AC/DC SOLUTIONS

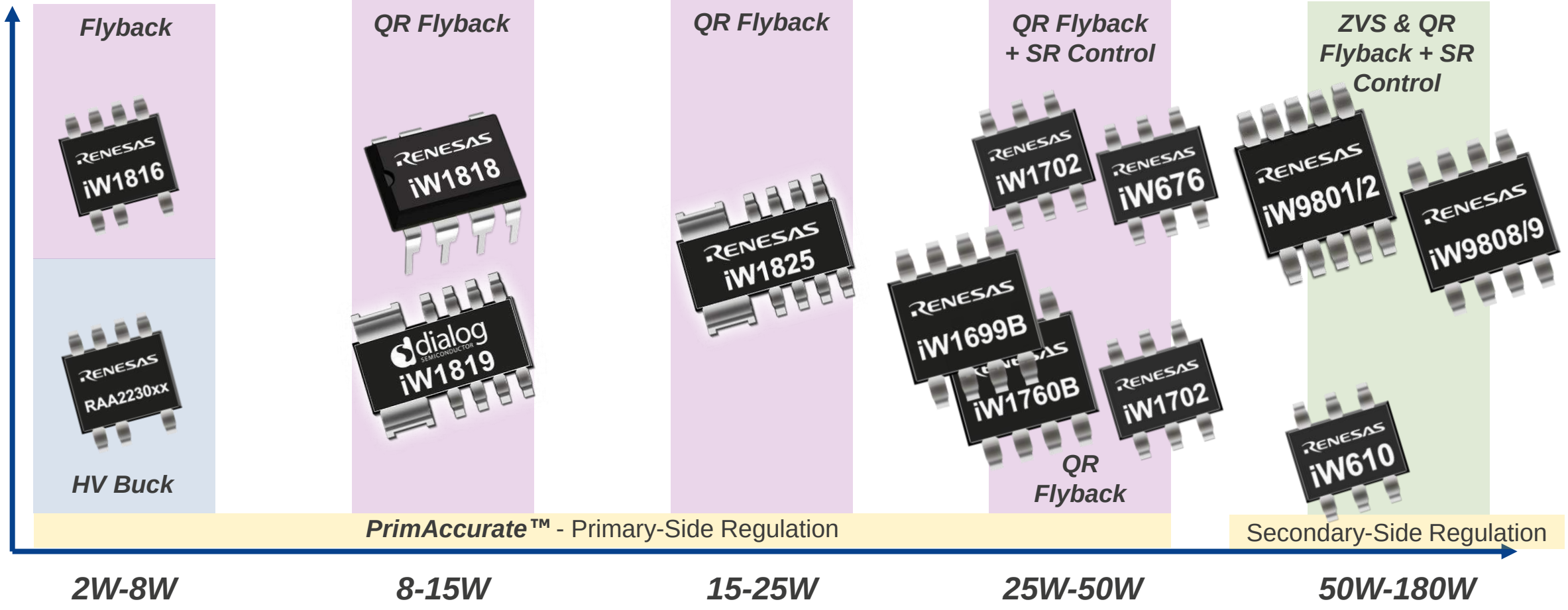
ROBUST, EFFICIENT, COMPACT, LOWEST STANDBY POWER SOLUTIONS

JANUARY 2023

RENESAS ELECTRONICS CORPORATION

RENESAS AC/DC TECHNOLOGY BY OUTPUT POWER

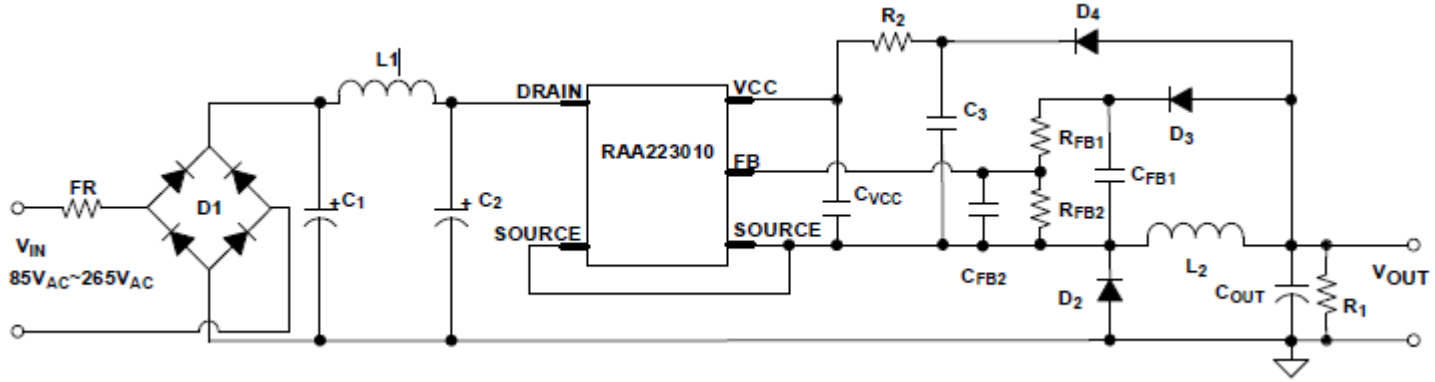
- Output power helps guide to correct topology



NON-ISOLATED AC/DC BUCK CONVERTERS (HV BUCK)

LOW STANDBY POWER, HIGH EFFICIENCY AT LOW TOTAL BoM COST

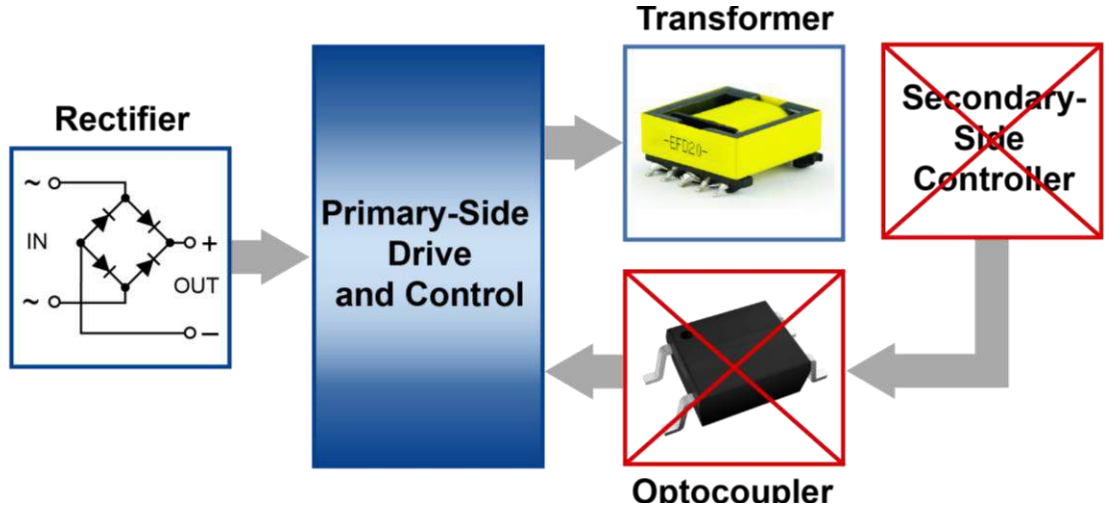
Filter Parts	Output Power Max (W)	Topology	AC Input Voltage (Min) (V)	AC Input Voltage (Max) (V)	DC Output Voltage (Min) (V)	DC Output Voltage (Max) (V)	Switching Frequency (KHz)
RAA223010 700V AC/DC Regulator with Ultra-L...	10	Non-isolated buck | Isolated Flyback	20	305	3.3	54	45
RAA223011 700V AC/DC Regulator with Ultra-L...	5	Non-isolated buck | Isolated Flyback	20	305	3.3	54	30
RAA223012 700V AC/DC Regulator with Ultra-L...	2.5	Non-isolated buck | Isolated Flyback	20	305	3.3	54	50
RAA223021 700V AC/DC Regulator with Ultra-L...	12	Non-isolated buck | Isolated Flyback	20	305	3.3	54	43



PRIMARY-SIDE REGULATION AC/DC CONVERTERS

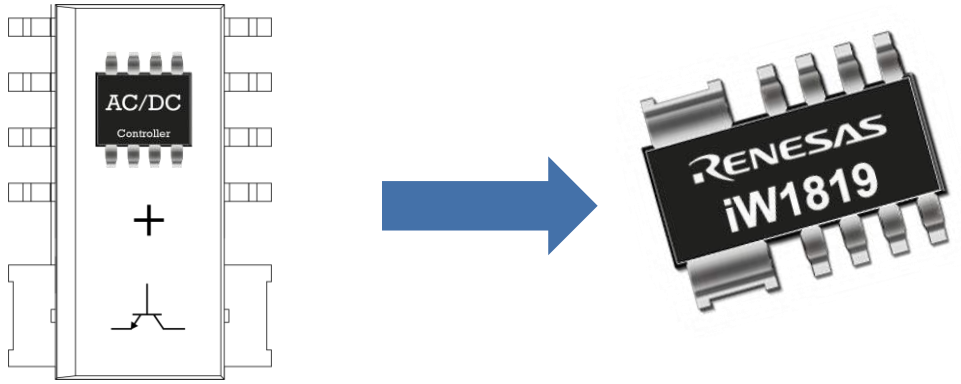
KEY FEATURES NEEDED FOR AC/DC CONTROLLER – RENESAS IS THE ANSWER!

