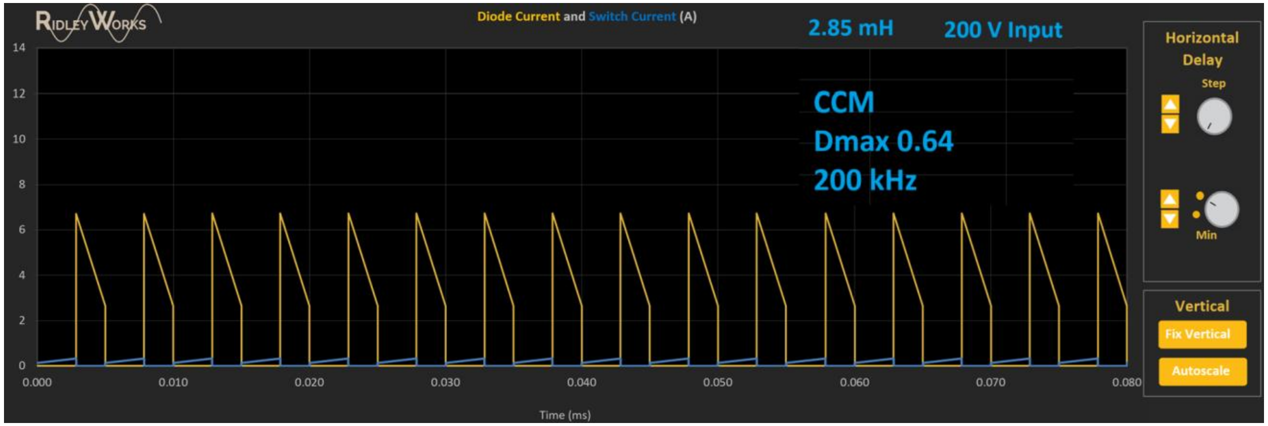
Winding design

Core losses

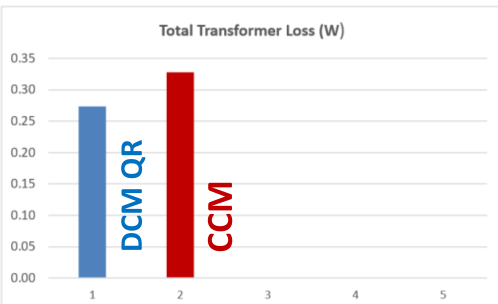
Proximity losses

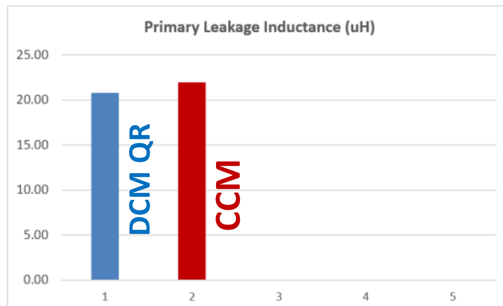
Multiple designs in very short time

Transformer Design CCM and QR



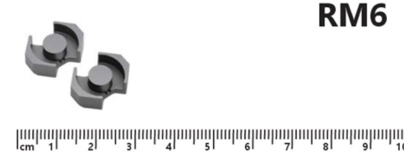
#2 Saved Transformer Design CCM		
Magnetizing Inductance	2849.73	uH
Primary Current Limit	0.382	A
Core Type	RM6	
Core Area	0.31	sq. cm
Core Material	R	
B max	0.297	T
Approximate Gap	0.19 / 18.4	mm/mils
AL Value	204.66	nH/n2
Leakage Inductance	21.93	uH
Primary Turns	118	
Wire Type	Magnet Wire	
Wire Size	33	awg
Layers	4	Split
Number of Strands	1	
Each End Margin	0.00	mm
Insulation	0.000	mm
Window Used	36.0	%
DC Resistance	2.0	Ohm
Secondary Turns	7	
Wire Type	Triple Insulated Wire	
Wire Size	20	awg
Layers	1	
Number of Strands	1	
Each End Margin	0.00	mm
Insulation	0.000	mils
Window Used	40.8	%
DC Resistance	7.5	mOhm

