

# Ultra Miniature PoE PD Solution

MP8017– IEEE802.3af Star Product

October, 2021

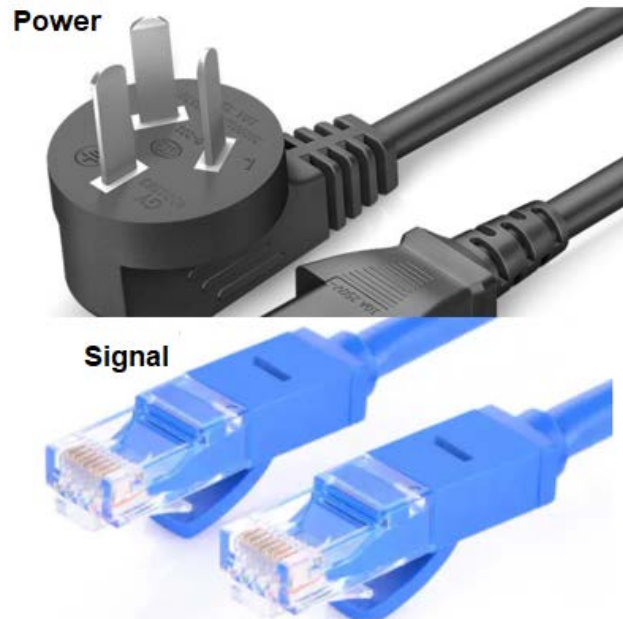


# Content

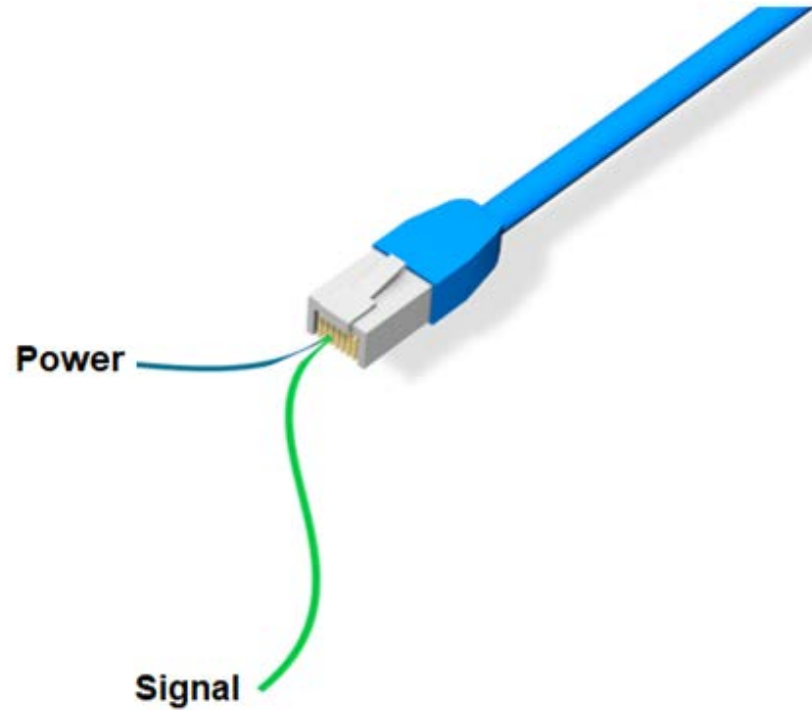
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  - A. What is PoE
  - B. PoE Power Ratings
  - C. PoE Protocol
- **Ultra Miniature IEEE802.3 af Solution**
  - A. Pain Points of PoE Design
  - B. How to Design a Optimized PoE Power
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  - B. MPS PD bt Solution
  - C. MPS PSE Solution

# What is PoE?

**P**ower **O**ver **E**thernet : **PSE** (**P**ower **S**ourcing **E**quipment) provide power to **PD** (**P**ower **D**evice) over Ethernet cable



Traditional Solution



PoE Solution

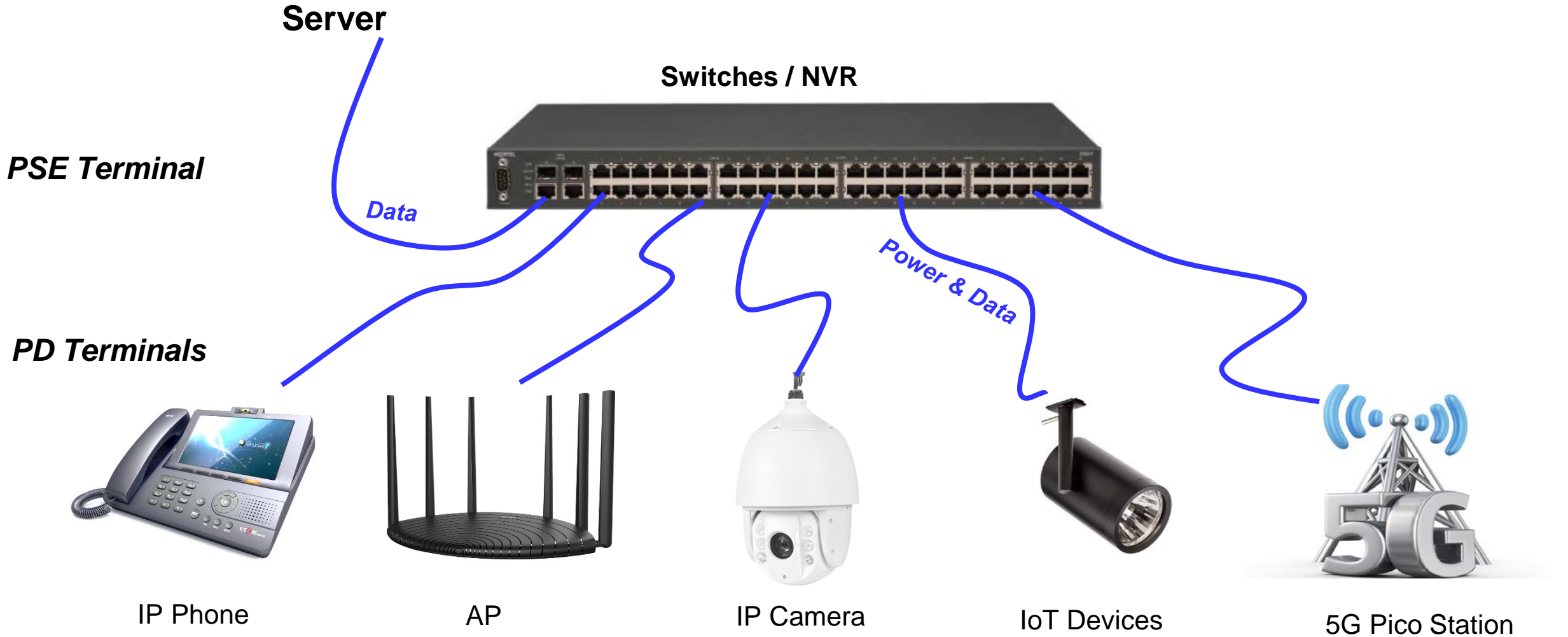
✓ Low Cost

✓ Easy to install

✓ Remote Control

✓ Good Compatibility

# What is PoE?



PoE power supplies are widely used.

# PoE Power Ratings



Up to 90W Power Supply

# af. PoE Power Ratings



2003

15W

IEEE 802.3af (POE)

	PSE		PD	
IEEE 802.3 af	$V_{OUT}$	44V – 57V	$V_{IN}$	37V – 57V
	$P_{OUT}$	15.4W	$P_{IN}$	13W
IEEE 802.3 at	$V_{OUT}$	50V – 57V	$V_{IN}$	42.5V – 57V
	$P_{OUT}$	30W	$P_{IN}$	25.5W
IEEE 802.3 bt	$V_{OUT}$	50V/52V – 57V	$V_{IN}$	~41V – 57V
	$P_{OUT}$	90W	$P_{IN}$	71.3W

	802.3 af			802.3 at	802.3 bt			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
PSE	4W	7W	15.4W	30W	45W	60W	75W	90W
PD	3.84W	6.49W	13W	25.5W	40W	51W	62W	71.3W

IEEE802.3af is type1 PoE, which supports class 1~3.

# at. PoE Power Ratings



2009

30W

IEEE 802.3at (POE+)

	PSE		PD	
<b>IEEE 802.3 af</b>	$V_{OUT}$	44V – 57V	$V_{IN}$	37V – 57V
	$P_{OUT}$	15.4W	$P_{IN}$	13W
<b>IEEE 802.3 at</b>	$V_{OUT}$	50V – 57V	$V_{IN}$	42.5V – 57V
	$P_{OUT}$	30W	$P_{IN}$	25.5W
<b>IEEE 802.3 bt</b>	$V_{OUT}$	50V/52V – 57V	$V_{IN}$	~41V – 57V
	$P_{OUT}$	90W	$P_{IN}$	71.3W

	802.3 af			802.3 at	802.3 bt			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
PSE	4W	7W	15.4W	30W	45W	60W	75W	90W
PD	3.84W	6.49W	13W	25.5W	40W	51W	62W	71.3W

IEEE802.3at is type2 PoE, which supports class 4 and 802.3af.

# bt. PoE Power Ratings



2018

90W

IEEE 802.3bt (POE++)

	PSE		PD	
<b>IEEE 802.3 af</b>	$V_{OUT}$	44V – 57V	$V_{IN}$	37V – 57V
	$P_{OUT}$	15.4W	$P_{IN}$	13W
<b>IEEE 802.3 at</b>	$V_{OUT}$	50V – 57V	$V_{IN}$	42.5V – 57V
	$P_{OUT}$	30W	$P_{IN}$	25.5W
<b>IEEE 802.3 bt</b>	$V_{OUT}$	50V/52V – 57V	$V_{IN}$	~41V – 57V
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	802.3 af			802.3 at	802.3 bt			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
PSE	4W	7W	15.4W	30W	45W	60W	75W	90W
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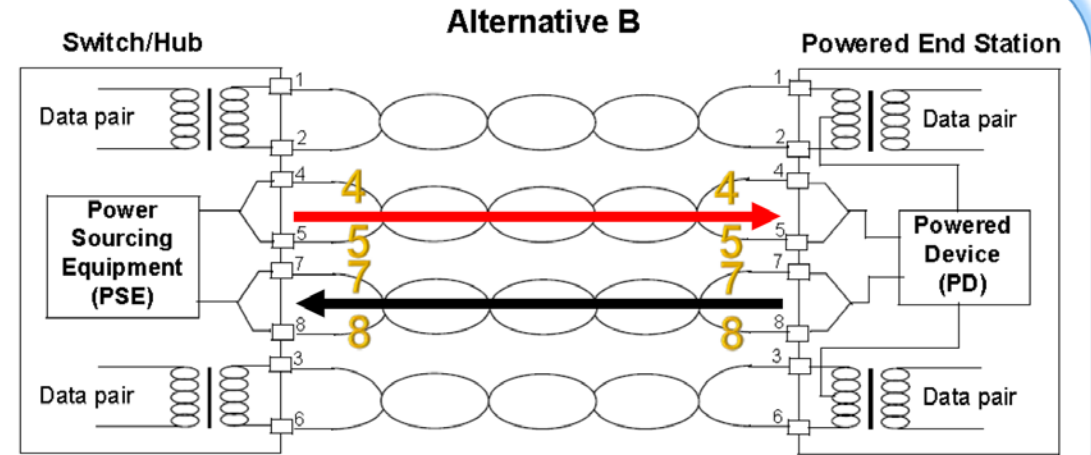
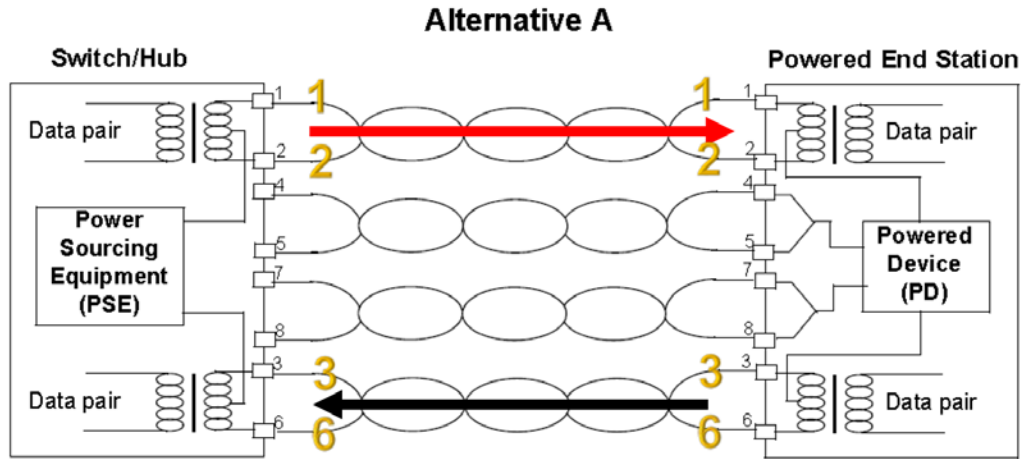
IEEE802.3bt include Typ3 and Type 4 PoE, which supports class 5~8 and 802.3at.