- ***PrimAccurate™*** - primary-side regulation
  - Highly accurate voltage and current control
  - Reduces BOM count & improve reliability by eliminating:
    - Optocoupler, secondary-side regulator
    - Many discrete parts
    - Optocoupler cannot guarantee > 5yrs operation
    - Based on 24/7 operation
    - Removing opto improves operating life of power supply



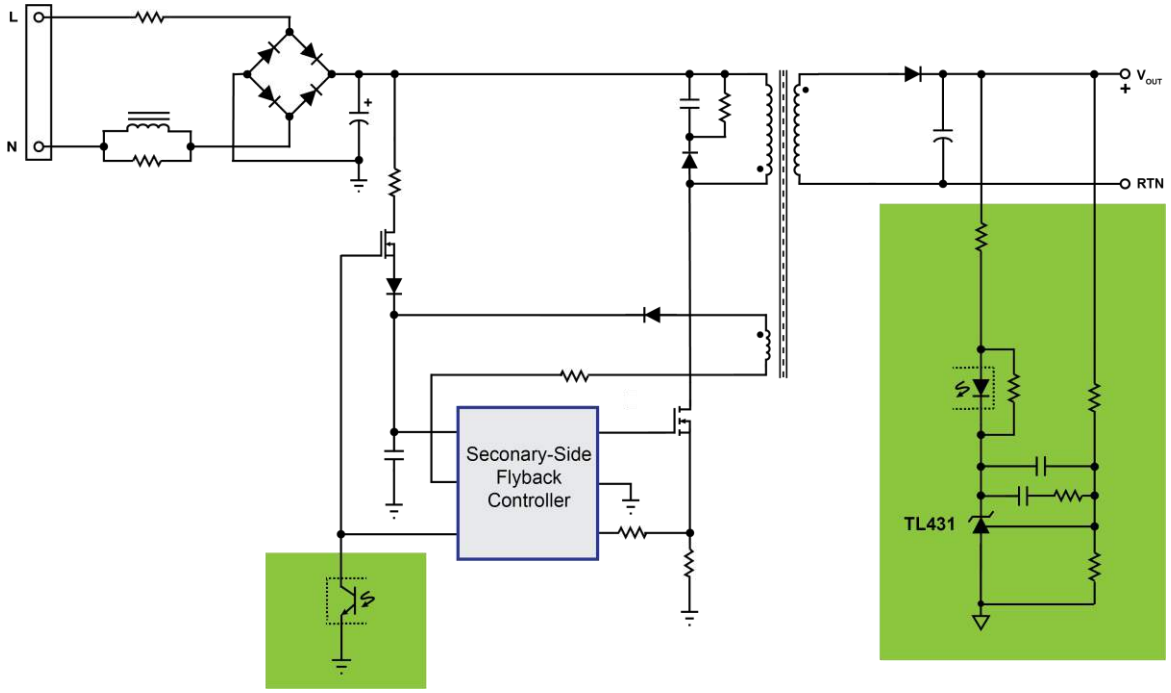
- ***EZ-EMI™***
  - Patented dithering technology
  - Easy to achieve EMI compliance
  - Reduce BOM count

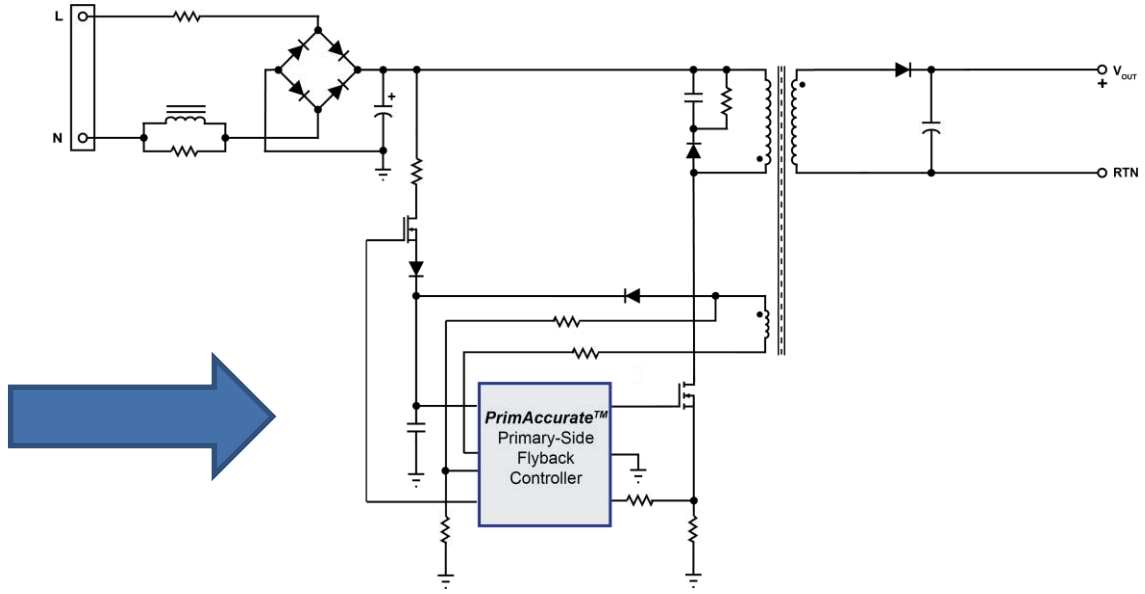
- Multi-Mode Control
  - High efficiency across broad load range
  - No audible noise



PrimAccurate™ - PRIMARY-SIDE CONTROL, VERY ACCURATE

IDEAL FOR UP TO 50W SOLUTIONS



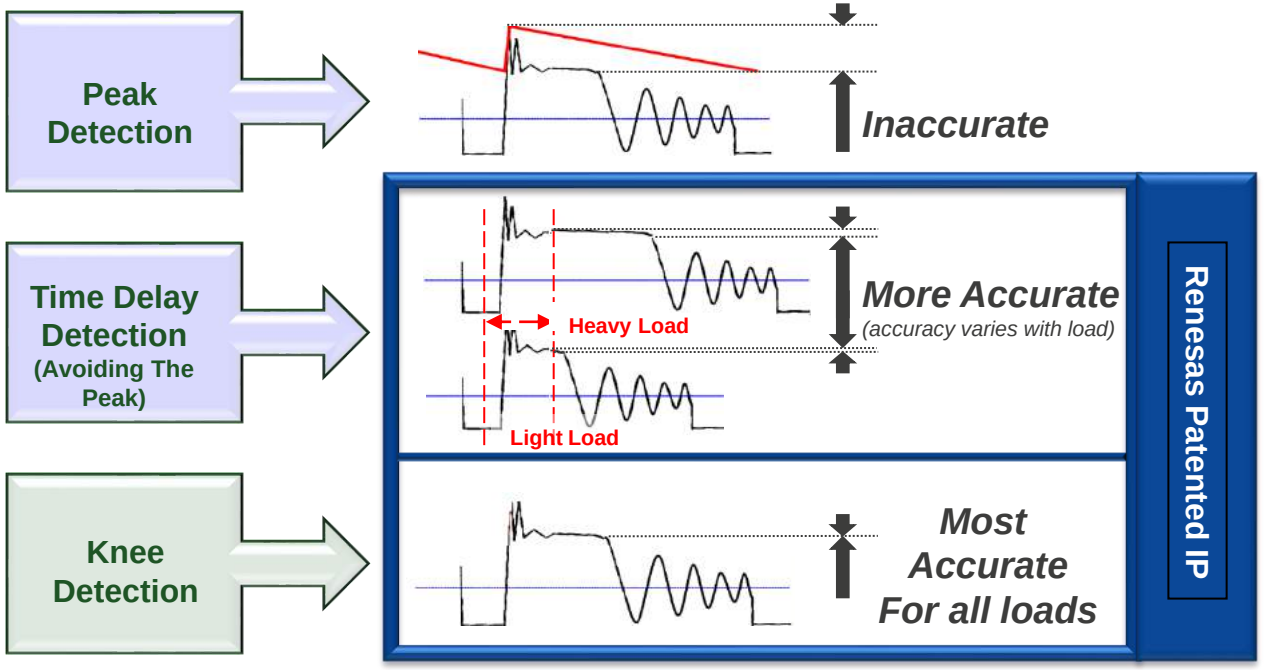


- ***Reduced BoM Cost***
- ***Higher Reliability***
- ***Good Accuracy without Secondary-Side Regulation Components!***

PrimAccurate™ - PRIMARY-SIDE CONTROL, VERY ACCURATE

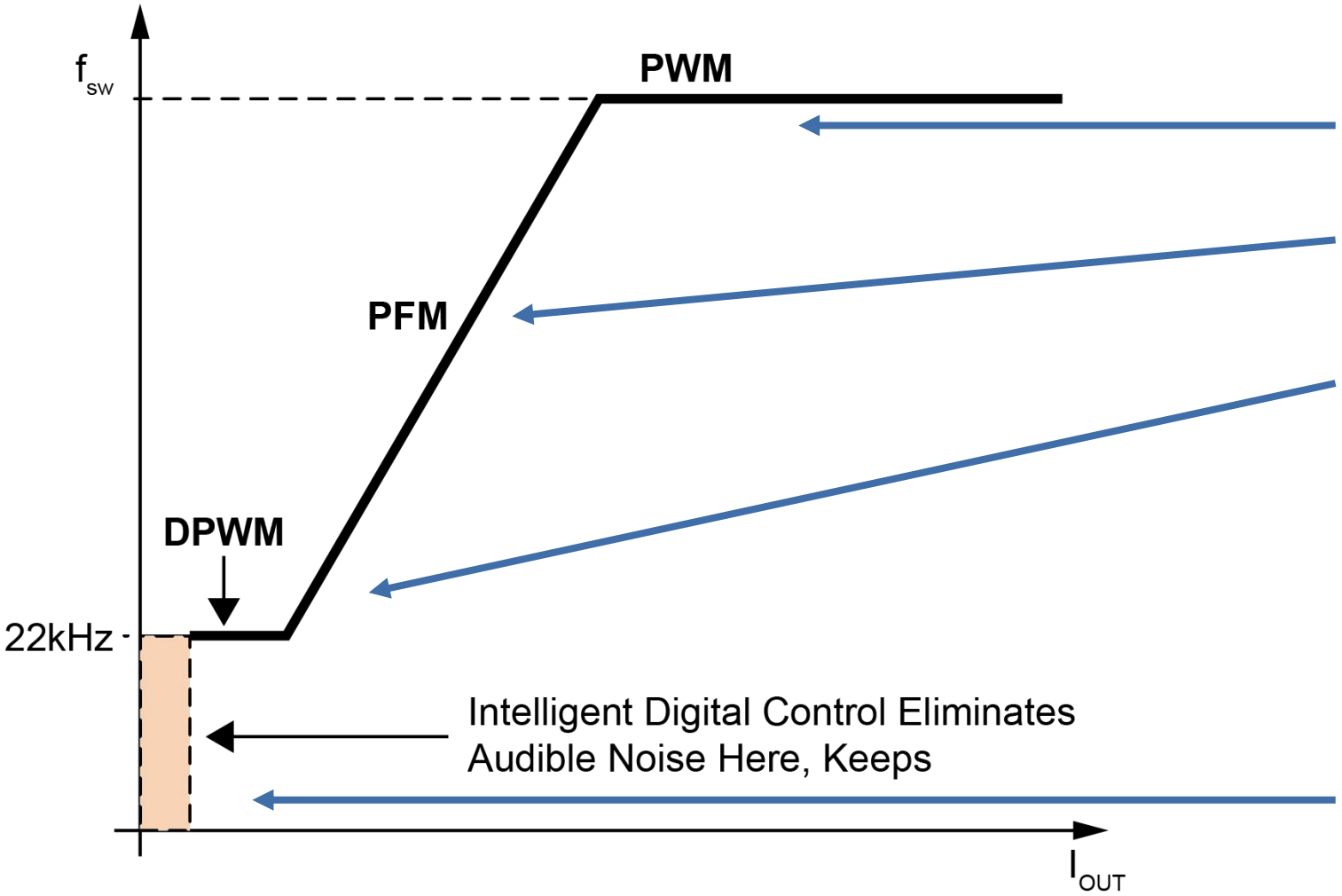
IDEAL FOR UP TO 50W SOLUTIONS

- Renesas' ***PrimAccurate***™ delivers up to ~50W with accurate and stable output.
- Others can only achieve 5W within ±5% (e.g. ST, PI)
- This outstanding performance due to the following reason:
  - Digital core for accurate control
  - Renesas IP (from former iWatt) on control method