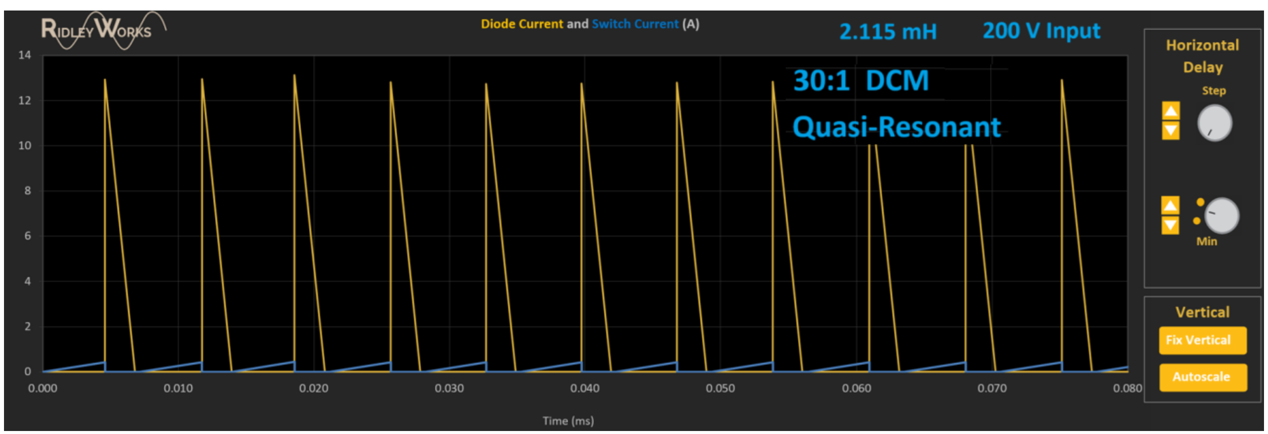




RidleyIQ™

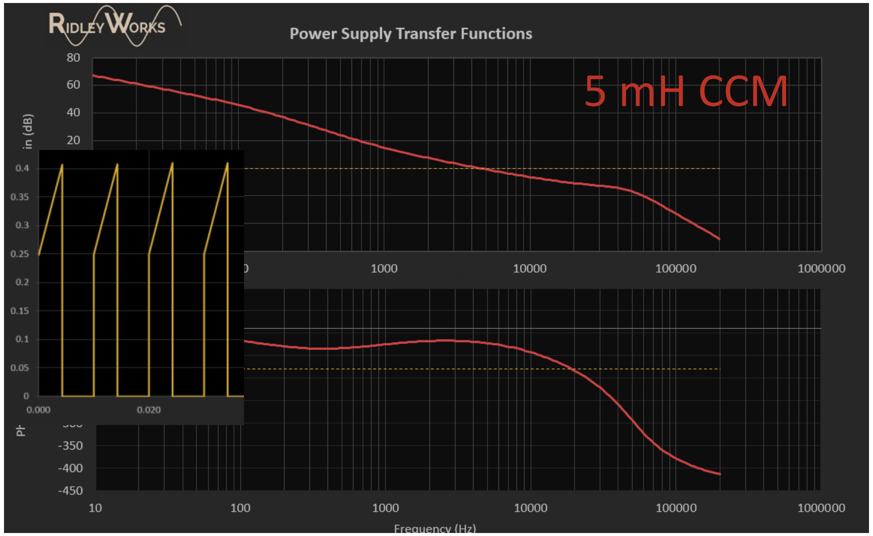
RM6

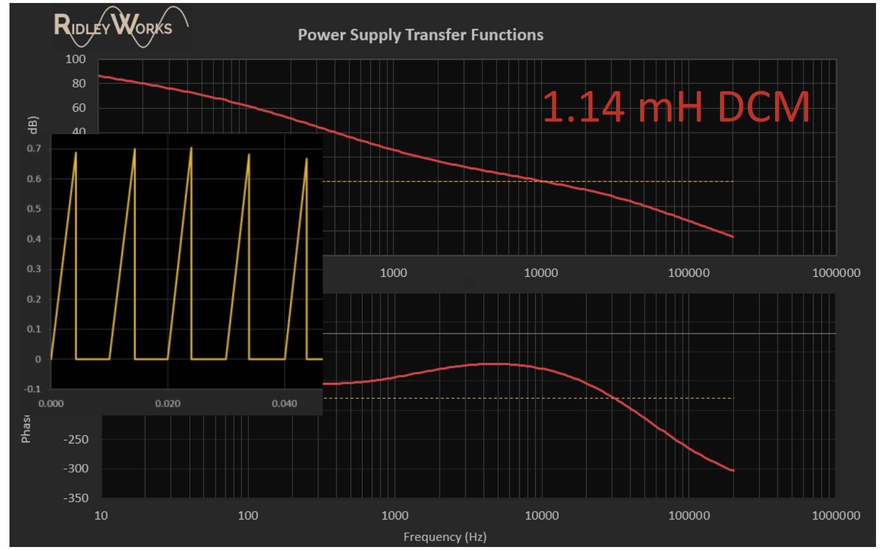


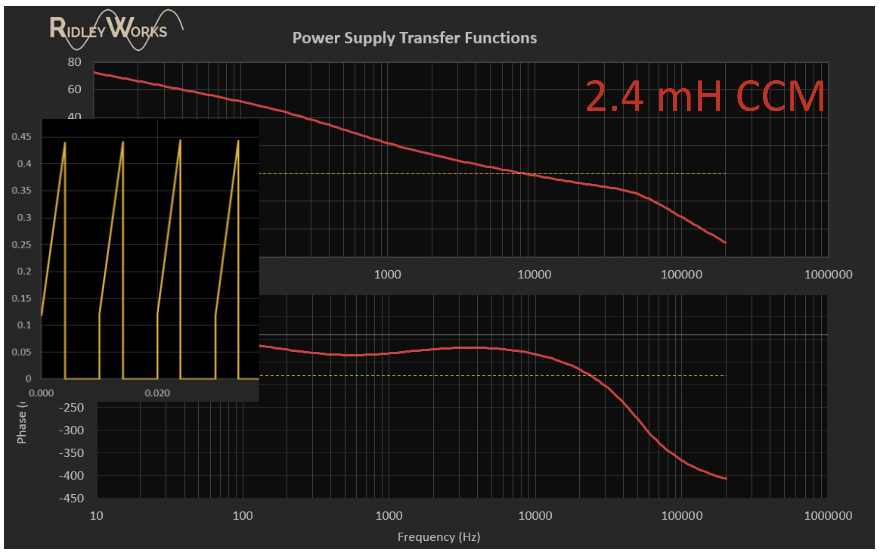


#1 Saved Transformer Design QR DCM		
Magnetizing Inductance	2114.71	uH
Primary Current Limit	0.529	A
Core Type	RM6	
Core Area	0.31	sq. cm
Core Material	R	
B max	0.298	T
Approximate Gap	0.26 / 34.4	mm/mils
AL Value	144.43	nH/n2
Leakage Inductance	20.81	uH
Primary Turns	121	
Wire Type	Magnet Wire	
Wire Size	33	awg