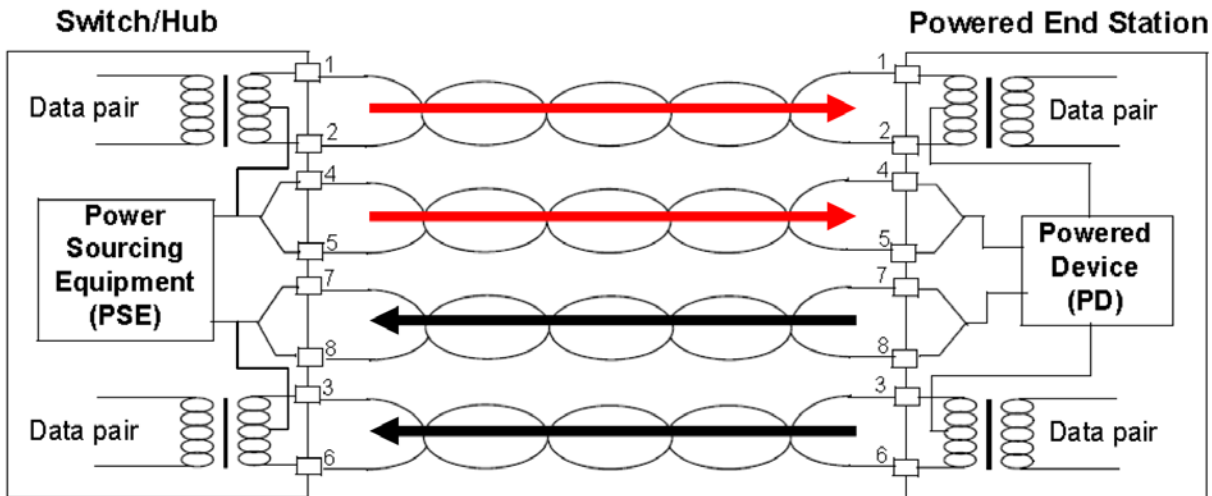


# POE Protocol- Connection

<30W



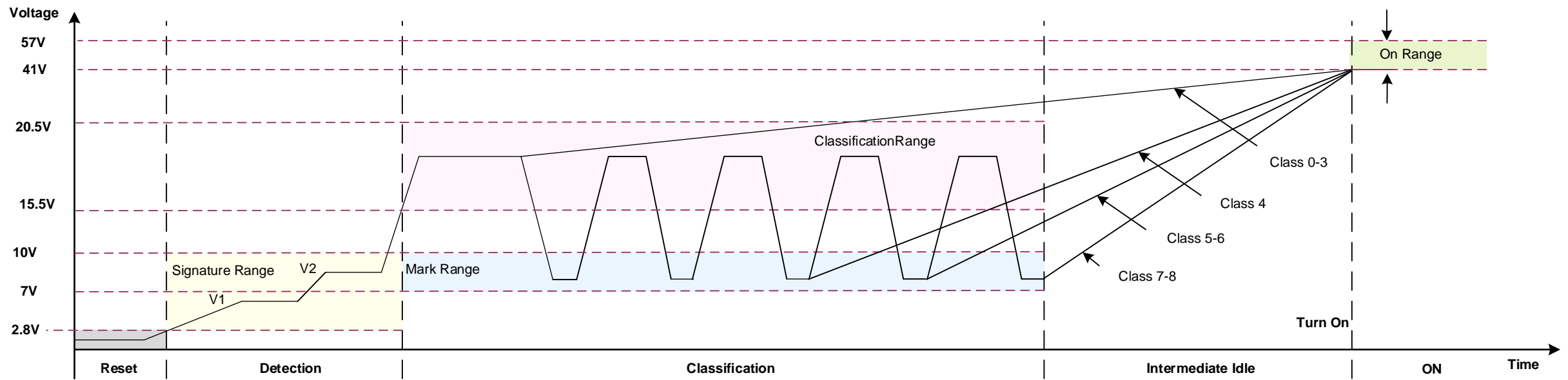
>30W



Note:

- af: total max cable impedance is 20Ω through 2-pair
- at: total max cable impedance is 12.5Ω through 2-pair
- bt: total max cable impedance is 6.25Ω through 4-pair

# POE Protocol- Handshake

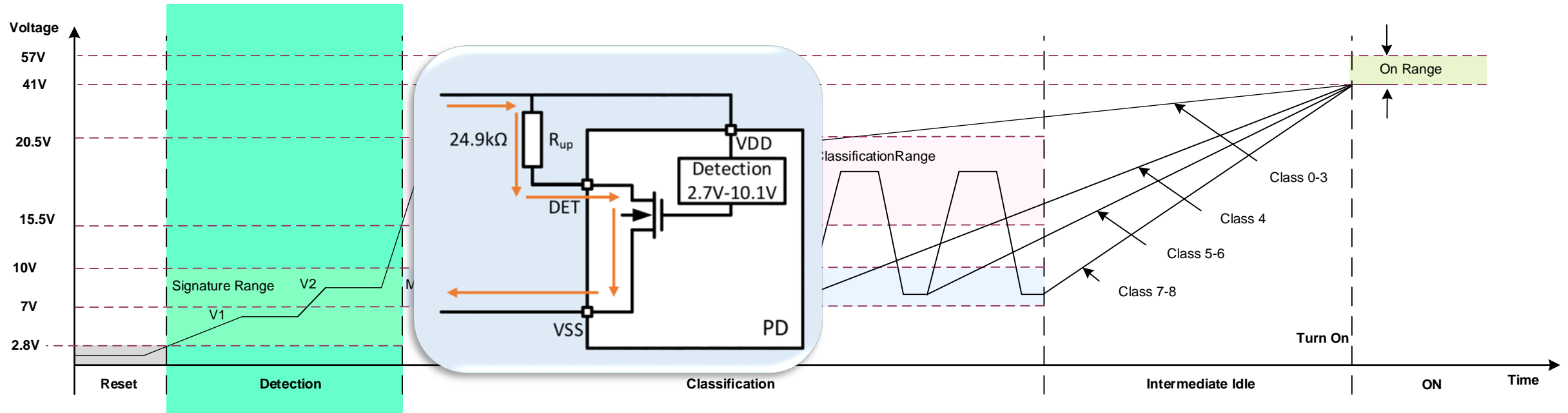


PD is connected?

PD need how much power?

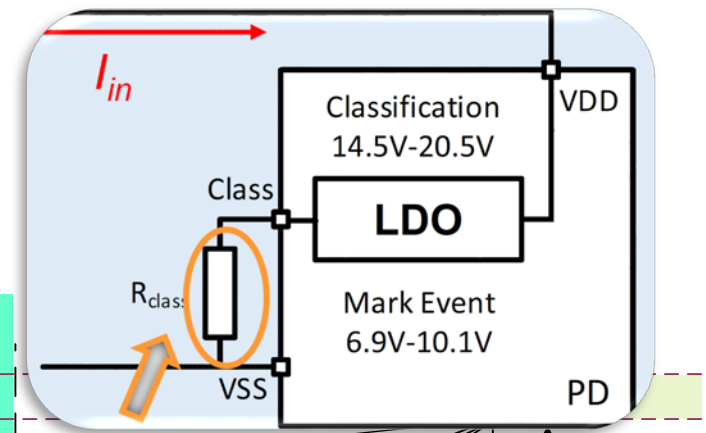
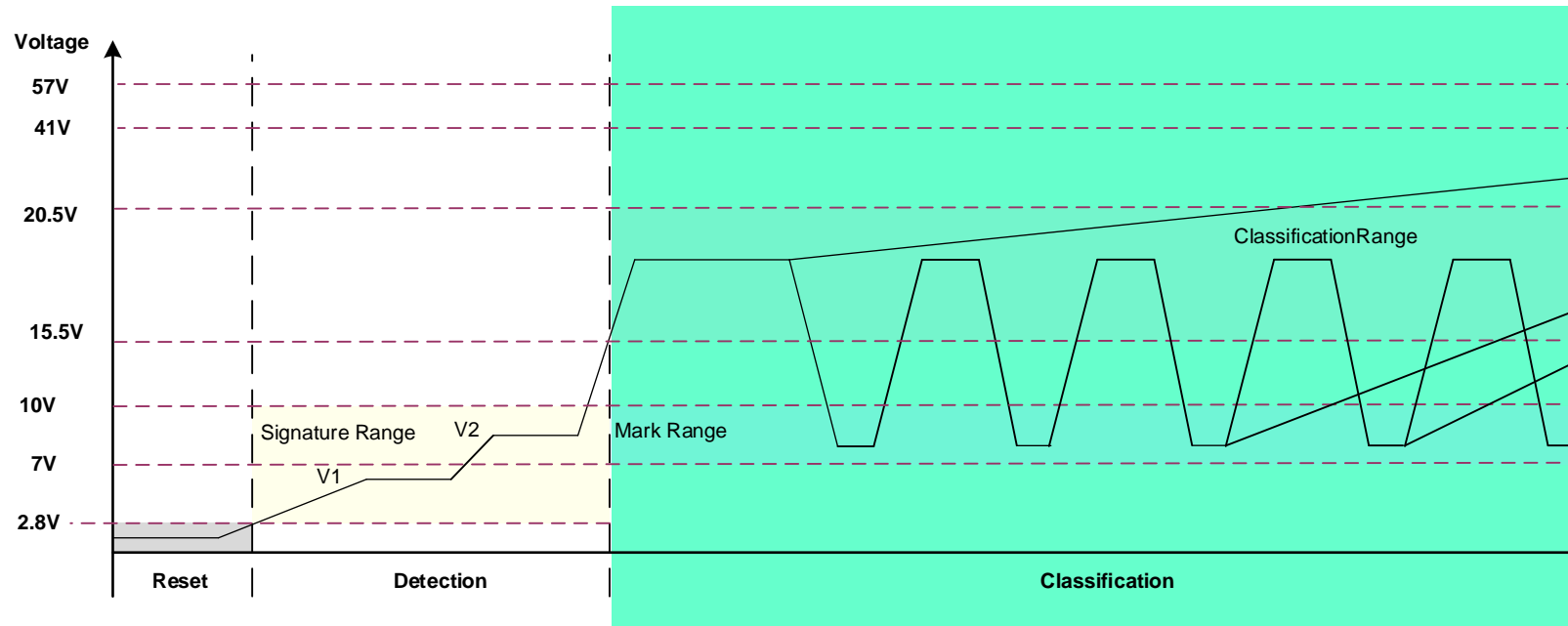
Power on

# POE Protocol- Detection



$R_{det} = (V_2 - V_1) / (I_2 - I_1)$ , if the resistor is between 23.7K~26.3K, a available PD is connect.