DIGITAL CONTROL – MULTI-MODE CONTROL

HIGH EFFICIENCY ACROSS FULL LOAD RANGE



PWM – Optimal Efficiency at High Loads

PFM/Burst Modes – Optimal Efficiency at Medium Load

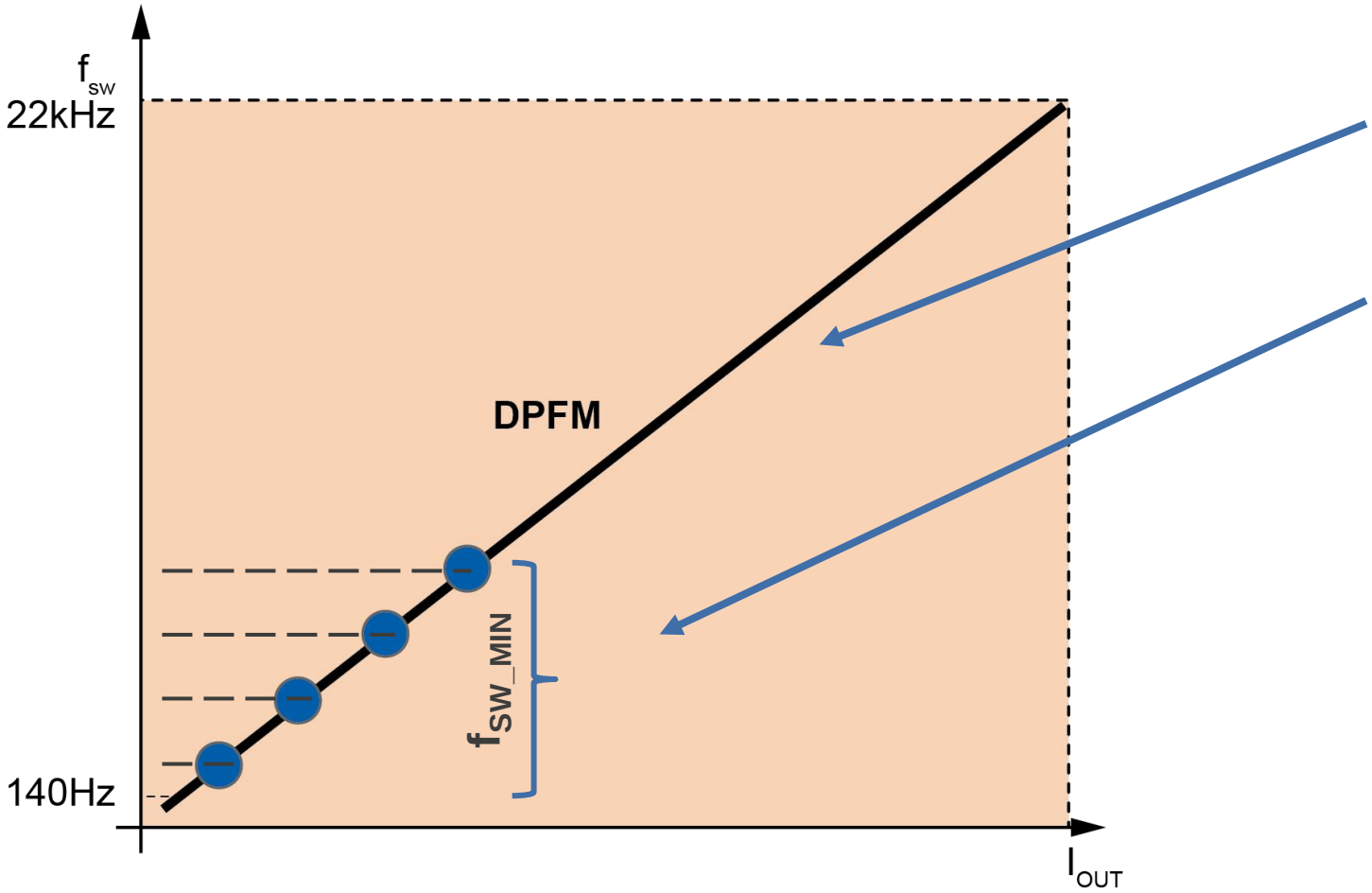
Deep PWM/Deep PFM – Optimal Efficiency at Light Loads with NO AUDIBLE NOISE

Multi-Mode Control – used in all parts and independent of other technologies – ***PrimAccurate™***, ZVS, etc.

Light-Load Mode Operation – See Next Slide for Details

LIGHT-LOAD AND NO-LOAD STANDBY POWER

EXTENSION OF MULTI-MODE CONTROL AT LIGHT LOADS



Deep PFM – Reduced Switching Frequency (no audible noise)

Deep Deep PWM – Fixed Minimum Switching Frequency

Lower f_{SW_MIN} = Lower No-Load Standby Power

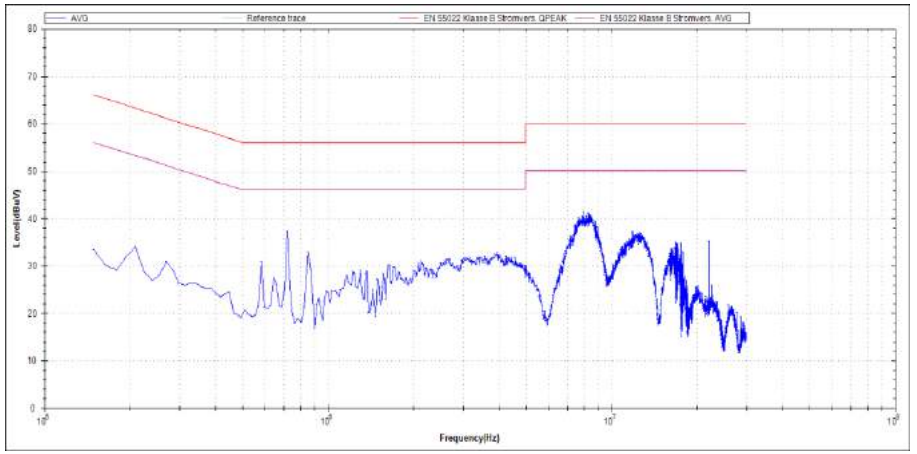
RapidCharge™ chipsets = low minimum switching frequency AND fast dynamic load response – Renesas Innovation!

EZ-EMI™ - LOWER EMI

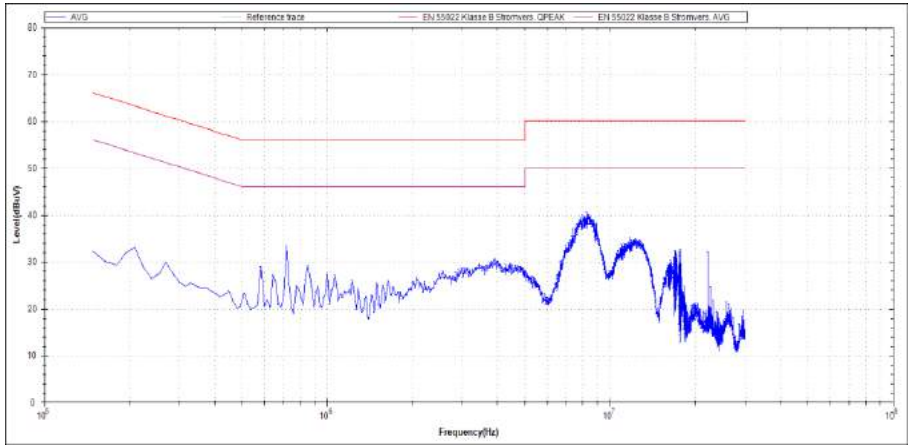
INTEGRATED CONTROL AND POWER SWITCH TECHNOLOGY REDUCES EMI

- EMI – Electromagnetic Interference
  - Patented frequency dithering scheme
    - Reduces overall EMI
    - Easier to design input filter – lower overall spectral noise
  - Valley hopping
    - Alternating valleys in quasi-resonant control
    - Further reduces EMI
  - Power BJT designs – Inherently lower EMI
    - BJTs have inherent soft-switching characteristics
    - iW1816/iW1819/iW1822 – all use power BJTs

EN55022 Class B AVG - Live



EN55022 Class B AVG - Neutral



POWER SUPPLY SOLUTIONS TO 150W+

SOLUTIONS FOR FIXED OUTPUT VOLTAGES AND USB PD SUPPORT

Primary	SR Control	Combo SR Control + Protocol	USB PD 3.0 w/PPS	P_{OUT}	Integrated FET/BJT	External FET/BJT	PSR/SSR/ ZVS	Key Feature
iW1816			No	5W	Int BJT		PSR	
iW1819	iW676	-	No	18W	Int BJT		PSR	Integrated 800V BJT
iW1825	iW676	-	No	25W	Int FET		PSR	Prog. Light-Load Mode
iW1702	iW676	-	No	Up to 50W		Ext FET	PSR	Scalable Power
iW9801		iW709	Yes	100W		Ext FET	SSR/ZVS	ZVS
iW9802	iW610	3rd Party Interface IC		Up to 180W		Ext FET	SSR/ZVS	ZVS
iW9808	iW610	3rd Party Interface IC		Up to 100W		Ext FET	SSR	QR CCM
iW9809		iW709	Yes	Up to 65W		Ext FET	SSR	QR CCM for USB PD

- 5W – Standby/Aux power supply
- 15W-65W:
  - Quasi-Resonant – Good Efficiency, Low Cost
  - Primary-Side Regulation – low cost, good performance
- 65W-180W:
  - ZVS – Highest Power Density
    - Lowest Power Dissipation
  - Complete USB PD Solutions – Small Size, High Efficiency

iW1816 – 800V, 5W *AccuSwitch*™ AC/DC CONVERTER

INTEGRATED HIGH-VOLTAGE BJT POWER DEVICE

Integrated 800V power BJT for AC/DC flyback converters to 5W

- Flyback controller plus power BJT in SOIC-7 package
- Advanced digital controller for best performance/cost ratio