Layers	4	Split
Number of Strands	1	
Each End Margin	0.00	mm
Insulation	0.000	mm
Window Used	36.0	%
DC Resistance	2.0	Ohm
Secondary Turns	4	
Wire Type	Triple Insulated Wire	
Wire Size	22	awg
Layers	1	
Number of Strands	2	
Each End Margin	0.00	mm
Insulation	0.000	mils
Window Used	33.5	%
DC Resistance	3.4	mOhm

RHP Zero Paranoia!

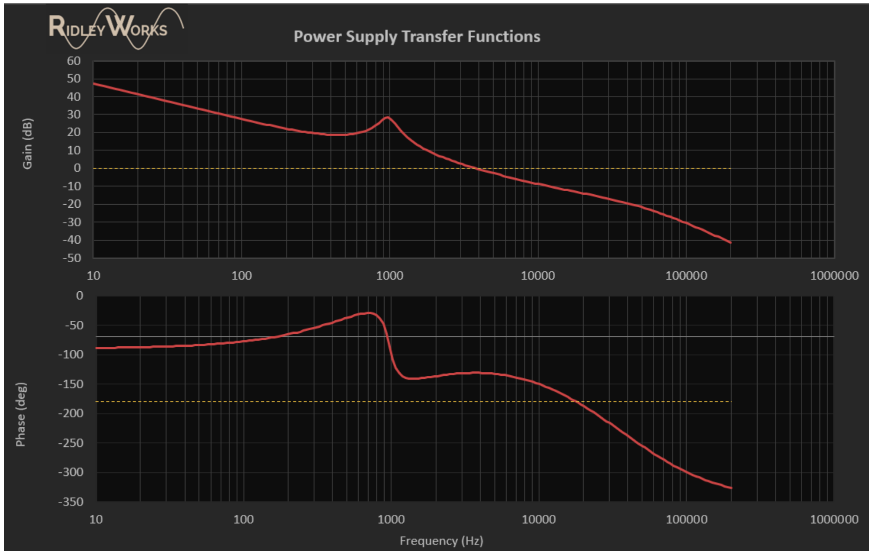






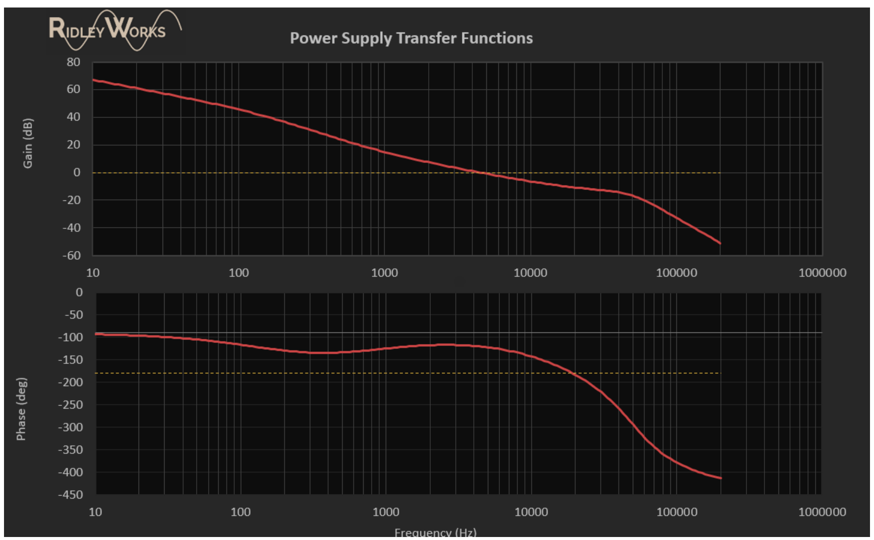
Don't Worry about the RHP Zero
Design the power stage wherever it wants to be