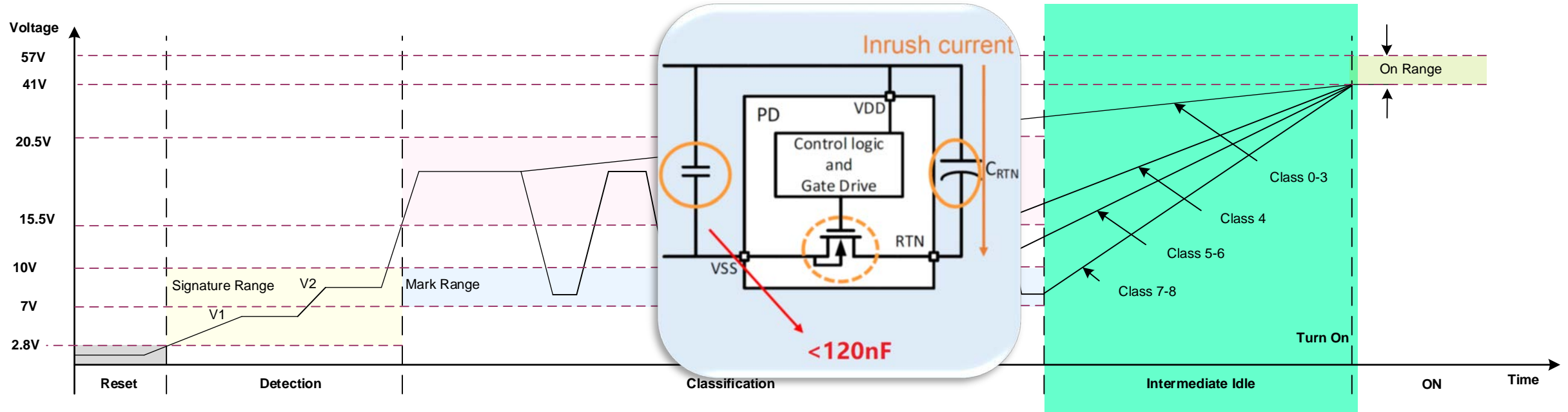
# POE Protocol- Classification



PD Class	Total Class Cycles	1, 2 Cycle Signature	3, 4, 5 Cycle Signature
0	1	0	-
1	1	1	-
2	1	2	-
3	1	3	-
4	2 or 3	4	4
5	4	4	0
6	4	4	1
7	5	4	2
8	5	4	3

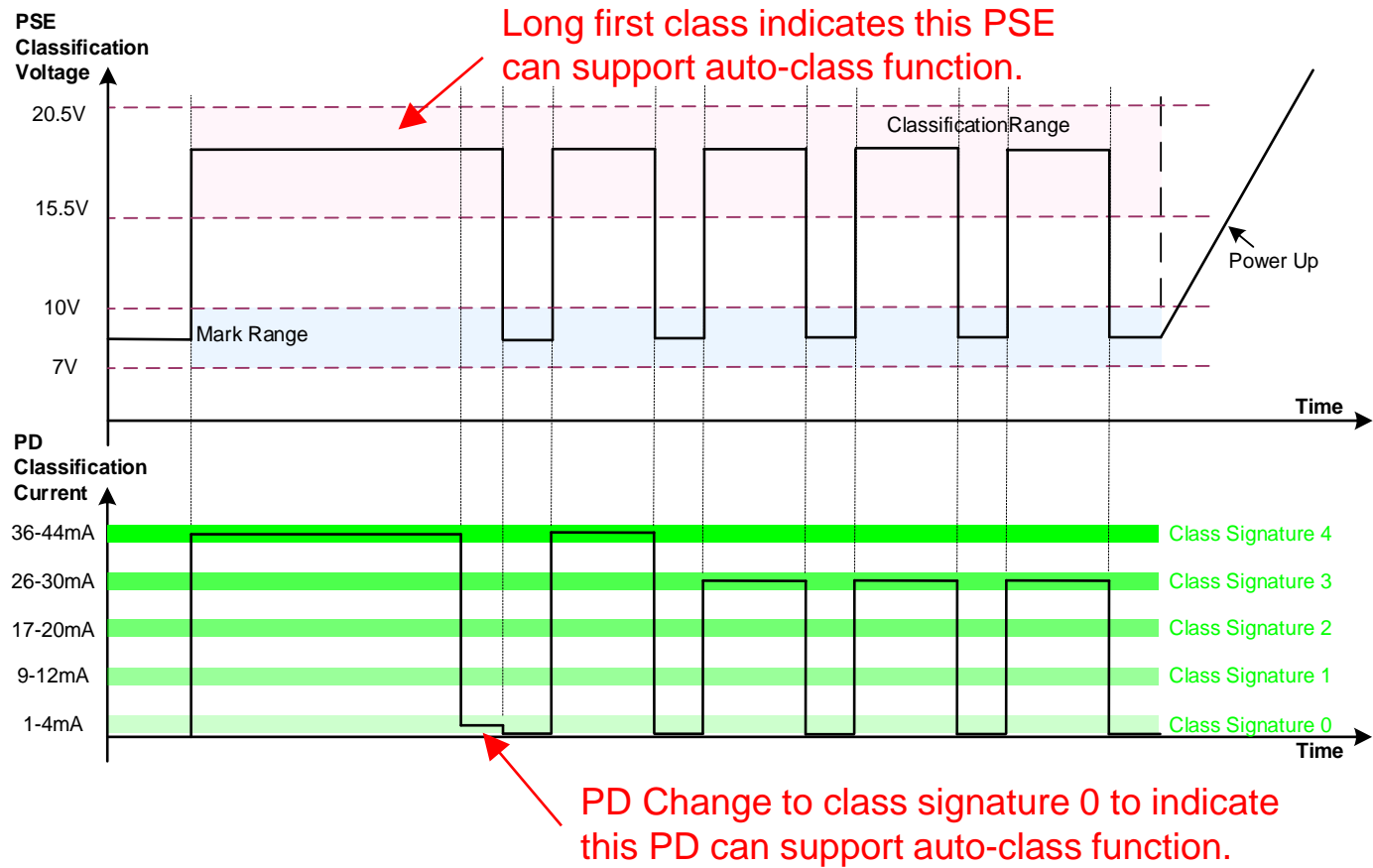
In classification period, PD tells PSE how much power is needed through different classification signature.

# POE Protocol- Power On



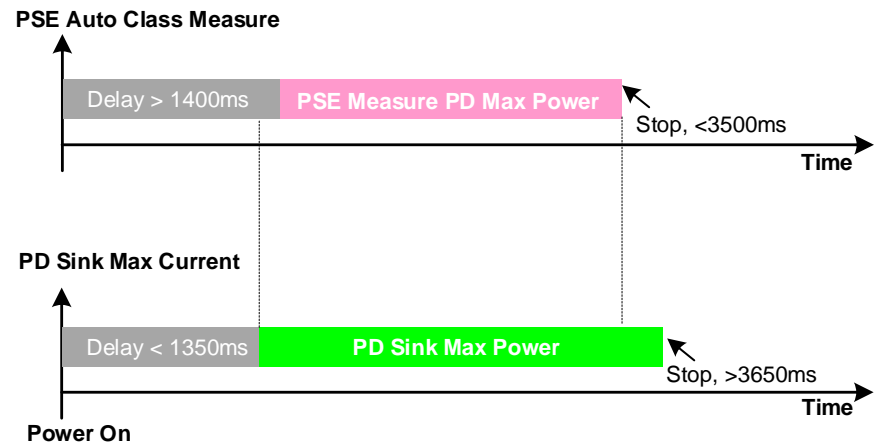
1. The PD input capacitor is  $<120\text{nF}$ , need a hot-swap MOSFET to isolate the big output capacitor.
2. After power on, the hot-swap MOSFET limits the current to charge output capacitor.

# POE Protocol- IEEE 802.3bt Auto Classification



**Auto Class Example with Class-8 PD.**

**Auto-class allows PSE to determine the actual maximum power of the connected PD, so that allocate power to more PDs with limited power source.**



**Auto Class Measure Time**

# POE Protocol- Maintain Power Signature



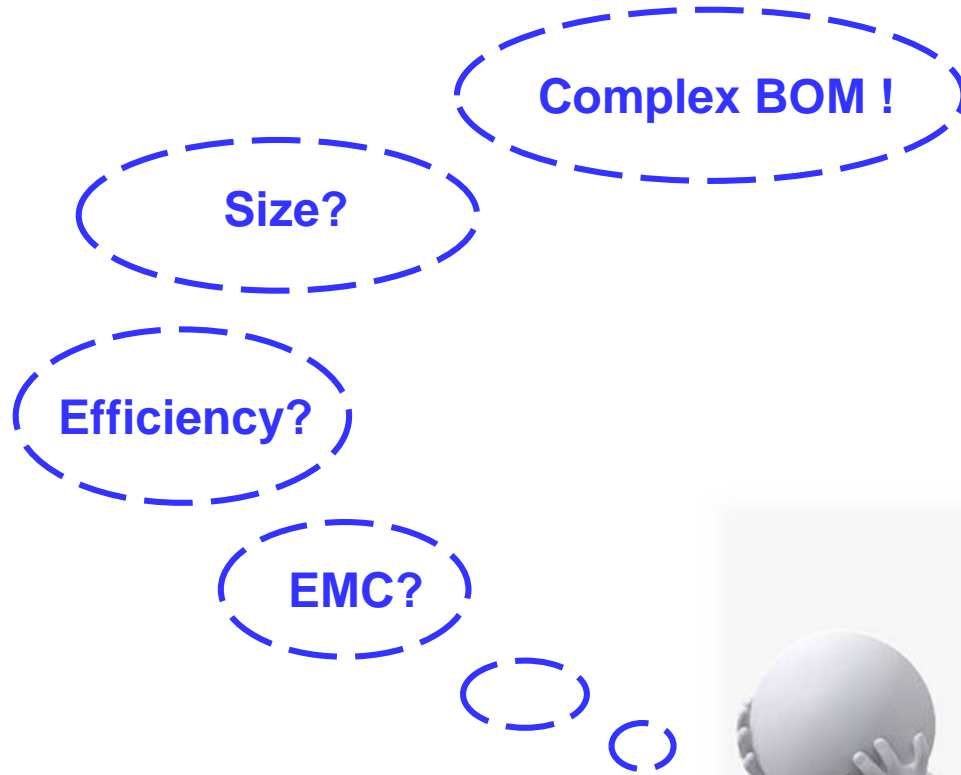
1. When PD is removed, PSE need stop power supply
2. But PD need maintain the minimum current to maintain the power signature.

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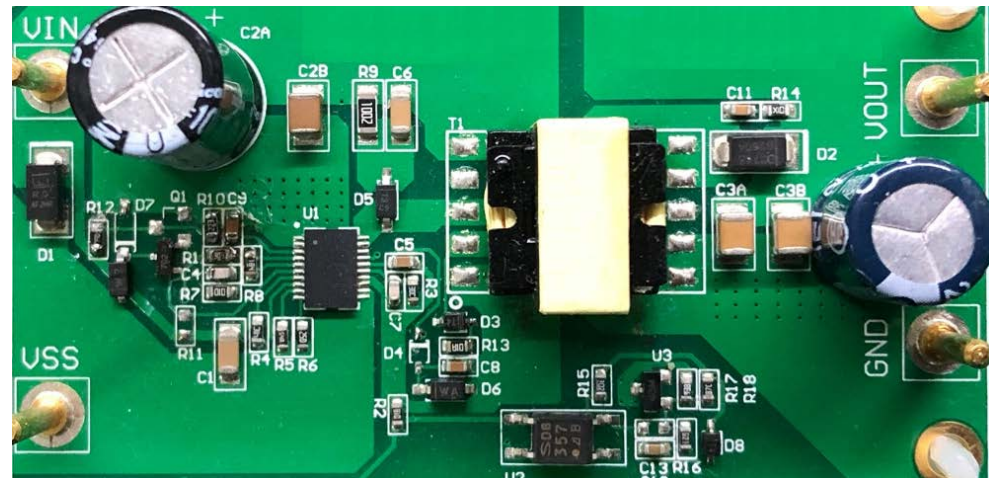
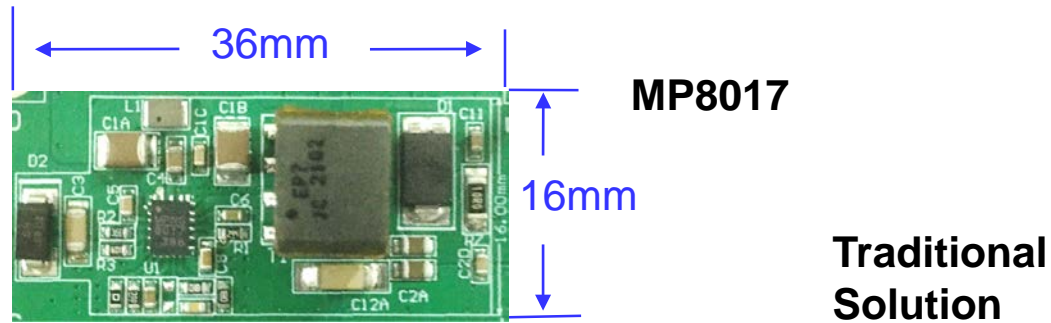


# Pain Points of PoE Design



# MP8017 Advantages

The MP8017 is an ultra compact IEEE802.3 af PoE PD solution, it integrates PD interface and fly-back converter.