***PrimAccurate*™ technology – primary-side regulation**

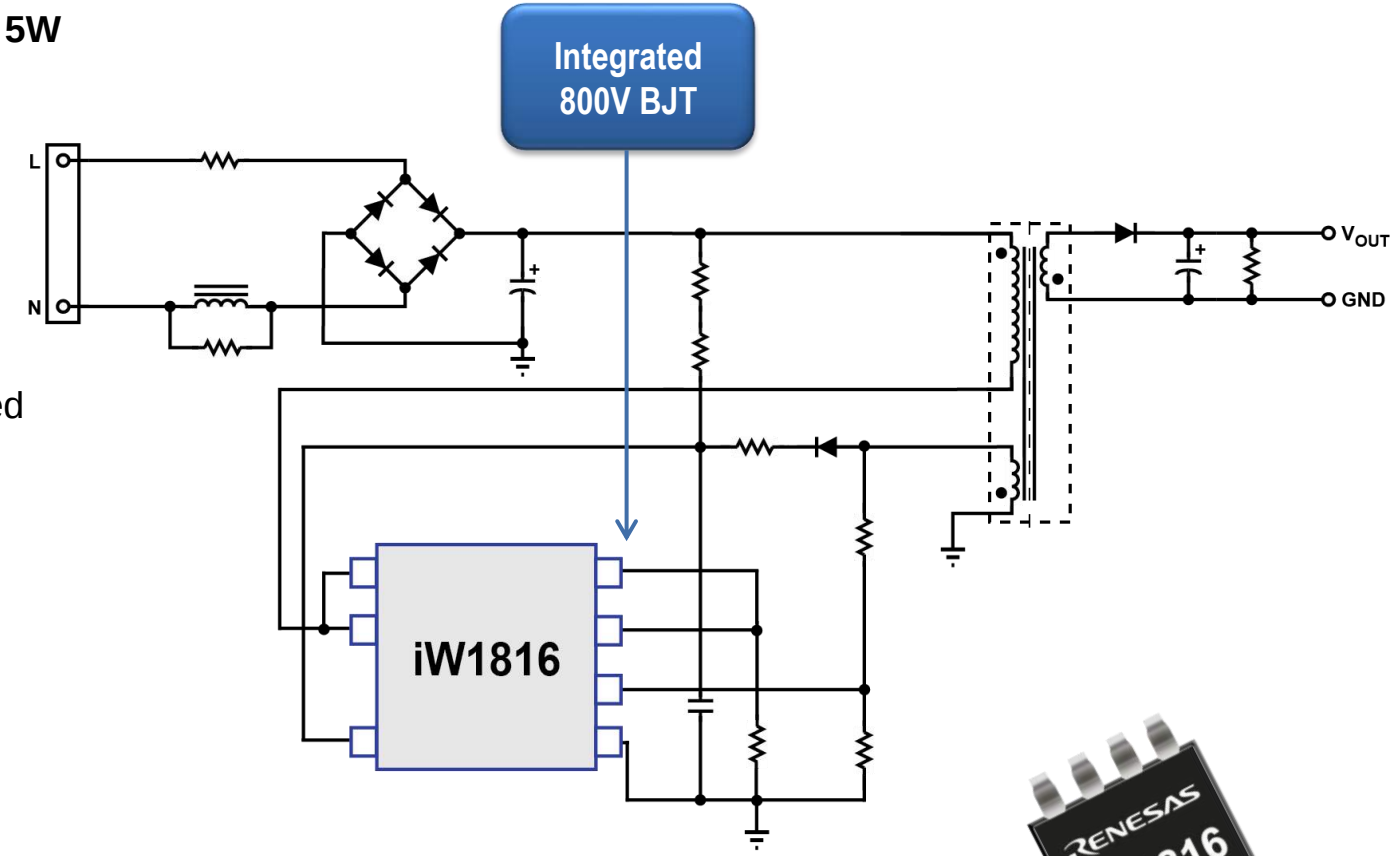
- Eliminates secondary-side regulation components
  - Optocoupler, voltage reference and passives
- Digital compensation loop – no external compensation required

***EZ-EMI*™ technology**

- Reduce EMI – simplify input filtering for low cost
- Power BJT – soft switching further reduces EMI

Rich Protection Features

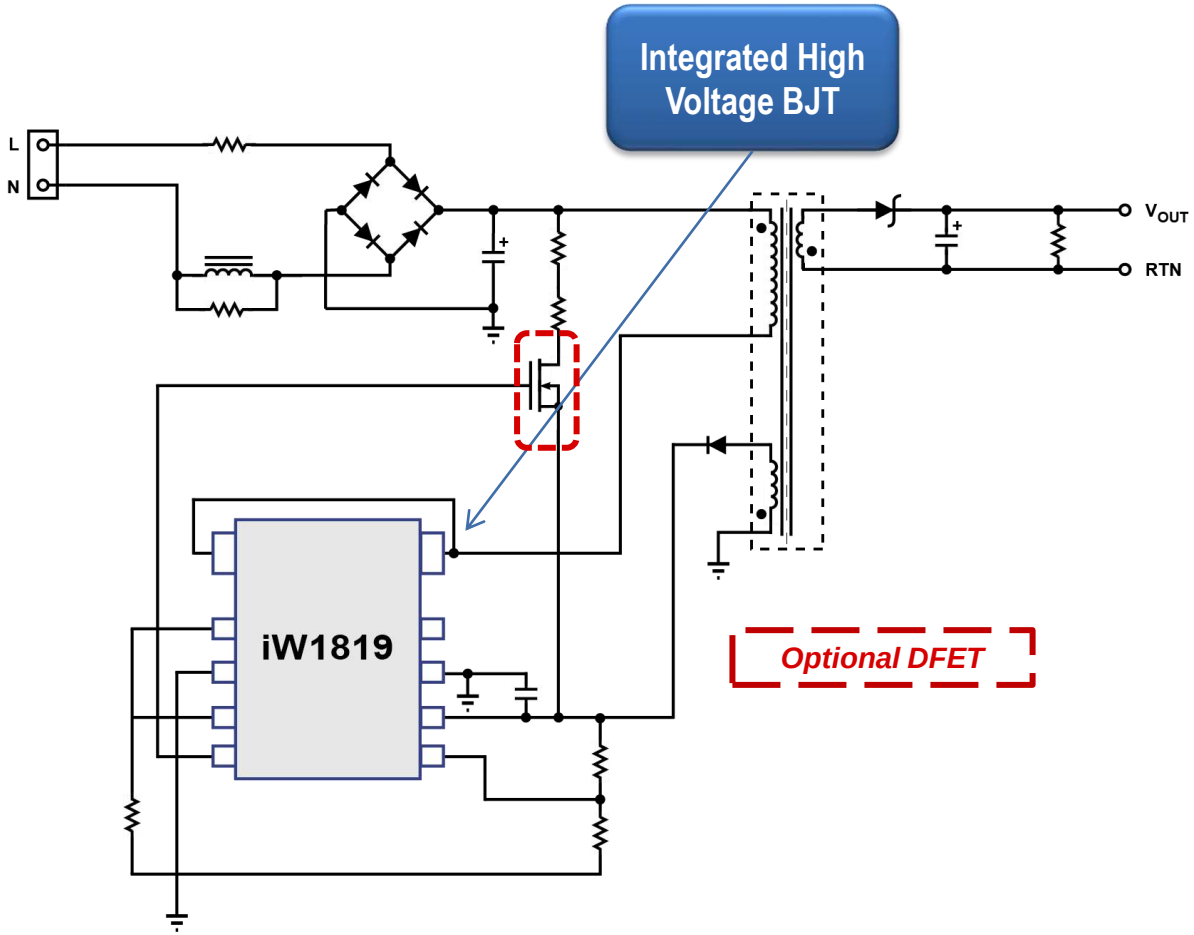
- Output over-voltage
- Output short circuit
- Built-in over temperature protection



iW1819 *AccuSwitch*™ CONVERTER

PrimAccurate™ CONTROLLER WITH INTEGRATED HIGH-VOLTAGE POWER BJT

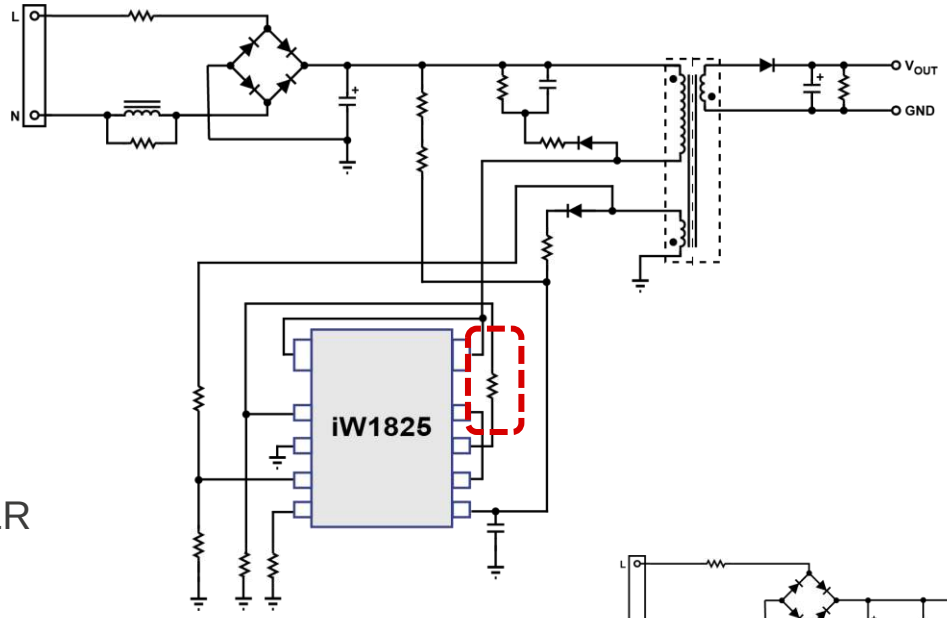
- Integrated high-voltage power BJT
  - Soft-switching for improved EMI
- iW1819 **– 18W, 800V rated**
  - iW1822 – 900V, pin-for-pin for high input voltages
- ***EZ-EMI***™ Technology
  - Reduces EMI filtering requirements
- High efficiency to reduce heat generation
- Unique SOIC-10 Batwing package
  - Based on JEDEC standard SOIC-14, fused leads
  - Allows high power output in surface mount package

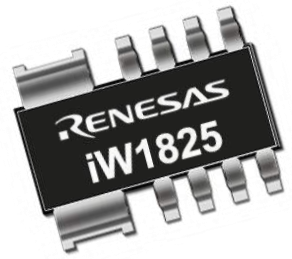


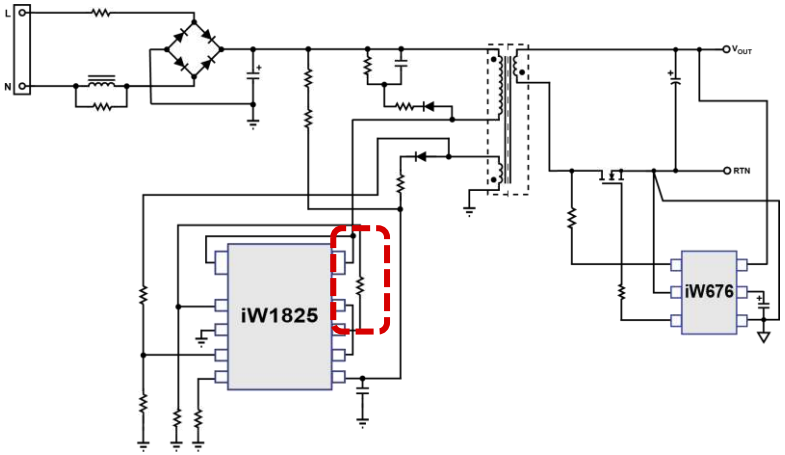
iW1825 – 25W *AccuSwitch*™ CONVERTER

700V POWER MOSFET INTEGRATED IN SO-10 PACKAGE

- Integrated 700V power MOSFET
- Configurable light-load mode
- Single-resistor configurable light-load mode
  - Sets minimum switching frequency at no-load
    - 140Hz, 1.6kHz, 2.4kHz, 3.6kHz
  - < 75mW is highest no-load power (3.6kHz)
  - < 30mW is lowest no-load power (140Hz)
  - iW676-3x w/active voltage positioning for best DLR
- < 75mW no-load power with fast DLR
  - Configurable to < 30mW
- High active-mode efficiency
  - Even higher with iW676 SR w/AVP
- ***EZ-EMI***™ - Easier EMI design
- SO-10 batwing package (Based on standard SO14 package)







iW1702 – PRIMARY-SIDE 45W AC/DC CONTROLLER

IDEAL FOR VIRTUALLY ANY APPLICATION INCLUDING APPLIANCES AND INDUSTRIAL APPLICATIONS

Quasi-Resonant DCM Flyback Controller

- 79kHz switching frequency
- Adjustable light-load mode
  - Enables faster/slower transient response, higher/lower no-load power
  - < 75mW with fast DLR, < 30mW with fast DLR using iW676 w/AVP
- Adaptive Multi-Mode Control
  - High efficiency across all load steps
- Optimized to start into large capacitive loads –330µF to 6000µF