Elimination of the Double Pole is more Important than RHP Zero



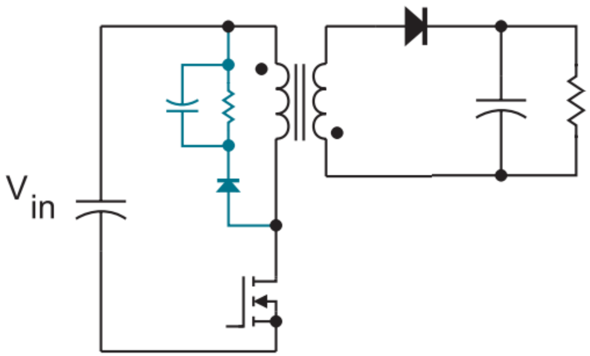
The voltage-mode LC filter COMBINED with the RHP zero can be a little more difficult.

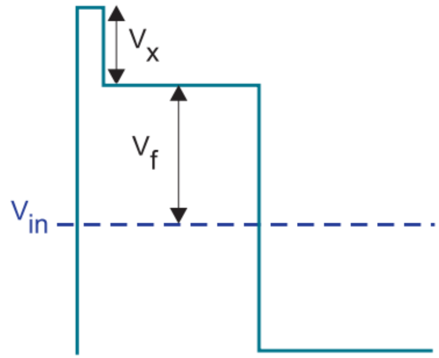
Low line full load is the key. Resonance is the highest, RHP zero is the lowest.

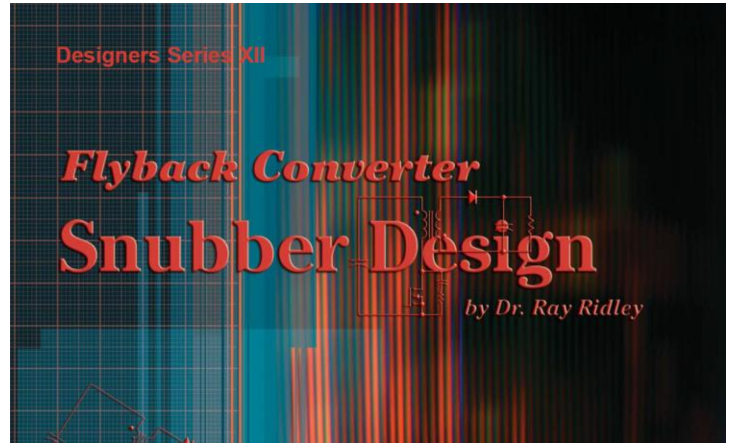


Solution– current-mode control!

RCD Clamp







$$P_{sn}^{\max} = P_l\left(1 + \frac{v_f}{v_x^{\max}}\right)$$

Dissipation is higher than the energy storage in the leakage inductor

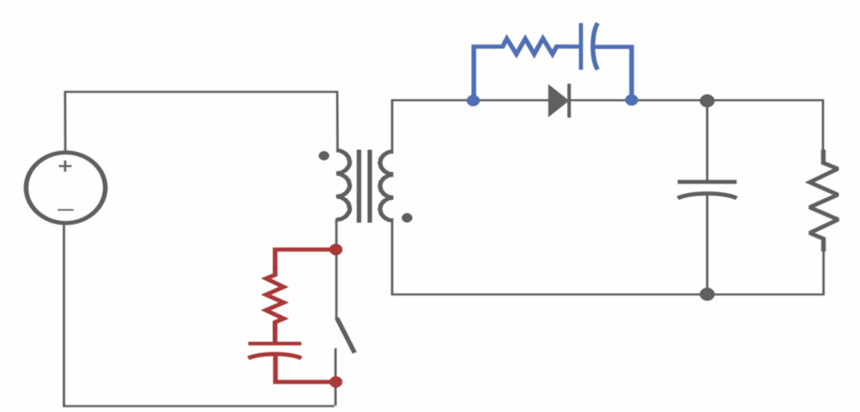
The harder you clamp, the more the dissipation.

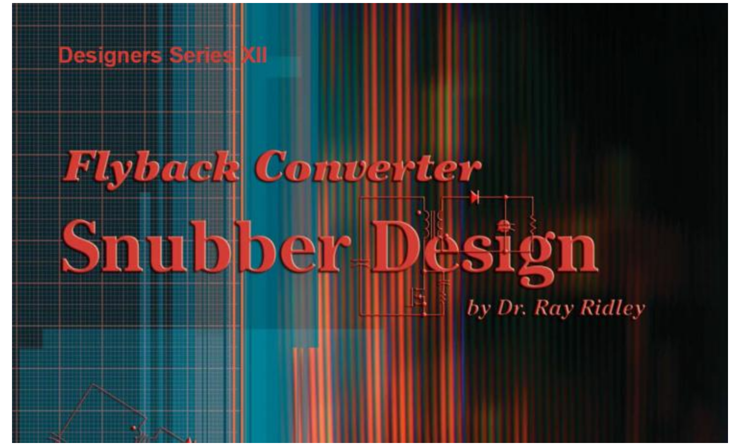
It sometimes looks like the RCD clamp is universal

It is not. All the products we have built did NOT use the RCD approach.