✓ Fully-integrated converter in **QFN(3x4mm) Package**

✓ **SW Feedback without Opto-Coupler/TL431**

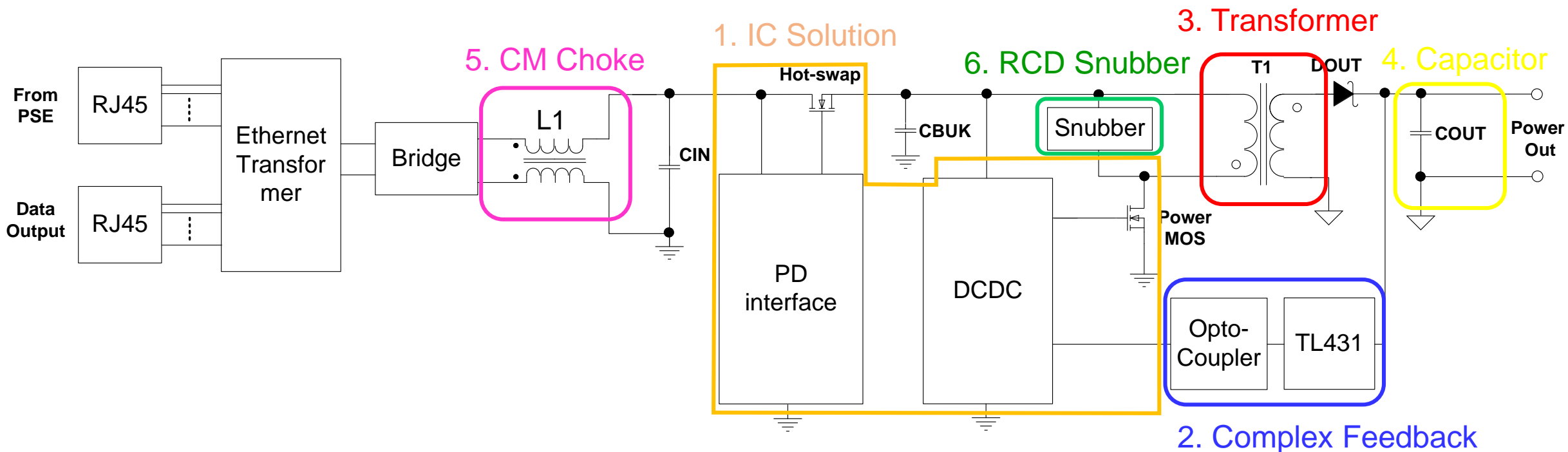
✓ **EP7 Transformer for 12W**

✓ **Small Input/Output Capacitor**

✓ **Good EMI without Common Choke**

✓ **Active Clamp Topology Saves RCD Clamp Circuit**

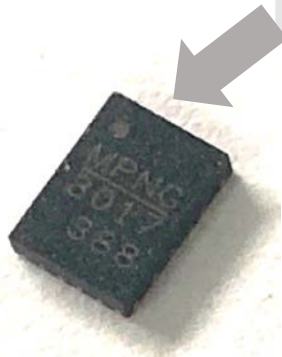
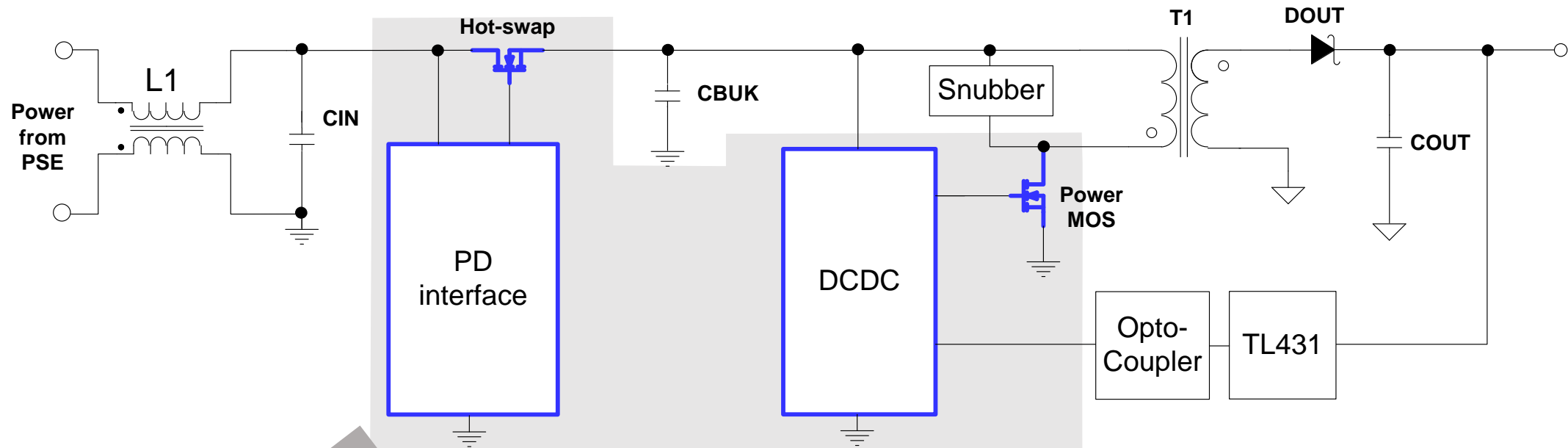
## 2, Design a Compact Solution



### Comments:

Base on the above some many circuit block, how to design a compact solution?

## 2.1, Choose a fully-integrated solution



### ❑ MP8017

- 4 in 1 fully-integrated solution
- In QFN (3mmX4mm) Package

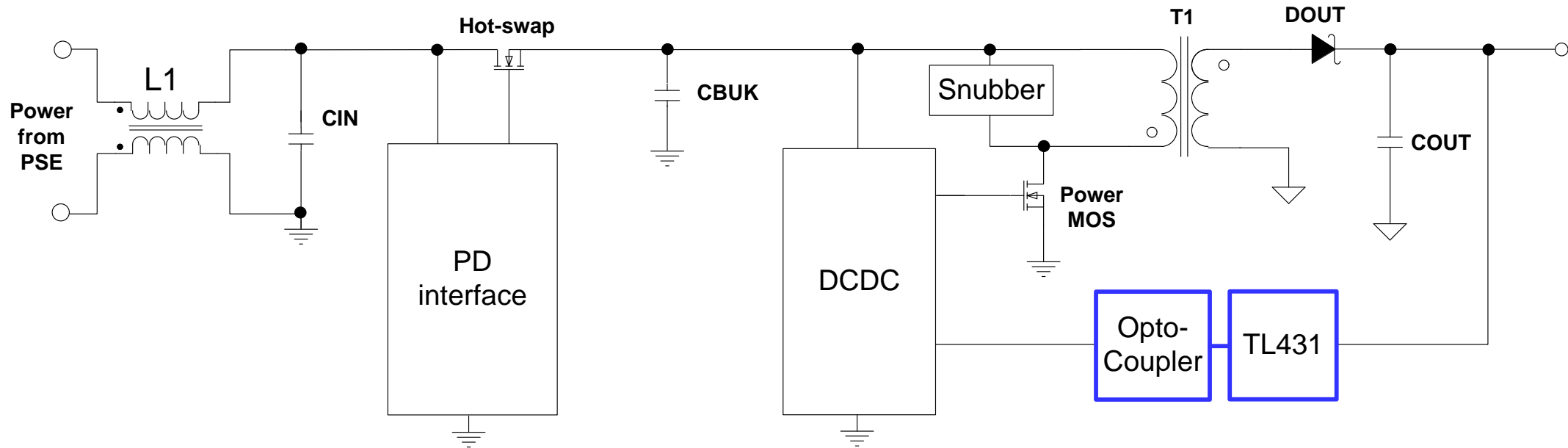
### Pain Points

1. Complex design, 2. Large layout area, 3. Lower Reliability. 4. Longer design period.

### MP8017 Advantages:

The MP8017 is fully-integrated PD interface and fly-back converter.

## 2.2, Does the Converter offer PSR feedback?

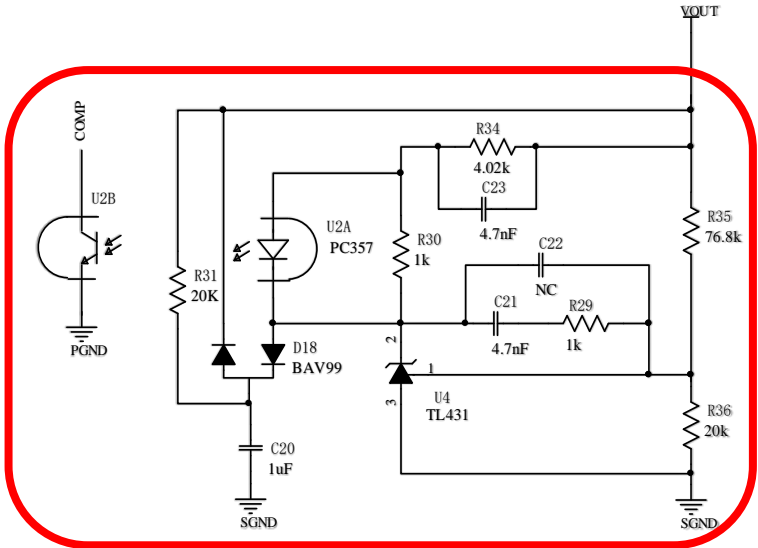


### Pain Points

1. Complex circuit with the Opto-coupler and TL431 network.
2. Hard to tune loop stability.
3. Need external soft-start circuit.
4. Large layout area and higher cost.

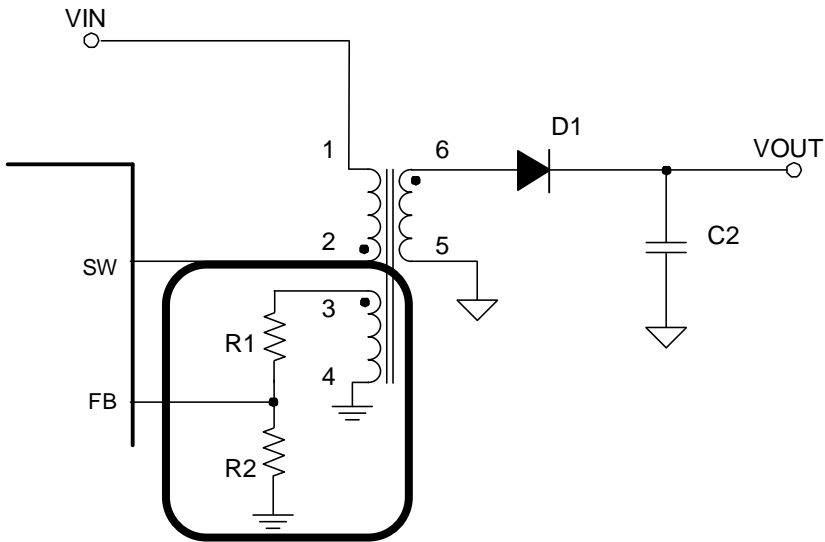
# 2.2, Does the Converter offer PSR feedback?

## Traditional SSR Feedback



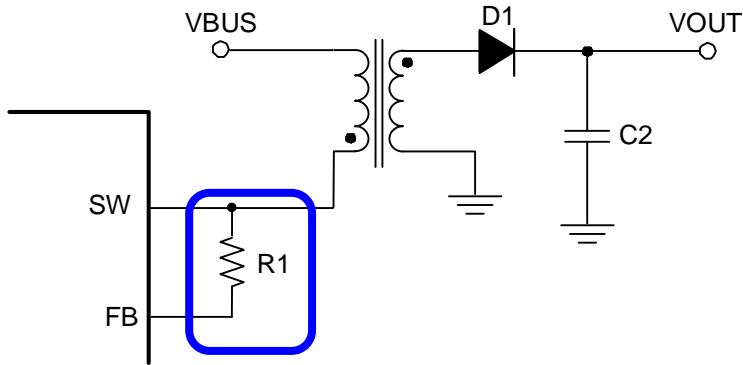
Complex TL431 / Opto-coupler

## Traditional PSR Feedback



Aux-winding + FB divider resistors

## MP8017 SW Feedback

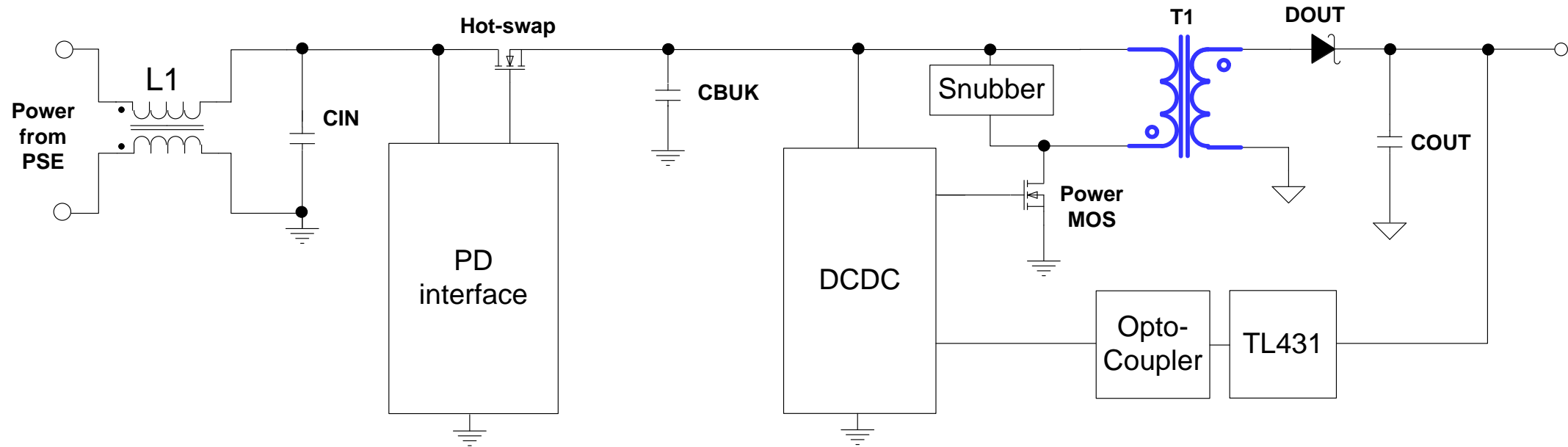


Only one resistor

### MP8017 Advantages:

- ✓ Simpler BOM and simpler design.
- ✓ Lower transformer cost without aux-winding.
- ✓ More primary-winding and secondary-winding to improve efficiency with same core.