***PrimAccurate*™ technology – primary-side regulation**

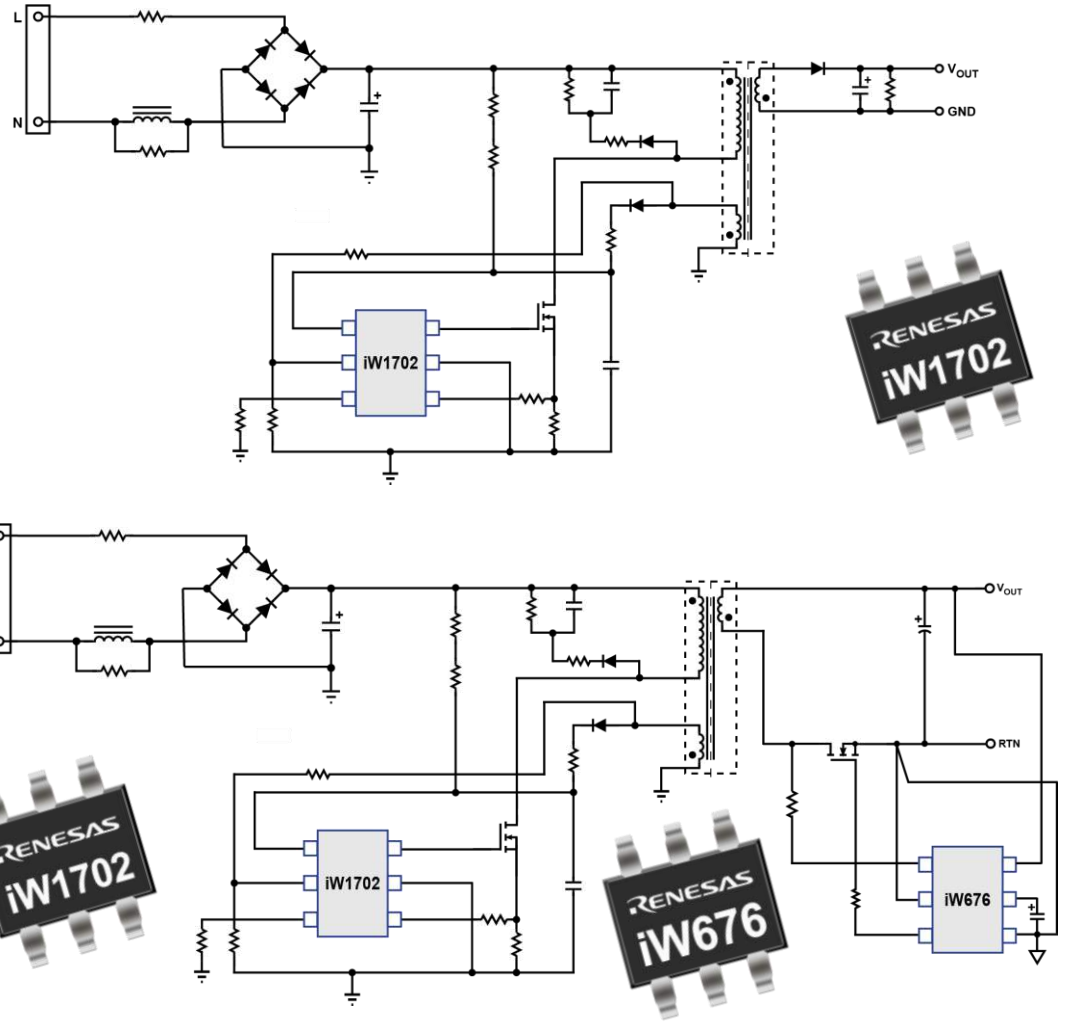
- Eliminates secondary-side regulation components
  - Optocoupler, voltage reference and passives
- Digital compensation loop – no external compensation required

Integrated safety functions

- External input over-voltage protection – iW1702-1x/1xB
- Single-point fault protections against AC line voltage brown-out
- Output short circuit and over-voltage protection

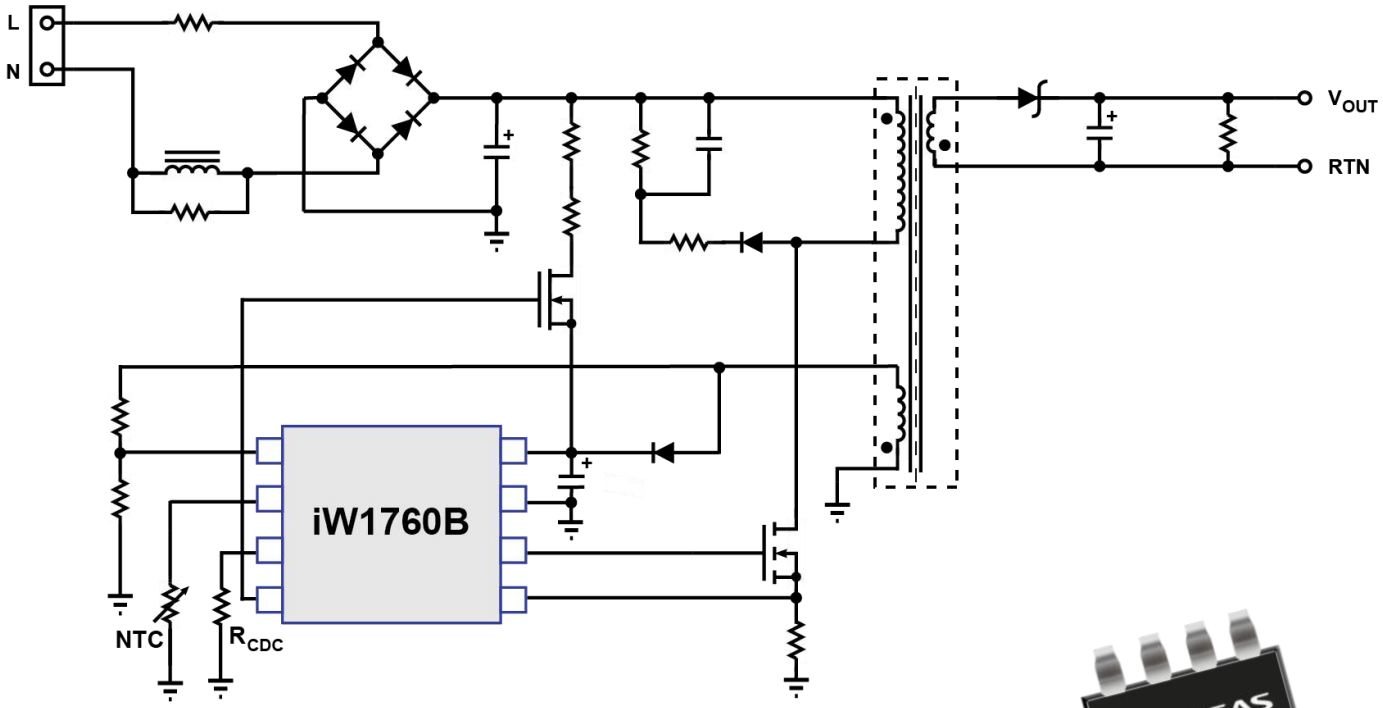
Robust and Efficient Solution

- Up to ~45W
- > 90% efficiency capable with iW676 synchronous rectifier controller



iW1699B/iW1760B – 45W AC/DC CONTROLLERS w/EXTERNAL OTP

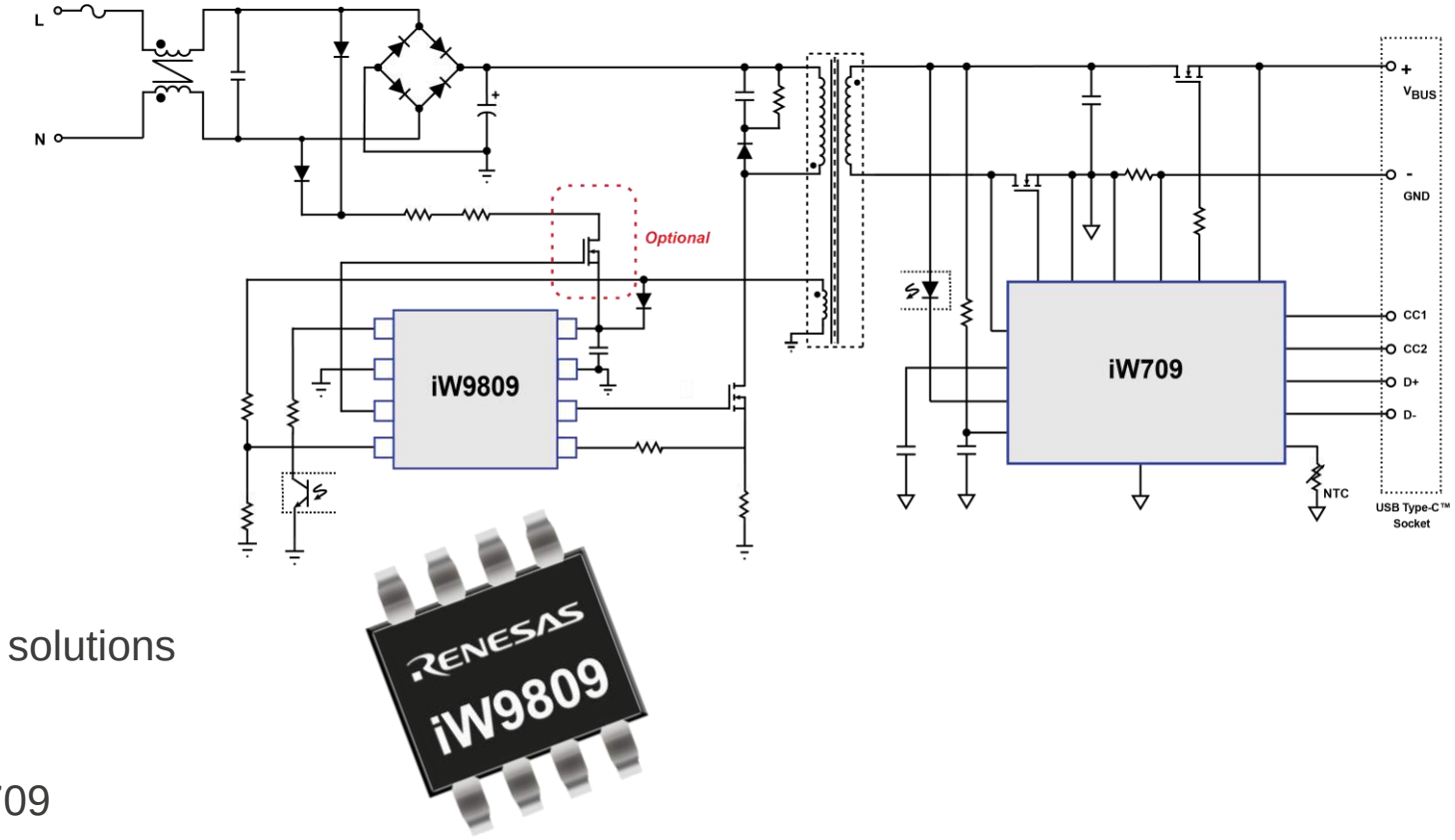
- iW1760B – 45W output power
  - Start-up into large C_{OUT}
- iW1699B – 45W output power
  - Optimized for 5V output voltage
- Optional external HV startup device
  - Reduce no-load standby power (<50mW)
- **SD pin for external NTC over-temperature protection (OTP)**
- External over-voltage protection (OVP) via the CFG pins
  - Extra layer of protection