The RCD clamp still usually needs an RC snubber

RC Snubbers

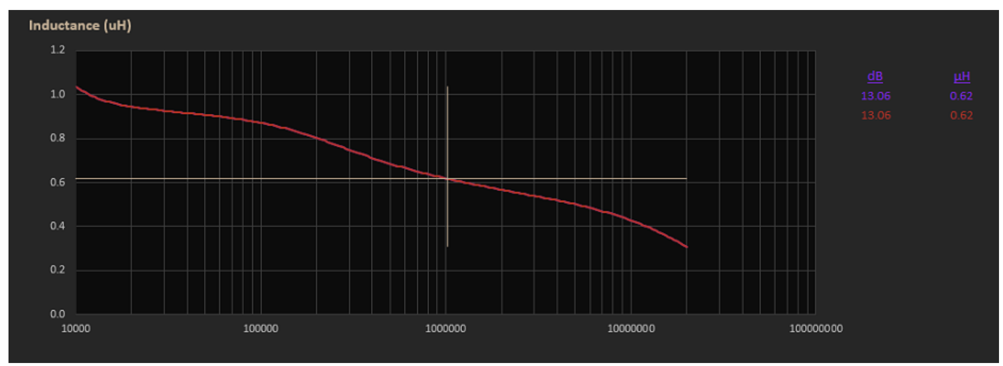




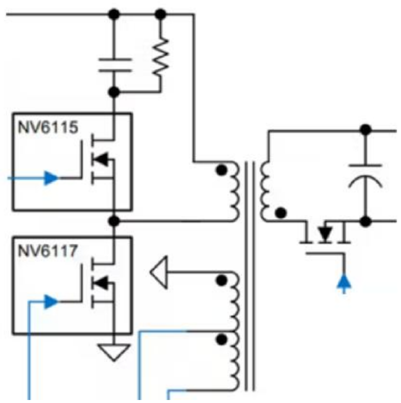
Dissipation can be higher than the energy storage in the leakage inductor

The harder you damp the ringing, the more the dissipation.

Do you need the diode snubber for DCM?



Active Clamp Flyback



Lots of chips available

I'm not a fan. My job is to make sure none of my designs ever fail.

Too much complexity.