# 2.3, How to reduce the Transformer Size



### Pain Points

How to reduce the transformer size to get lower solution size and cost?

## 2.3, How to reduce the Transformer Size

17.7x13.5x12.3mm



EP13

9.5x8.9x11mm



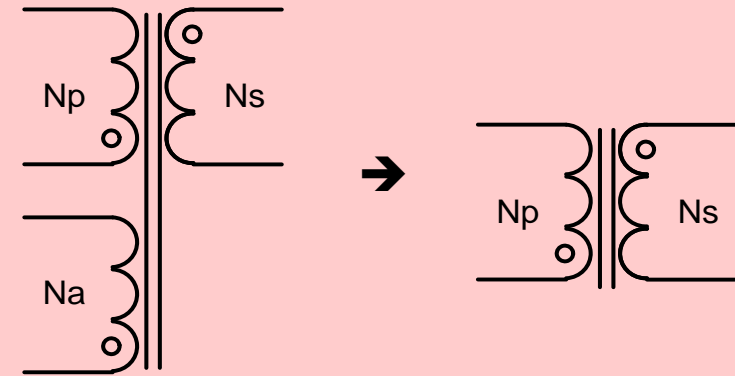
EP7

MP8017 12W

### MP8017 Advantages:

- ✓ Fewer winding without aux-winding.
- ✓ Fewer winding turns with up to 650KHz frequency.

Fewer Winding

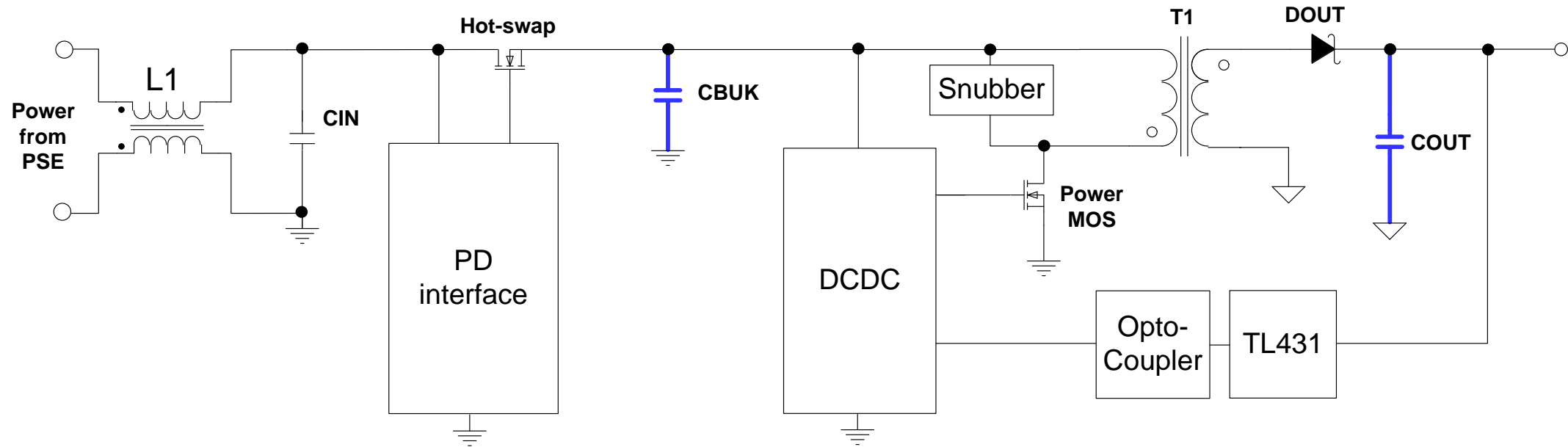


High Frequency  
250KHz → 650KHz

$$n = \frac{V_{IN} \times D}{A_E \times B_{MAX} \times F_{SW}}$$



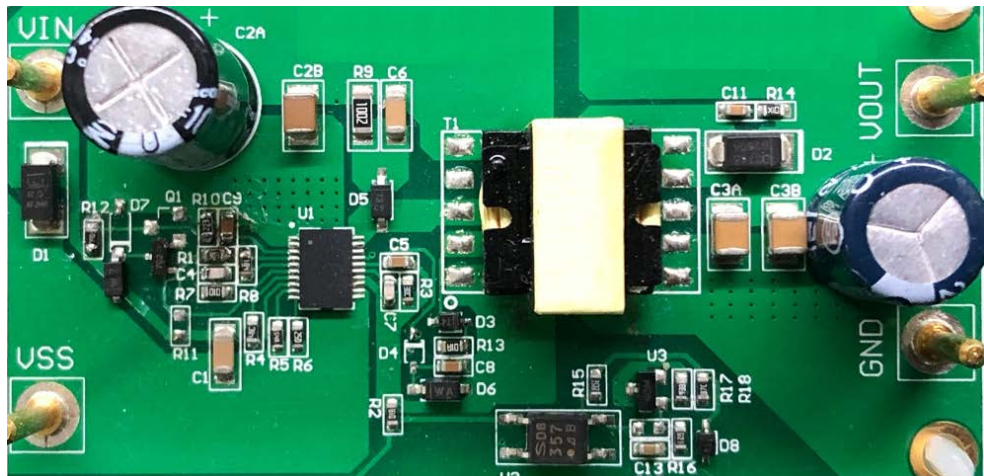
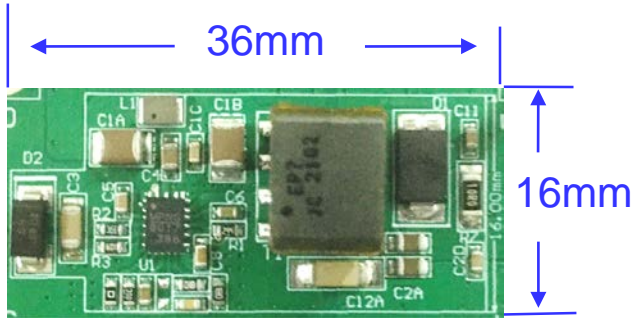
## 2.4, How to reduce Input/Output Cap.



### Pain Points

How to reduce the input/output capacitor?

## 2.4, How to reduce Input/Output Cap.



### MP8017 Advantages:

- ✓ High frequency requires fewer capacitors.
- ✓ CCM control get lower current spike.

High Frequency  
250KHz → 650KHz

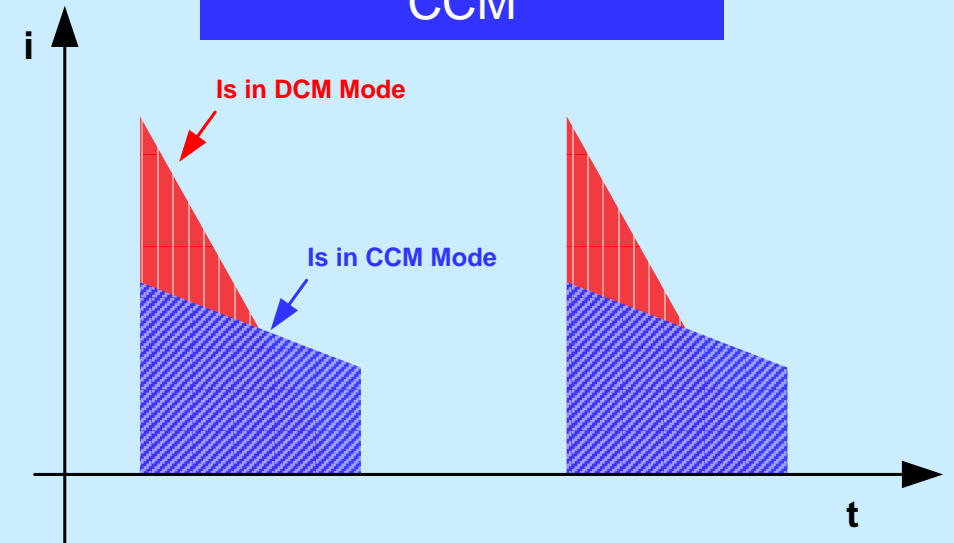
VIN ripple

$$\Delta V_{IN} = I_{IN} \times \frac{V_{IN}}{C_{IN} \times (N \times V_{OUT} + V_{IN}) \times F_{SW}}$$

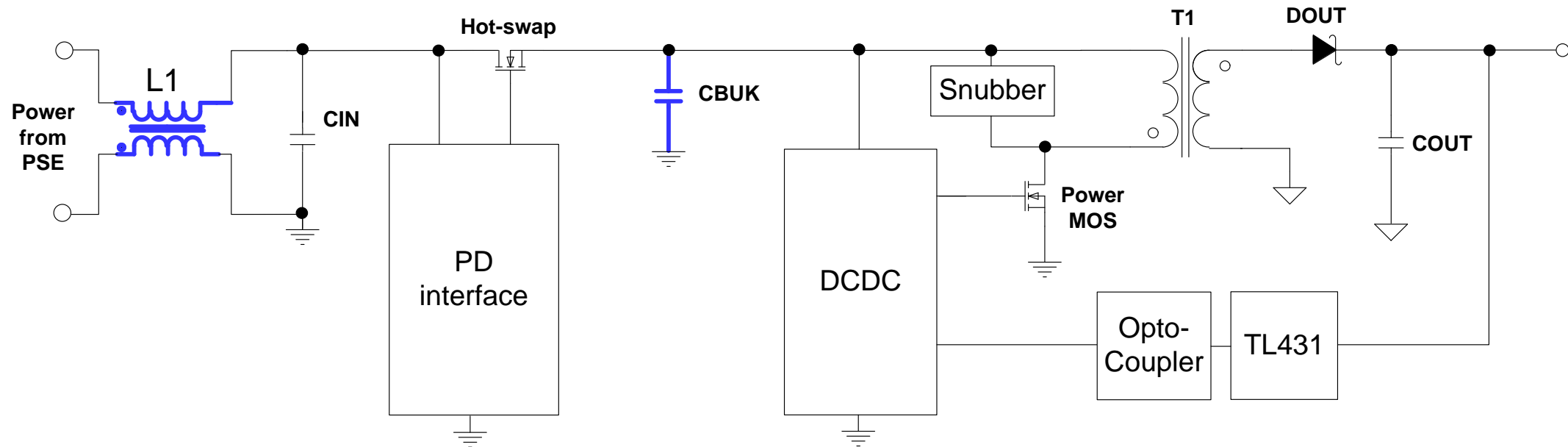
VOUT ripple

$$\Delta V_{OUT} = I_{IN} \times \frac{N \times V_{OUT}}{(V_{IN} + N \times V_{OUT}) \times F_{SW}} \times \frac{I_{OUT}}{C_{OUT}}$$