iW9809 – PRIMARY-SIDE QUASI-RESONANT CONTROLLER

USB PD APPLICATIONS UP TO 65W; HIGH RESOLUTION VOLTAGE/CURRENT CONTROL

- Quasi-resonant DCM flyback converter for rapid charge
  - Supports CCM operation at low input voltage
  - Allows slightly smaller transformer designs
- 75kHz switching frequency
- Active start-up support
  - <20mW no-load power capable
- User-programmable internal OTP sensor
- Adaptive Multi-Mode Control
  - High efficiency across all load steps
- Works with the iW709 Secondary-Side IC
  - Provides lowest total BOM cost for USB PD solutions
- Secondary-side regulation technology
  - External opto; regulation integrated into iW709

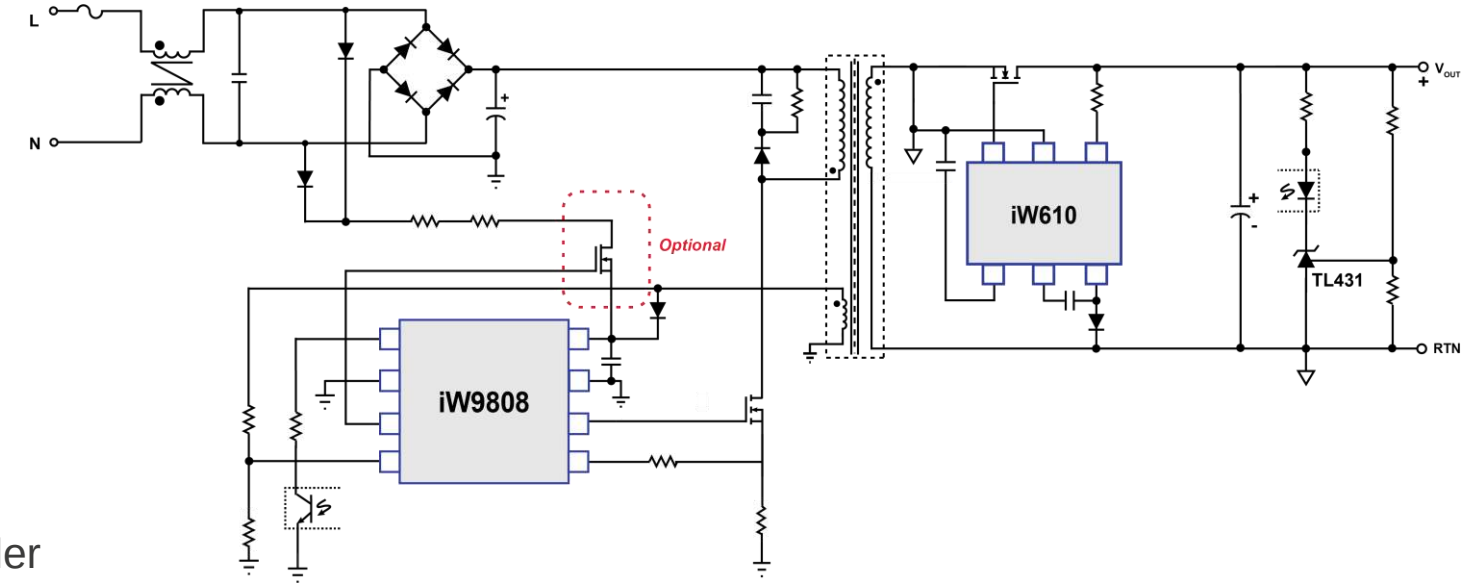


iW9808 – PRIMARY-SIDE QR* CONTROLLER

WORKS WITH TL431 FOR 100W+ APPLICATIONS

Sampling Now!

- Quasi-resonant DCM flyback converter for high power
  - Supports CCM operation at low input voltage
  - Allows slightly smaller transformer designs
- Up to 200kHz switching frequency
- Active start-up support
  - Low no-load power capable
- User-programmable internal OTP sensor
- Adaptive Multi-Mode Control
  - High efficiency across all load steps
- Works with TL431 – industry standard controller



Works with TL431 Secondary-Side Controller

* QR: Quasi-Resonant switching

SYNCHRONOUS RECTIFIER CONTROLLERS

LOWER BOM COST, HIGHER EFFICIENCY

- iW673 and iW676 – DCM Mode Controllers for Primary-Side Regulation Applications
  - Digital adaptive turn-off control minimizes deadtime
- iW676 – Benefits of iW673 with:
  - AVP (Active Voltage Positioning):
    - Fast dynamic load response (DLR)
    - No additional parts
  - Supports Direct Charge down to 3V
  - 100V Drain-Source sensing
  - Output voltage from 12V down to 3V, under all CVCC load conditions
- iW610 – CCM/DCM Mode Controllers that support quasi-resonant flyback, ZVS flyback and active-clamp flyback
  - Digital adaptive turn-off control minimizes deadtime
  - Supports high-side and low-side configurations
    - Proprietary Vcc charging technology
    - No aux winding needed, high-efficiency optimized
  - Supports 3V-28V output voltage range
  - 140V Drain-Source sensing
  - SOT23-6 package

Synchronous Rectifier Controllers	Max Input Voltage	Max DRAIN Voltage	Optimized Output Voltage Range	CCM	DCM	ZVS	Active Voltage Positioning
iW673/iW676	25V	60V/100V	5V-9V/3V-12V	No	Yes	No	No
iW610	28V	140V	3V-28V	Yes	Yes	Yes	No

iW676 – 100V RATED SYNCHRONOUS RECTIFIER CONTROLLER

INCREASE SYSTEM EFFICIENCY FOR FLYBACK POWER SUPPLIES

Secondary-side synchronous rectifier controller

- Improve efficiency by using MOSFET rectifier on flyback secondary
  - Reduce power loss and heat generation
- Supports DCM flyback topology and primary-side regulation
- Supports Direct Charge applications down to 3V
- 100V Drain-Source sensing
- Output voltage from 12V down to 3V, under all CVCC load conditions
  - Works up to 25V output voltage with voltage clamp
- SOT23-6 package

Digital adaptive turn-off control technology

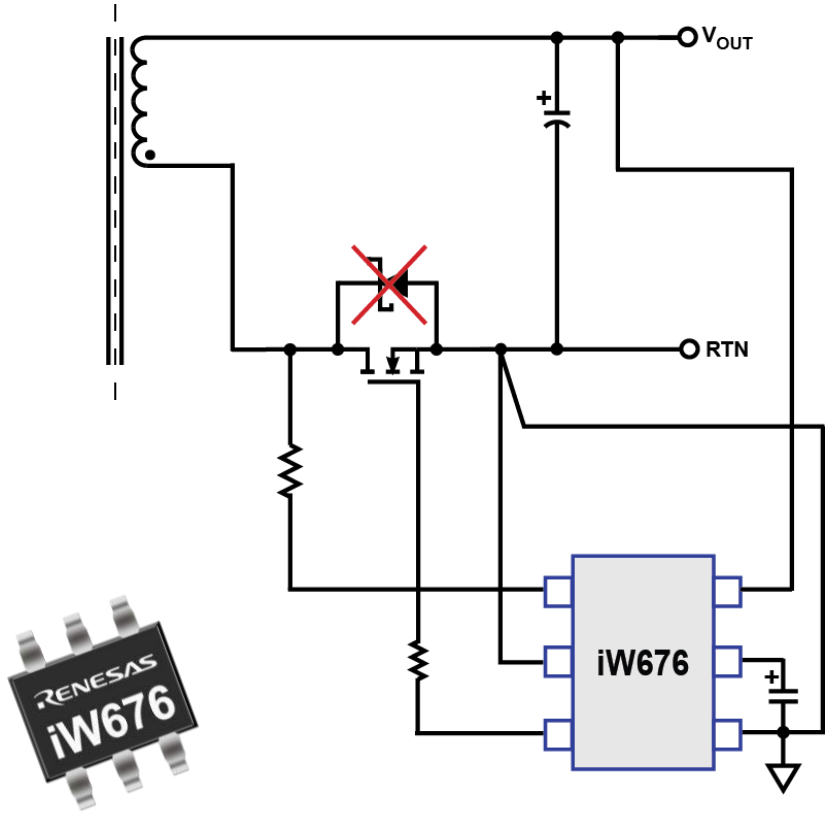
- Minimizes dead-time
- Removes need for parallel Schottky diode