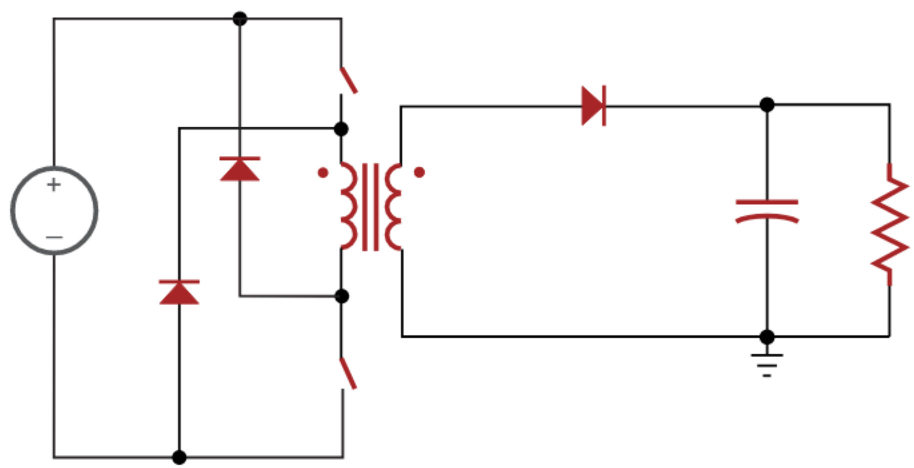
Two-Switch Flyback

Lower on-resistance

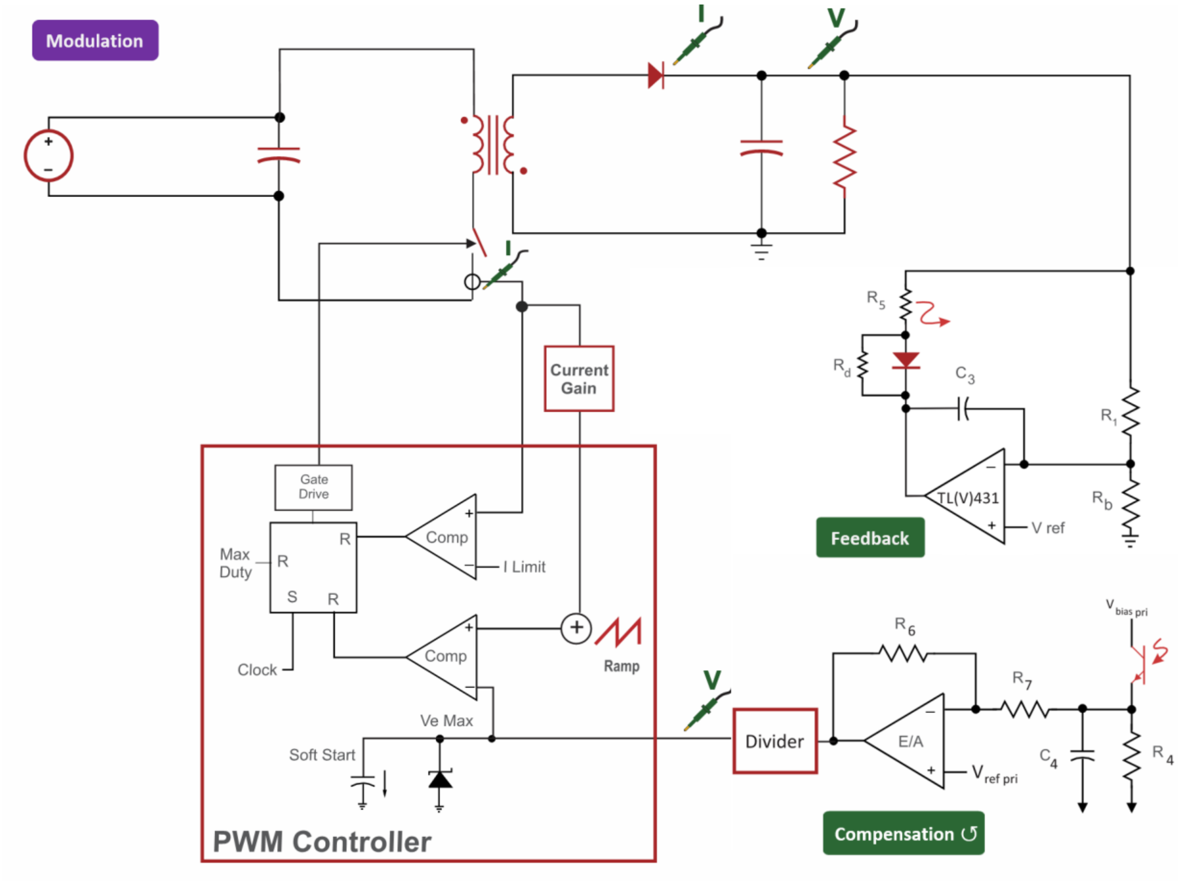
Rugged

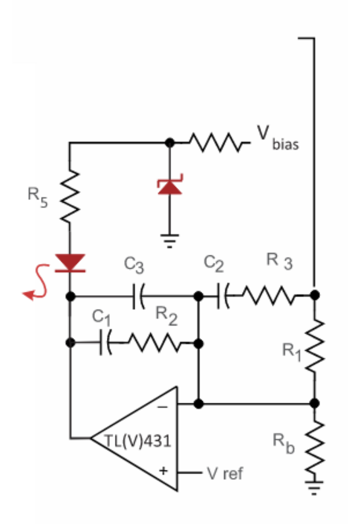
Energy recovered

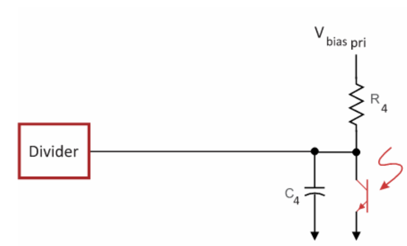
WCA is much easier!



TL431 Feedback







Ridley Engineering's First Project (1991)

12 VDC to 240 VAC Input (4 versions)

24 V 0.5 A Output

5 V auxiliary 0.1 A

Control primary bias winding 12 V 50 mA

Safety Isolation

UC2843 Controller (>50%)

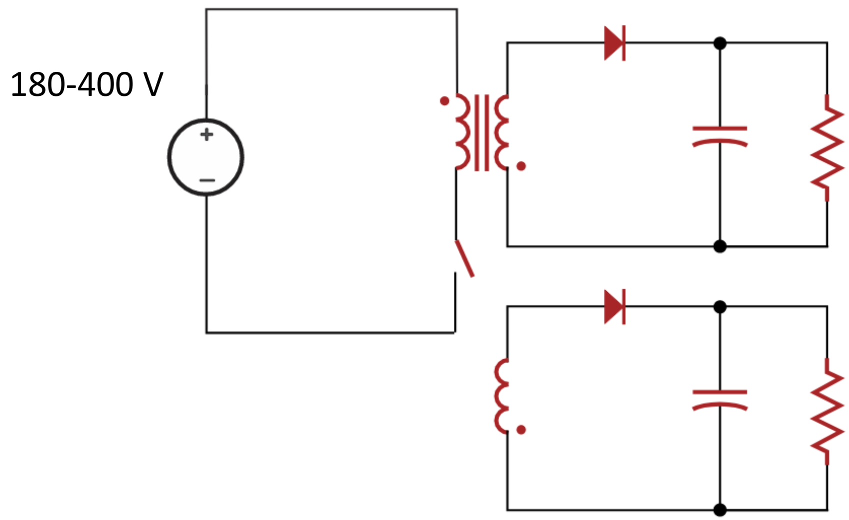
100 kHz switching frequency

RC snubbers only

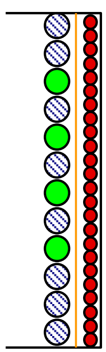
No feedback across isolation boundary

Transformer RM6 core

Ridley Engineering's First Project (1991)

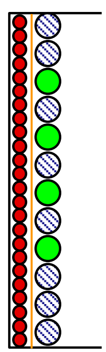


Problem: How to get the best coupling between the two outputs?