CCM



# 2.5, Hard to Pass EMI test?

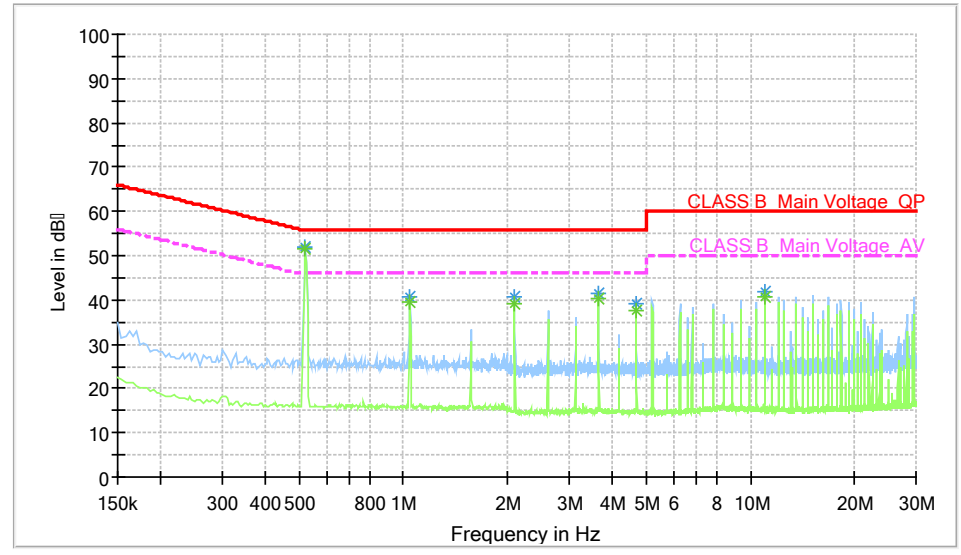
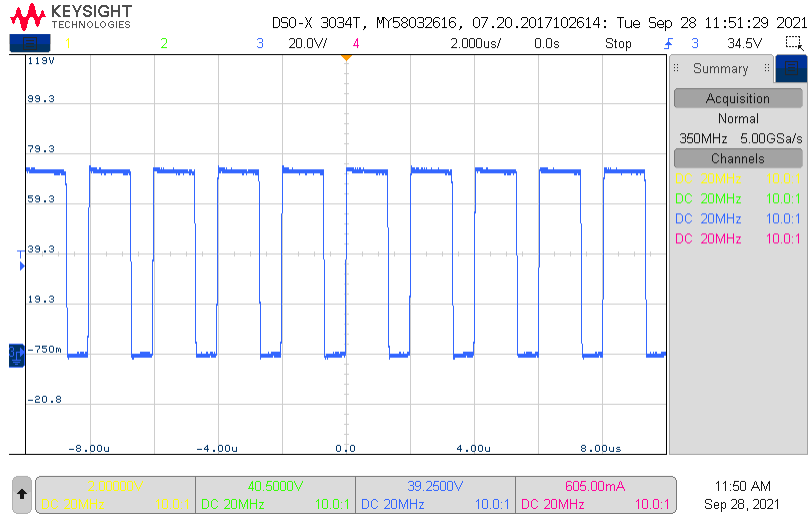


### Pain Points

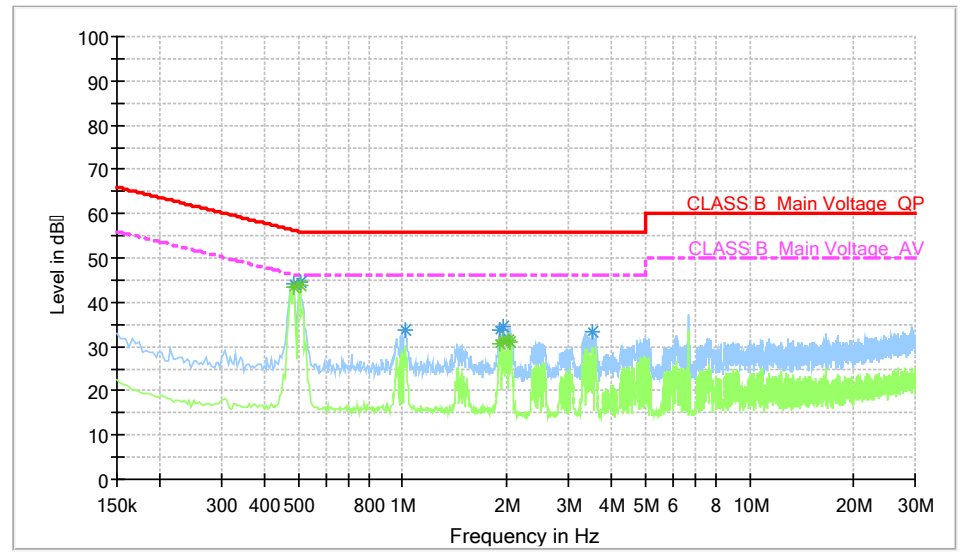
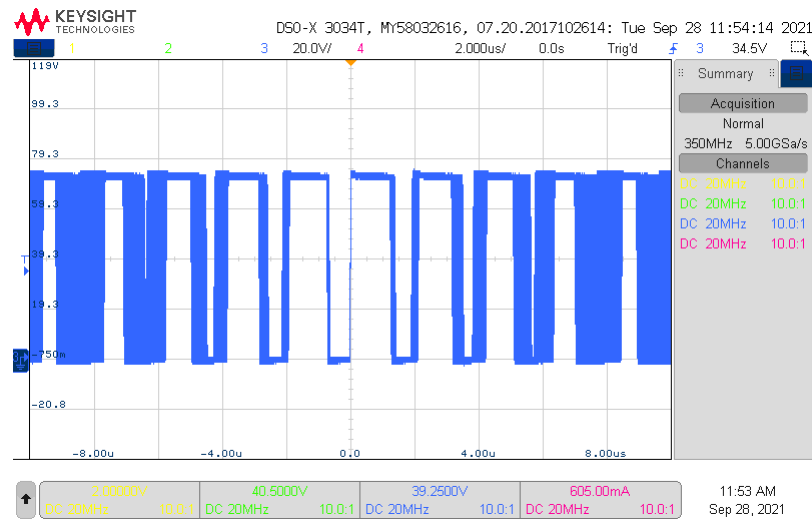
1. Hard to tune EMC performance.
2. CM choke increases cost and solution size.

# 2.5, Hard to Pass EMI test?

No Frequency Dither



MP8017 Frequency Dither



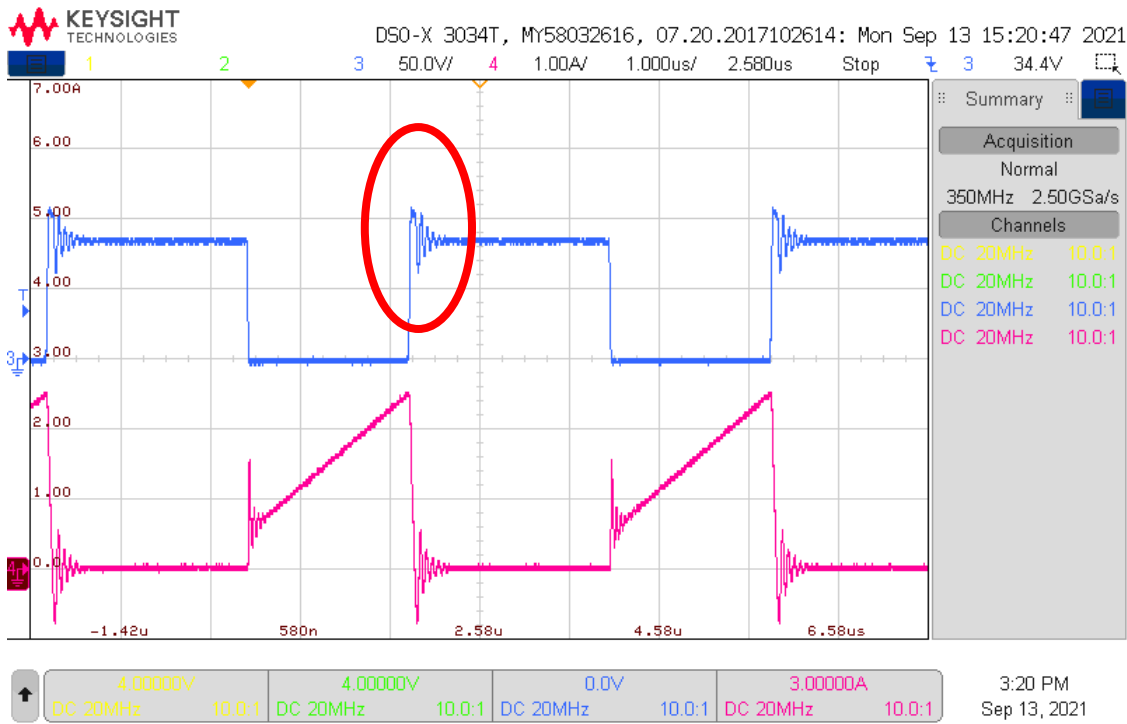
## MP8017 Advantages:

- ✓ MP8017 offers spread-spectrum frequency dithering, it typically reduce of 4-6 dB at the fundamental switching frequency and 10-20 dB for higher-frequency harmonics

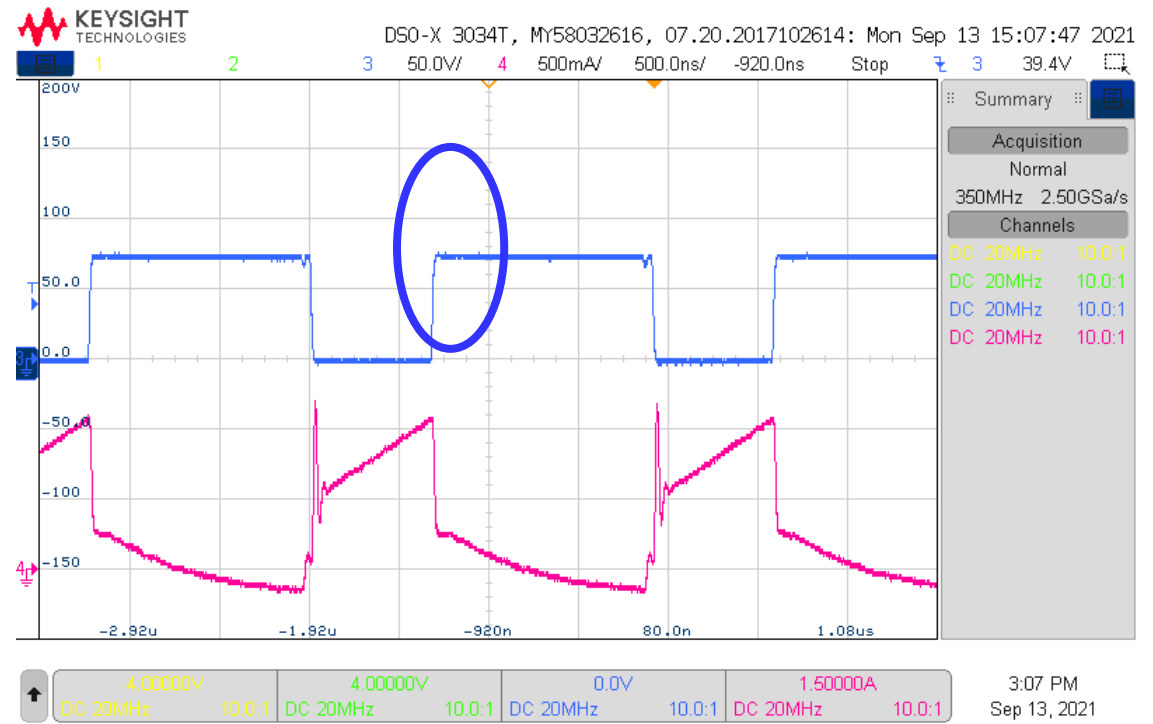


# 2.5, Hard to Pass EMI test?

Normal SW



MP8017 SW

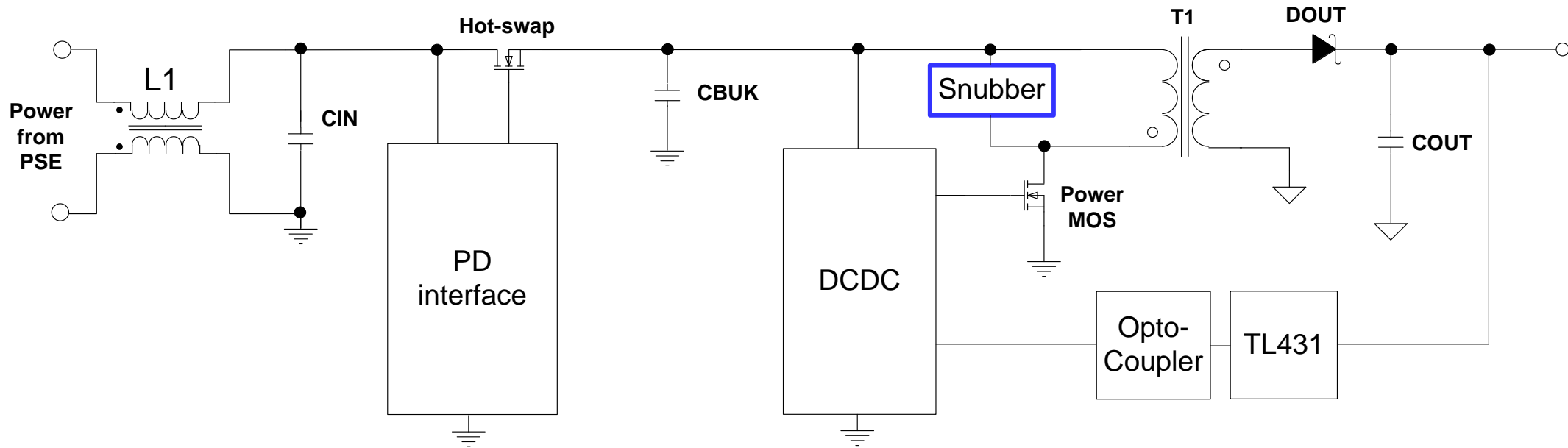


## MP8017 Advantages:

- ✓ Advance Subber control topology get smooth SW waveform, which strongly improves EMI performance.