Intelligent low power management mode technology

- Enables ultra-low no-load standby power flyback converters

Active voltage positioning (AVP) – iW676-3x options

- Fast dynamic load response (DLR)
- No additional parts

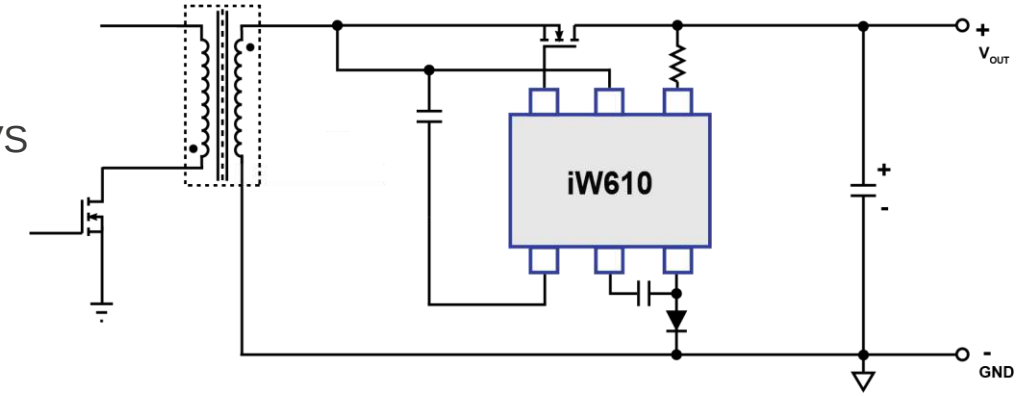


iW610 – SR CONTROLLER OPTIMIZED FOR ZVS

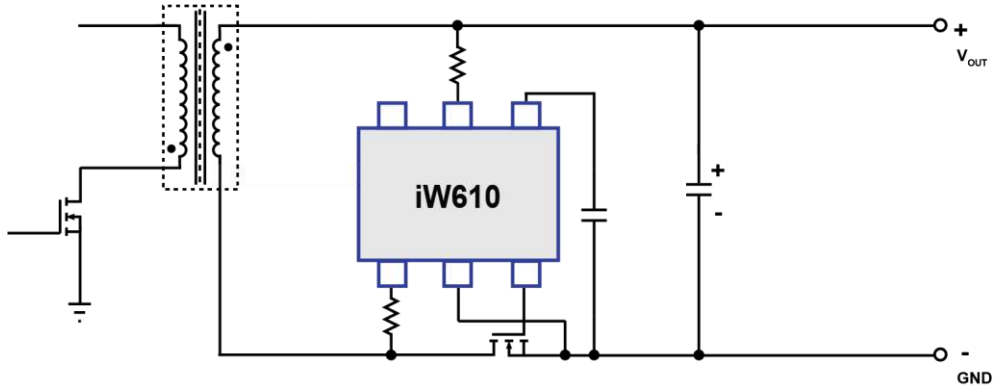
- Secondary-side synchronous rectifier (SR) controller for High Power Density AC/DC adapters
- Support for multiple flyback topologies: QR, DCM/CCM mode, active clamp, ZVS
- Patented V_{CC} charging technology
  - Reduces power consumption, thermal issues, system BOM cost
  - Simplifies transformer design and construction
- Supports high-side and low-side SR control
  - No auxiliary winding required
  - High-side offers easy EMI design
- Wide operating output voltage: 3V – 28V
  - Supports multi-level output voltage/current, USB PD 3.1 applications
- Intelligent digital control reduces no-load power consumption

Small SOT23-6 Package

Sampling Now!



High-Side Synchronous Rectification



Low-Side Synchronous Rectification

NEW PLATFORM TREND TO HIGH POWER DENSITY (HPD)

ENABLING TECHNOLOGIES

12W/in^3

Goal	Advantages	Trade-Offs	Solution
Reduce solution size by using higher f_{SW}	Smaller transformer; Lower conduction losses	Higher f_{SW} causes higher core losses (Tx) and switching losses (FET)	Zero Voltage Switching (ZVS)! Reduces switching losses
Reduce Total Solution Size, Improve Efficiency			

>25% More Power!

>15W/in^3

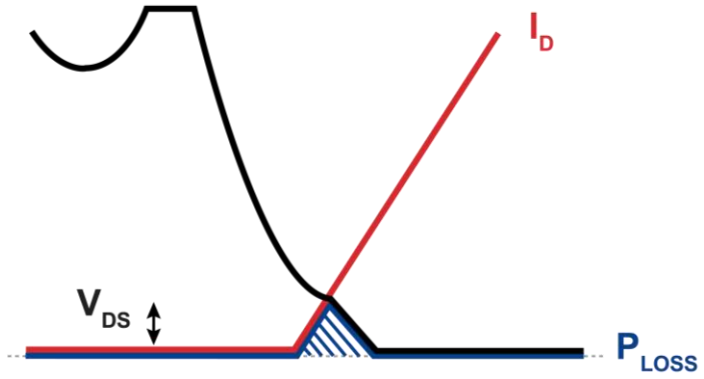
Renesas' Next Generation Digital ZVS – Zero Voltage Switching – Flyback Controllers: High Power Density for Best Size/Efficiency/Cost

ZVS – NEW GENERATION FLYBACK CONTROL TECHNOLOGY

ZVS IMPLEMENTATION – USES DCM, CDCM AND CCM

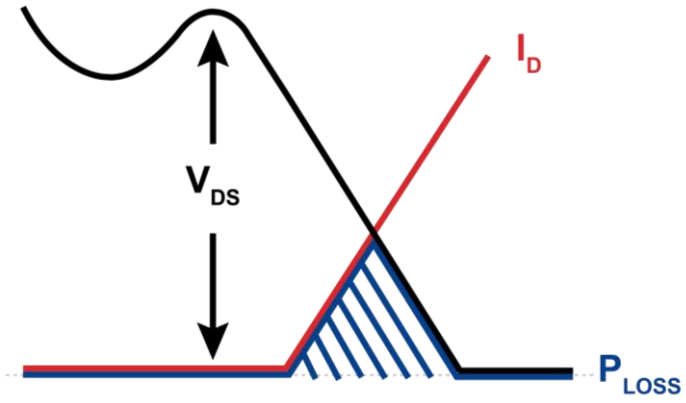
- **Goal: Higher Power Density**
  - Same physical size, higher output powers
- **How?**
  - Higher switching frequencies
    - Reduces transformer size and cost
  - **BUT – requires better technology to maximize performance**
    - Or else higher F_{SW} (switching frequency) means lower efficiency (higher switching losses)
  - **Zero Voltage Switching!**
    - Reduce switching losses = less heat
    - System efficiency increase to 91-94%

100W+ Chargers in Half the Size Using Zero Voltage Switching (ZVS) | Renesas



ZVS Flyback Converter

BIG Switching
P_{LOSS} = HOT!!



Conventional Silicon MOSFET

Small Switching
P_{LOSS} = Cool

iW9801 & iW9802 – NEW ZVS PRIMARY-SIDE AC/DC CONTROLLERS

RENESAS' AC/DC CONTROLLERS FOR HIGHEST POWER DENSITY

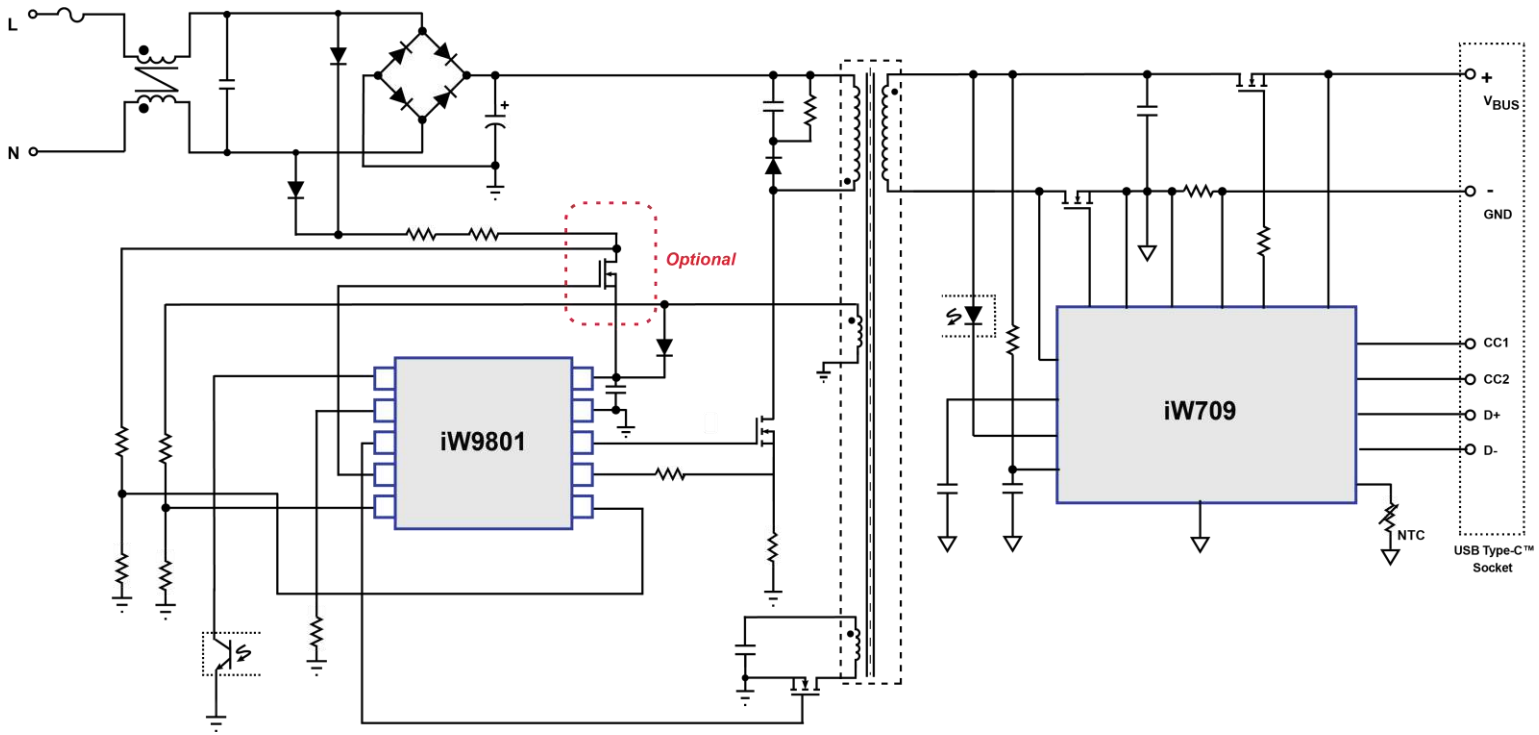
- Patented ZVS – Zero Voltage Switching
  - Reduces primary FET switching losses
  - Up to 94% efficiency
  - Up to 200kHz switching frequencies for smaller, lighter transformer & smaller passive components
- SSR – Secondary-Side Regulation
  - High accuracy regulation voltage and current control
  - Eliminates loop components
- Supports DCM & CCM operation
  - Smaller magnetics using CCM at low line
- Adaptive Multi-Mode Control (MMC)
  - Improves efficiency over the load range
  - Eliminates audible noise
- Input voltage and X-cap discharge circuits
- Drives GaN devices directly or via external GaN driver

Primary-Side	Secondary-Side Regulation	Synchronous Rectifier	Output Power	V_{BUS} Switch Driver(1)	Qualcomm® Quick Charge™	USB PD 3.0 with PPS	Direct Charge	D+/D-
iW9801	iW709	Integrated	45-100W	✓	QC 2.0, 3.0, 4+	✓	✓	
iW9802	TL431	–	45-150W+	✓	User Defined Interface			