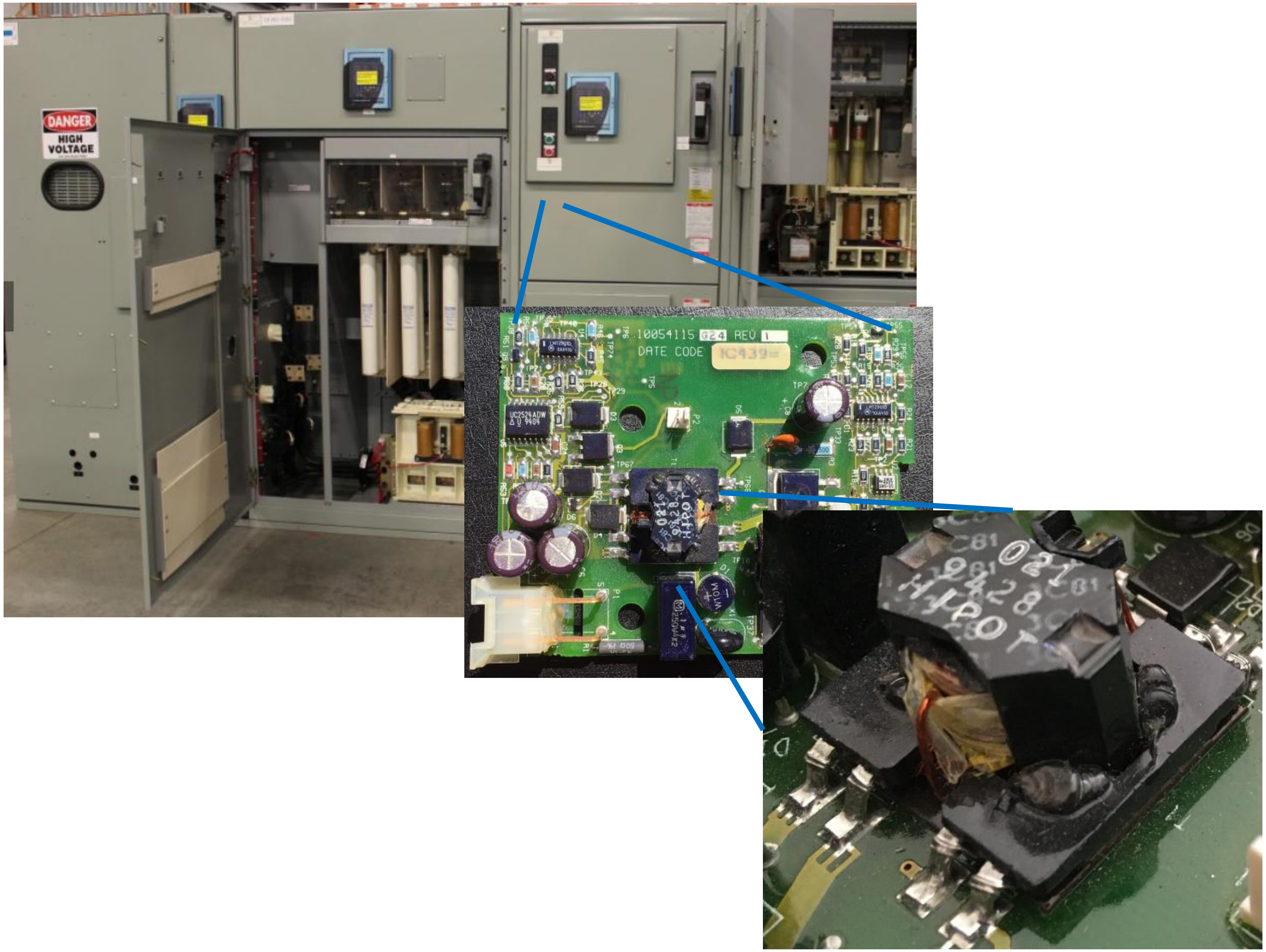
Regulation = **+/- 20%**

Change the Transformer Windings



Regulation = **+/- 2%**

Ridley Engineering’s First Project (1991)



The intricacies of winding arrangements in this small transformer enabled a 10,000 A breaker

How to Learn More

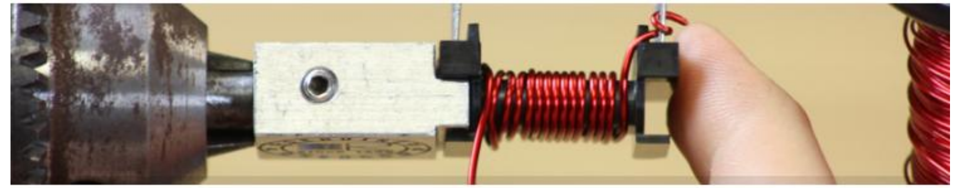
Email info@ridleyengineering.com
For full demo