## 2.6, Advance Snubber Design.

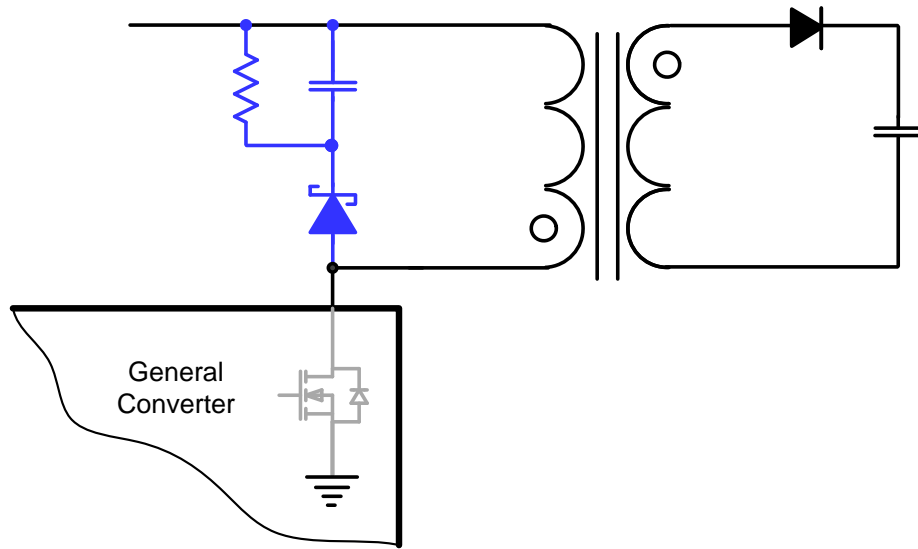


### Pain Points

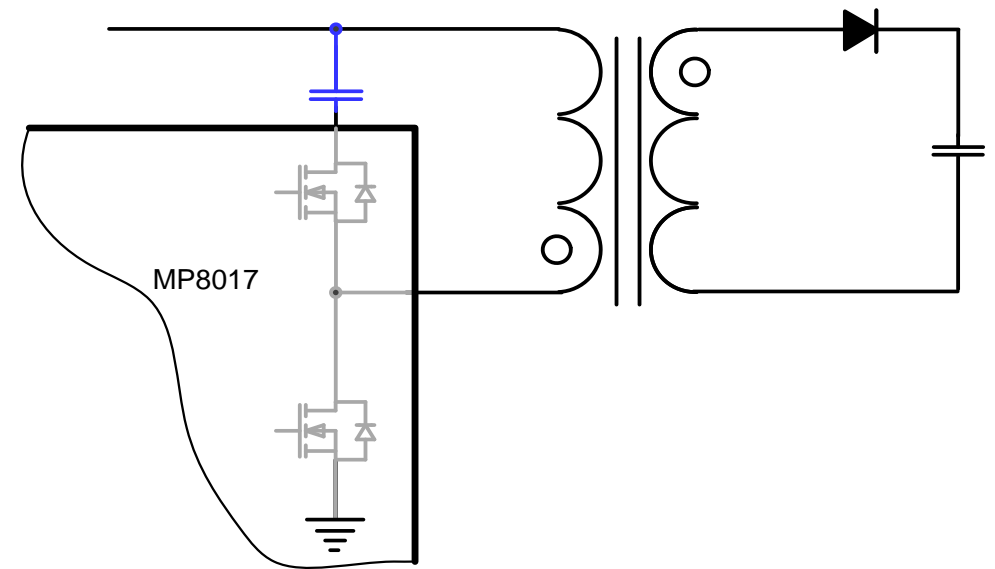
1. RCD clamp circuit increases layout area.
2. RCD clamp circuit consumes leakage inductance energy. which decreases efficiency and increases temperature.
3. Hard to layout in small loop.

## 2.6, Advance Snubber Design.

General Converter



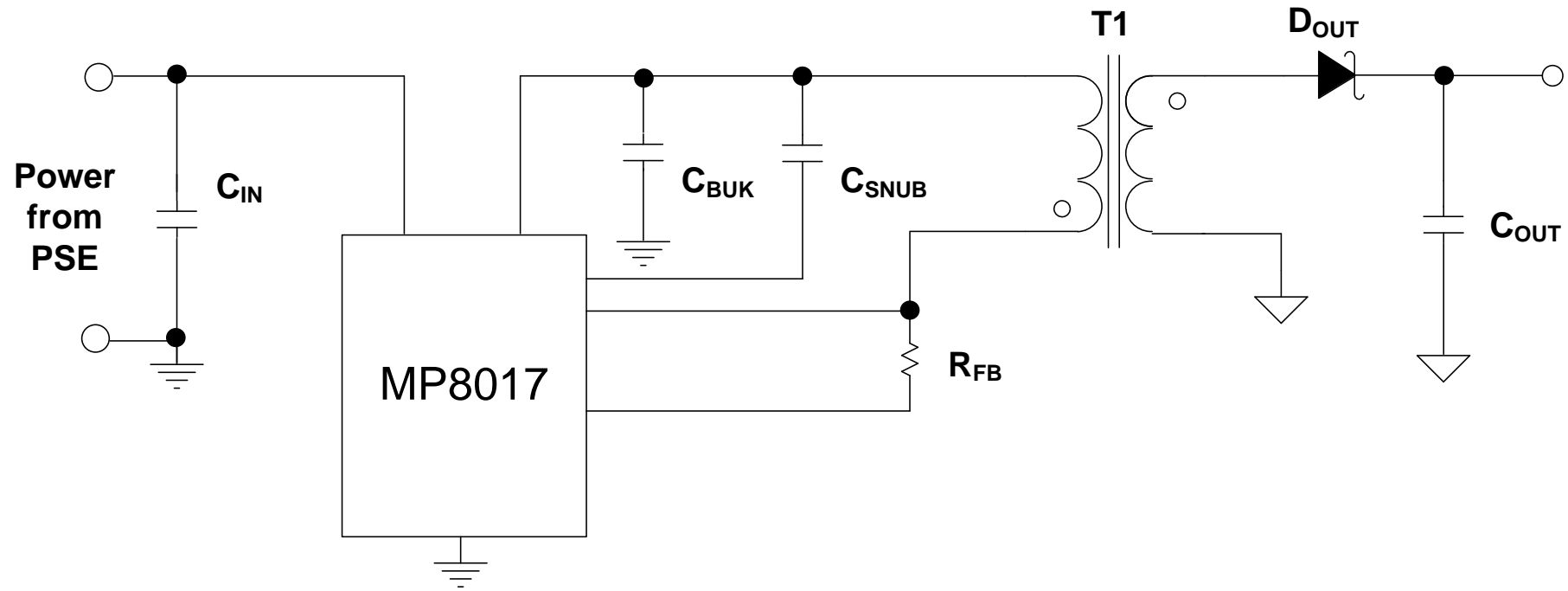
MP8017



### MP8017 Advantages:

- ✓ Snubber only need a C instead of RCD.
- ✓ Leakage inductor energy can transfer to output, which improves efficiency.
- ✓ Smaller loop for highly impact solution.

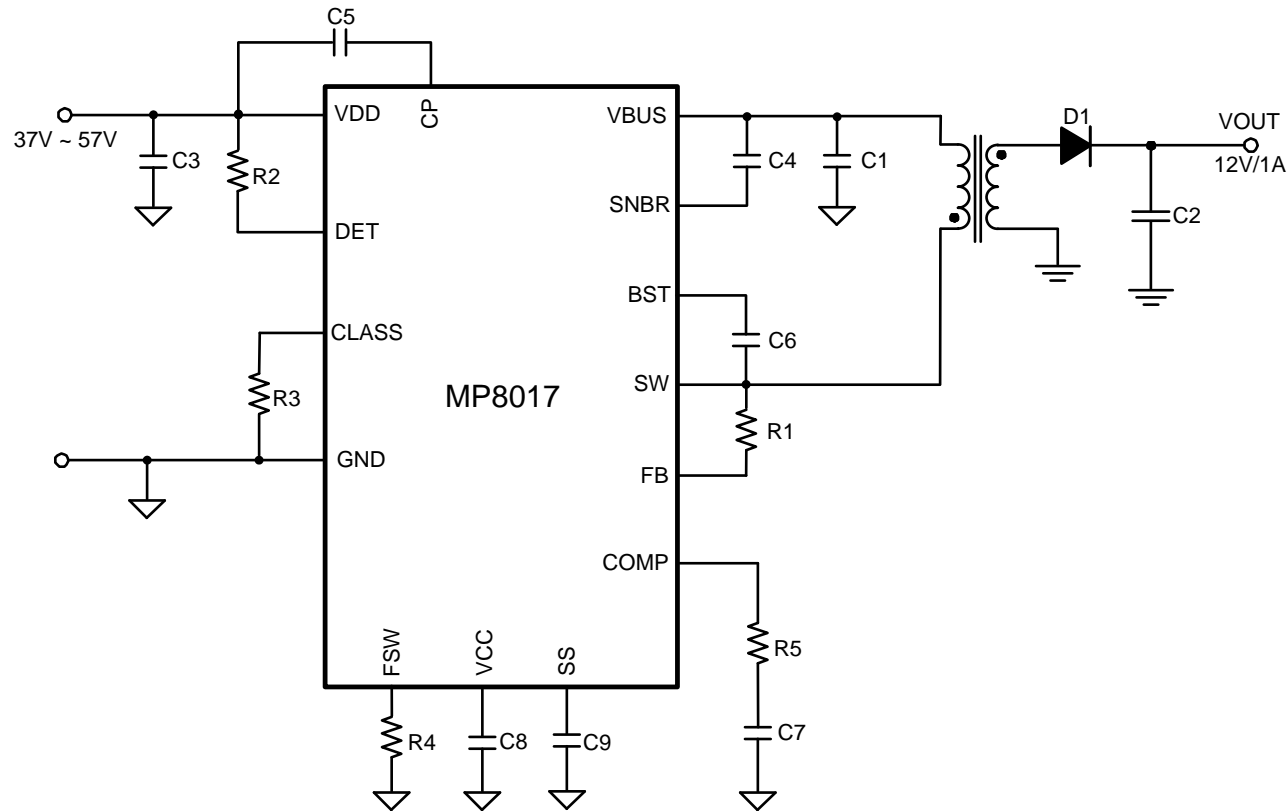
# MP8017 Ultra Miniature Design



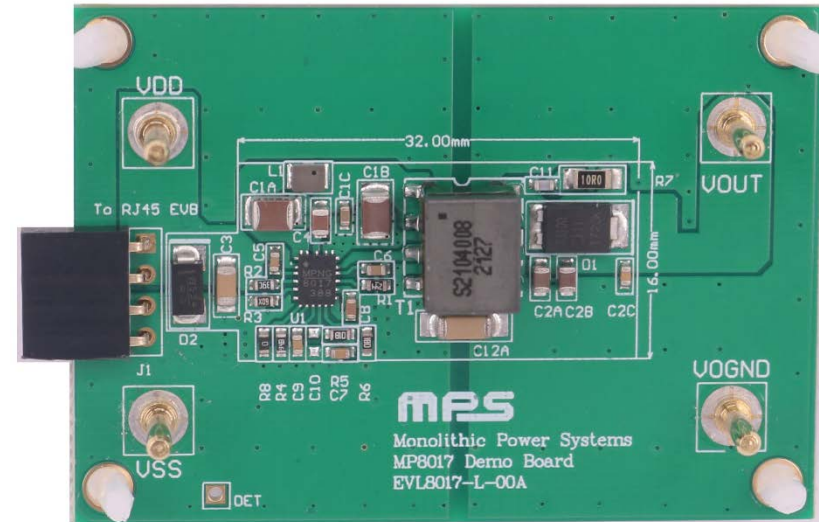


# MP8017 Ultra Miniature Design

MP8017 Circuit



MP8017 Evaluation Board



12V 12W	EVB is available.
5V 12W	EVB is available.