(1) V_{BUS} Switch Driver: Integrated charge pump that drives an external N-channel MOSFET, protects V_{BUS} from output short-circuit damage and enables lower cost, easier sourcing vs P-channel

iW9801 – ZVS PRIMARY-SIDE CONTROLLER

IDEAL HIGH-POWER DENSITY FOR 65W+ USB POWER DELIVERY CHARGERS



ZVS Primary-Side IC

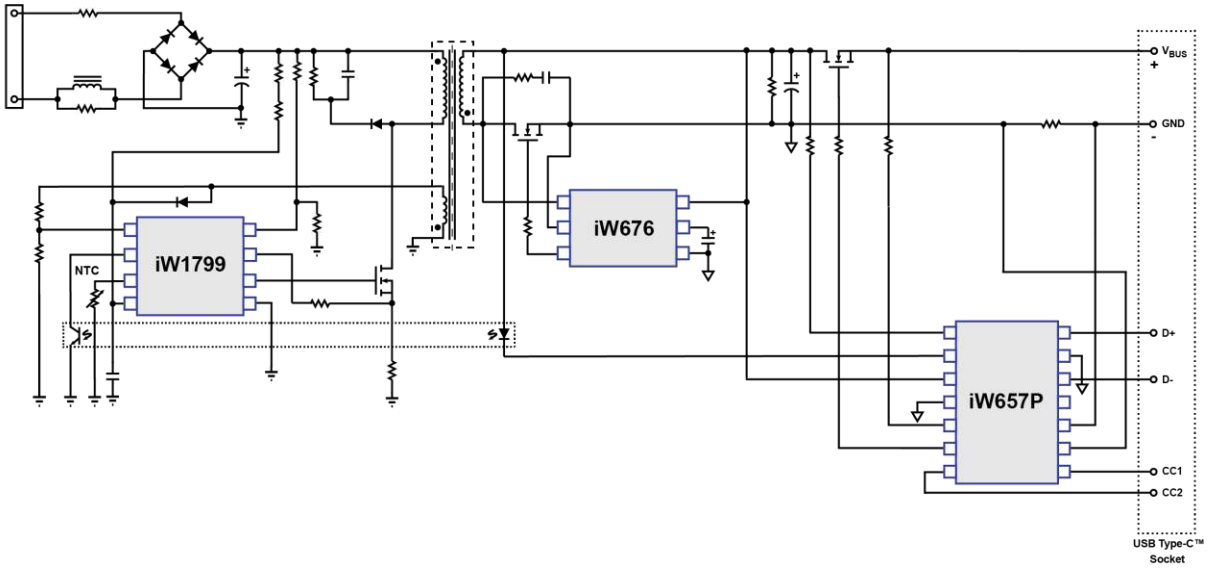
Integrated Secondary IC (CVCC Regulation + SR + USB Protocol +V_{BUS} FET Driver)

- ZVS control
  - Higher efficiency at higher f_{SW}
- CCM and DCM operation
  - Reduce transformer size further for universal input applications
- Active start-up support
  - < 20mW no-load power capable
- User-programmable internal OTP sensor
- Adaptive Multi-Mode control
  - High efficiency across all load steps
- Works with the iW709 secondary-side IC
  - Provides lowest total BOM cost for USB PD solutions
- Secondary-side regulation technology
  - External opto, regulation integrated into iW709

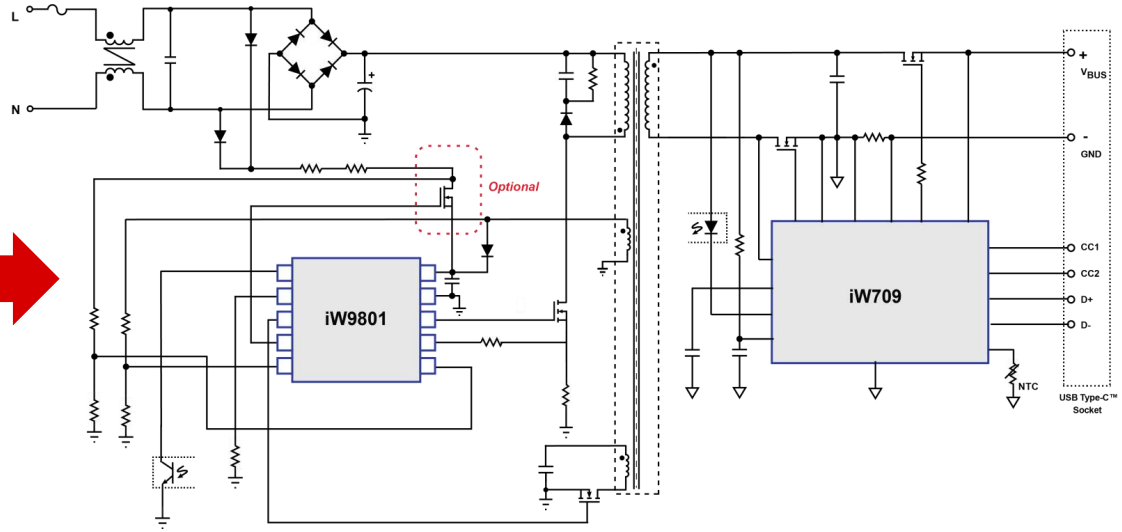
NEW ZVS SOLUTION – 100W HIGH POWER DENSITY, REDUCED BOM

CLICK HERE FOR RENESAS' *RapidCharge™* PRODUCT PORTFOLIO

Current 3-Chip Solution



New 2-Chip Solution



Primary-Side IC
iW1799

SR IC
iW676

USB-PD IF IC
iW657P

Primary-Side IC
iW9801

Integrated Secondary IC (CVCC Regulation + SR + USB Protocol+V_{BUS} Driver)
iW709

iW709 – ZVS SECONDARY-SIDE IC FEATURES

SYNCHRONOUS RECTIFIER CONTROL, SECONDARY-SIDE REGULATION CONTROL AND PROTOCOL IC

- Supports USB PD3.0 with Programmable Power Supply (PPS)
  - Supports output voltage 3.3V to 21V in 20mV steps; output current in 50mA steps
  - High resolution accurate multi-level output voltage and current control
- Built-in digital loop compensation minimizes external component count
- Optimized V_{DS}-based SR timing and driving control for ZVS or active clamp flyback (ACF) with wide output range
  - SR driving voltage optimized for high efficiency in low voltage Direct Charge applications
- Built-in NFET driver for V_{BUS} switch
  - Integrated charge pump drives external N-channel MOSFET, protects V_{BUS} from output short-circuit damage and enables lower cost, easier sourcing vs P-channel
- Programmable active fast discharge from a high voltage to 5V at device unplug or from a high voltage level to a lower level upon request with built-in switch or external switch
- Intelligent low power mode for very low no-load standby power when paired with iW9801 (ZVS/ACF)
- Supports DCM and CCM operation
- 16-Lead QFN package

PD3.0 AND PPS CERTIFIED

iW709 IS A USB PD 3.0 AND PPS CERTIFIED PD CONTROLLER, AND IS LISTED ON THE USB-IF WEBSITE

USB Enabling Connections™ About USB-IF > Developers > Compliance > Logo License Request Pressroom > Document Library Products

PRODUCTS

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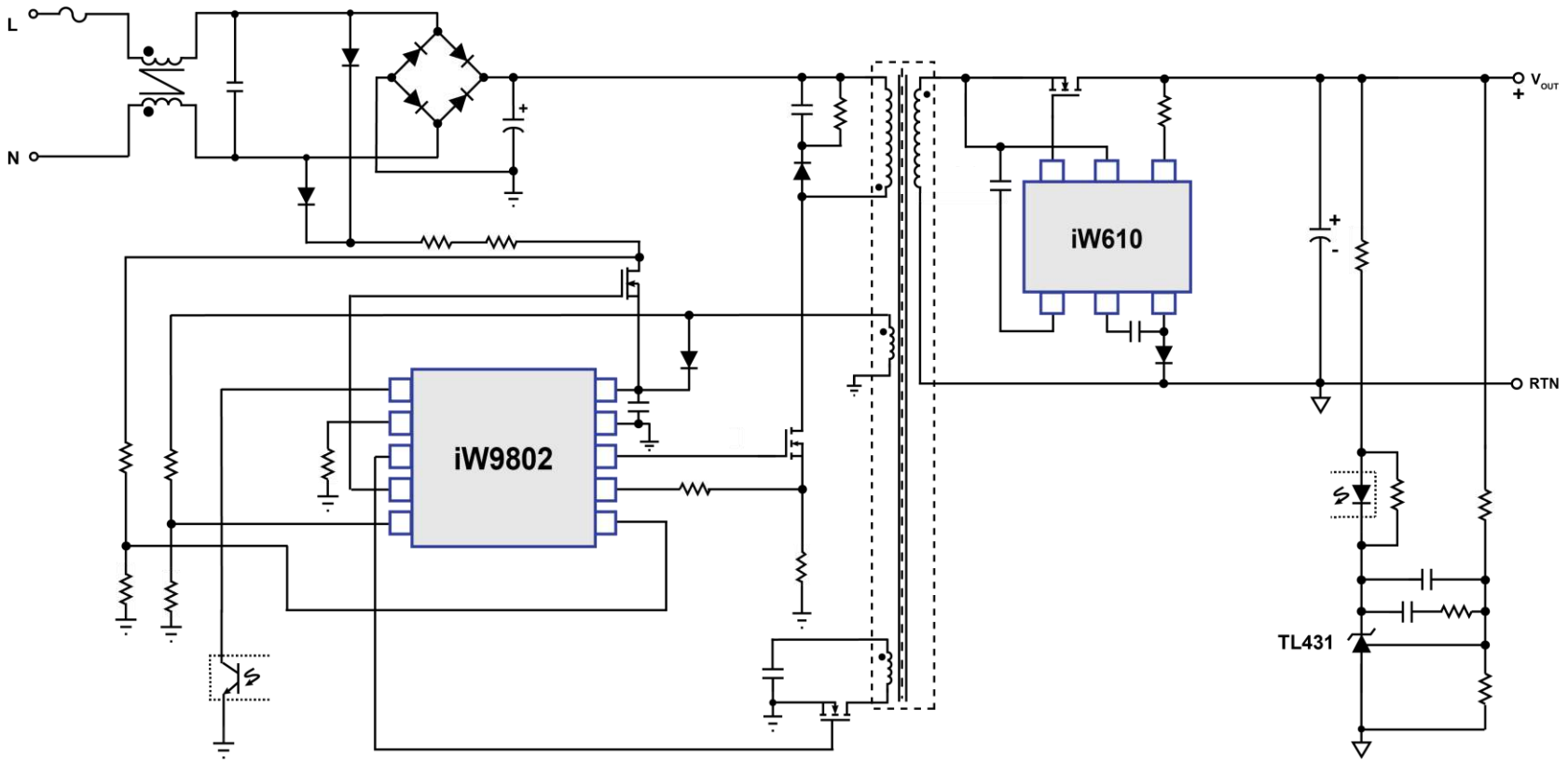
Name	Company	Features	Speed	Marketing Categories	Certification Date
iW709 	Dialog Semiconductor (UK) Ltd	Power Delivery 3.0, PPS,5v Prog,9v Prog,USB Type-C Source,5V Fixed,9V Fixed,Programable Power Supply (PPS)		PD Controller	10/29/2020

iW9802 – ZVS PRIMARY-SIDE CONTROLLER

WORKS WITH SECONDARY-SIDE REGULATION CIRCUIT, TL431 FOR FIXED OUTPUT VOLTAGE APPLICATIONS



- ZVS control
- CCM and DCM operation
- Works with external SR control on secondary and TL431
  - Ideal for fixed-voltage applications
- High switching frequency
  - Reduced transformer size
- Small SOIC-10 package

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