Frequency Response Analyzers

A New Small-Signal Model for Current-Mode Control

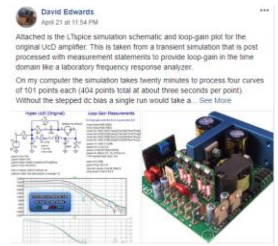
Raymond B. Ridley

Free Book



> Education > Power Design Workshop > Intro

POWER SUPPLY DESIGN WORKSHOPS



Power Supply Design Center Facebook Group

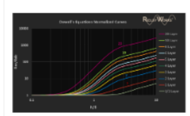
Power Supply Design Center Articles

[113] THE ADVENTURES OF 'OHM

This custom-designed comic strip is for all the electrical engineers who are suddenly working from home.

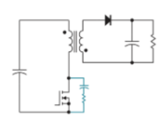
[112] THE POWER OF DOWELL'S EQUATIONS AND CURVES

The standardized curves of Dowell's equations are a superb tool for designing better high-frequency magnetics. A careful balance of layer count and wire or foil count is needed to reach an optimum design.



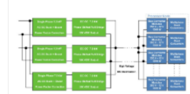
[A24] FLYBACK CONVERTER SNUBBER DESIGN

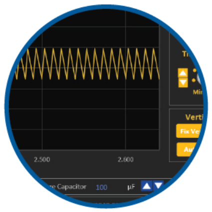
In this article, we will talk about practical design techniques for the most commonly used snubber and clamp circuits for the flyback converter.



[111] ZVS FULL-BRIDGE CONVERTER EMPLOYING AN ACTIVE SNUBBER

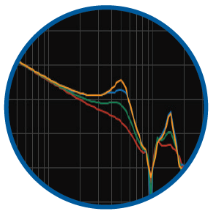
The ZVS full bridge converter can be enhanced greatly by implementing an active snubber on the secondary side of the transformer.





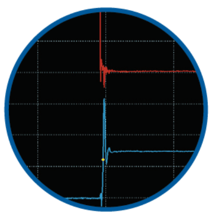
RidleyWorks® Lifetime License

- Power Stage Designer
- Power Stage Waveforms
- Magnetics Designer
- Transfer Function Bode Plots
- Closed Loop Design
- Automated FRA Control
- LTspice® Automated Link
- LLC Designer



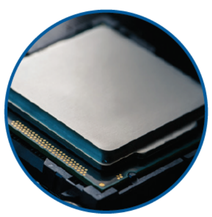
4-Channel Frequency Response Analyzer

- Frequency Range 1 Hz - 20 MHZ
- Source Control from 1 mV - 4 V P-P
- Built-In Injection Isolator
- Bandwidth 1 Hz - 1 kHz
- Automated Setup from RidleyWorks®
- Drect Data Flow into RidleyWorks®



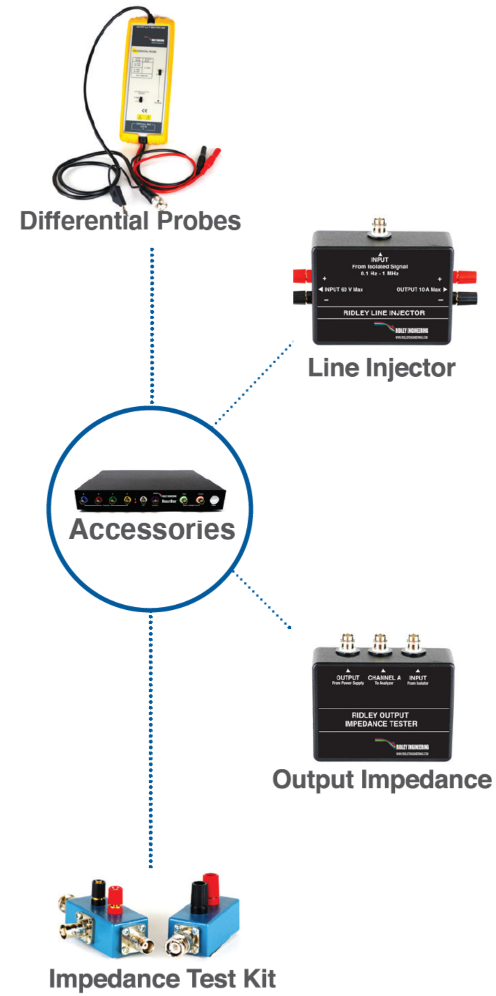
4-Channel 200 MHz Oscilloscope

- Picoscope® 5444D 4-Channel Oscilloscope
- 200 MHz Bandwidth
- 1 GS/s at 8-bit res; 62.5 MS/s at 16-bit res
- Signal Generator up to 20 MHZ
- Computer Controlled



Embedded Computer

- Intel® Computer with 32 GB RAM, 256 GB SSD
- Intel® HD Graphics 620
- Integrated Dual Band Wireless, Bluetooth 4.2
- Dual HDMI and USB Ports, Ethernet



Ridley Engineering