- 1. SCH
- 2. PCB
- 3. BOM
- 4. Transformer
- 5. Test Report

**Comment:**

MP8017 has 5V and 12V EVB, and can provide fully design files, please contact with MPS FAE for it.



# Content

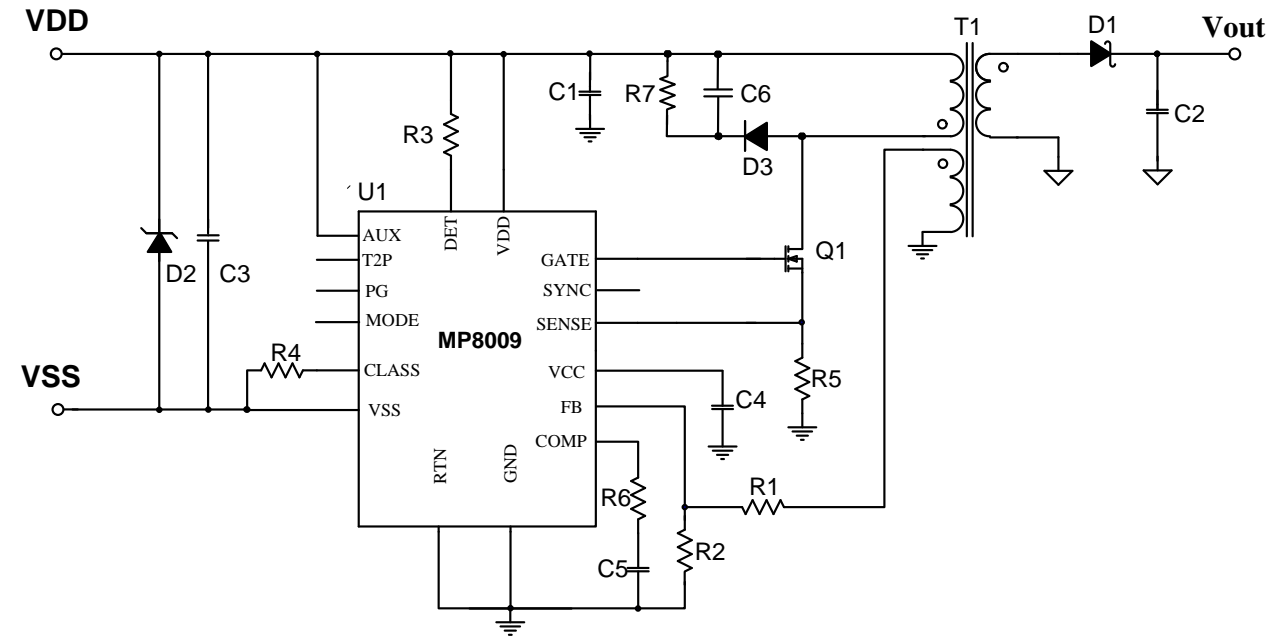
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## 3.1, IEEE802.3at PD solution- MP8009

### FEATURES

- Compatible with 802.3af/at specifications
  - 0.48Ω PD switch
  - 120mA/800mA PD inrush/Operation current limit
- **Support Primary-Side Regulated Fly-back**
  - >30kHz frequency to avoid audio noise
  - Diode compensation for good regulation
  - Easy design with off-the-shelf transformer
- **Support High Efficiency Forward Solution**
  - Support active-clamp forward topology
  - 92% efficiency for 5V/5A Output
- **Frequency Dithering to Improve EMI**
- 2A GATE and 0.8A SYNC Drivers
- Hiccup Protection for OLP, SCP, OVP, OTP
- QFN28-4mmx5mm Small Package

### Application Circuit



## 3.2, IEEE802.3bt PD solution- MP8030

### FEATURES

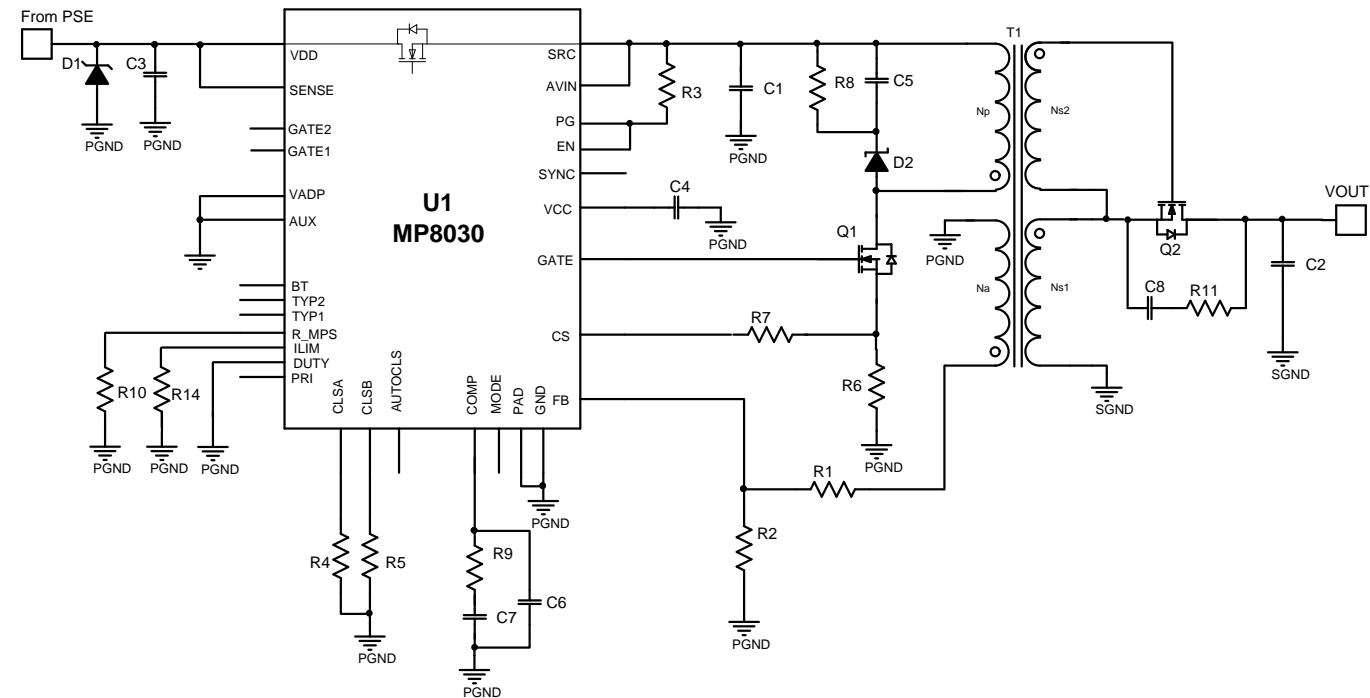
#### PD

- Compatible with 802.3af/at/bt specifications
- Integrate HV-MOS for <51W PD Design
- GATE1 for External FET in >51W Design
- **GATE2 NMOS Driver for Adaptor Supply**
- **Automatic Maintain Power Signature (MPS)**
- Support Automatic Classification

#### DCDC

- **Support Flexible Topology Design**
  - PSR Fly-back
  - SSR Fly-back
  - SSR Active-Clamp Forward
- 2A GATE and 0.8A SYNC Drivers
- 15ms Soft-start Time
- **EMI Reduction with Frequency Dithering**

### Application Circuit

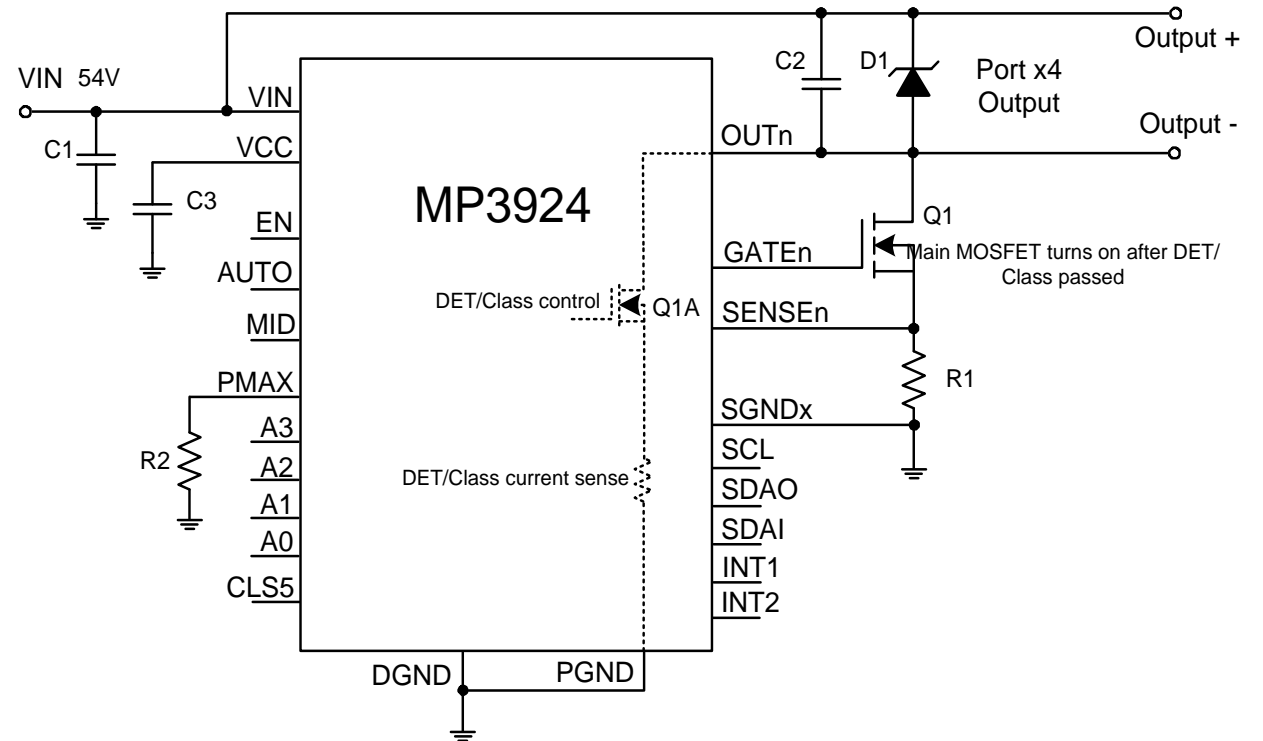


## 3.3, IEEE802.3at PSE solution- MP3924

### FEATURES

- IEEE802.3af/at Compliant
- Quad Port PSE Controller
- 0.25Ω Current Sense Resistor
- Automatic Mode and I2C Command Control Mode
- Auto Over Input Power Shutdown
- Internal VCC Power Supply
- 3-wire I2C Interface for Isolated Application
- Two INT Pins for Interrupt Priority Selection
- DC Load Disconnect Detection
- Thermal Protection

### Application Circuit



# 3.4, EA certification

## ➤ What is EA certification?

Authorized by [EA Alliance](#), the benefits will span across the entire PoE business ecosystem – including component manufactures, system vendors, and ultimately the customers. The benefits are summarized into 5 core categories:

1. Reducing Installation Time
2. Improving Customer Support at Lower Cost
3. Improving End-Customer Perception of PoE (and, thus, adoption)
4. Reducing Overall Evaluation Costs
5. Alleviating Additional Development Costs

## ➤ MPS Product with EA certification

<b>MP8009</b>	<b>EA Certificated, see link:</b> <a href="#">Certified Products   Ethernet Alliance PoE Certified Products (unh.edu)</a>
<b>MP8030</b>	<a href="#">Certified Products   Ethernet Alliance PoE Certified Products (unh.edu)</a>
MP8017	Under Process
MP3924	Under Process
More	.....

## PoE Certification Members



**Thank You!**

[www.monolithicpower.com](http://www.monolithicpower.com)