

PoE Design and MPS Star Product

MP8017– IEEE802.3af Solution

September, 2022

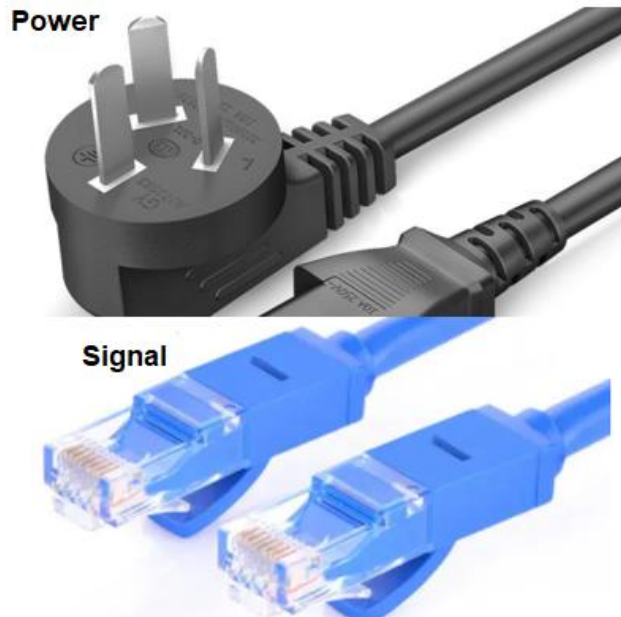


Content

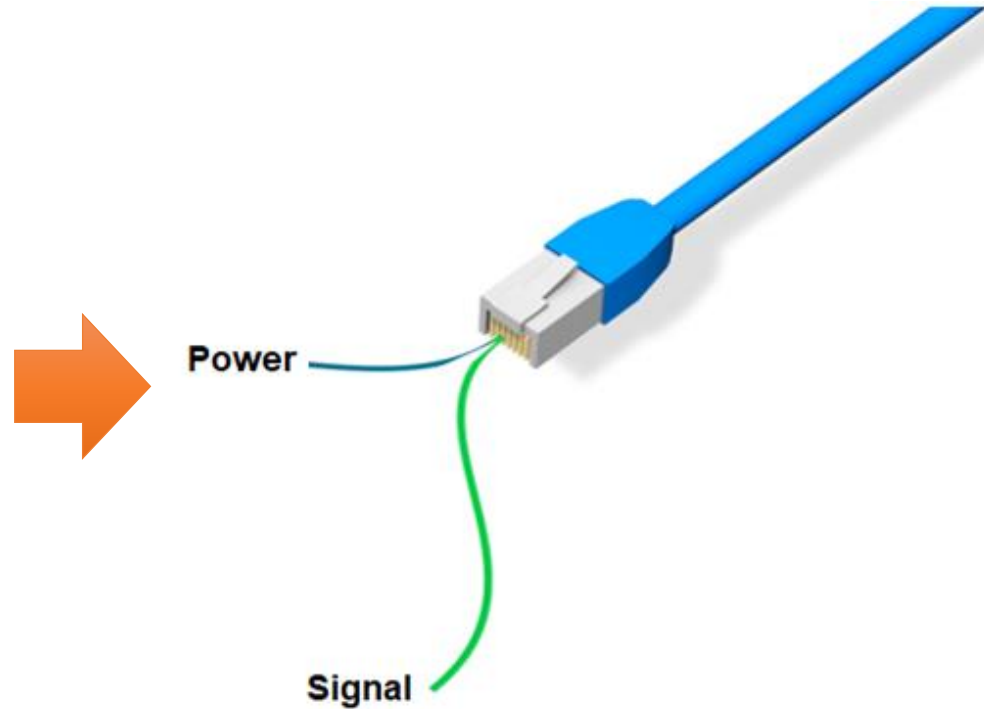
- **PoE Introduction**
 - A. What is PoE
 - B. PoE Power Ratings
 - C. PoE Protocol
- **MPS Star PoE PD Solution**
 - A. Pain Points of PoE Design
 - B. How to Design a Optimized PoE Power
 - C. MP8017- IEEE802.3af Solution
- **MPS Other PoE Solutions**
 - A. MPS PD at Solution
 - B. MPS PD bt Solution
 - C. MPS PSE Solution

What is PoE?

Power **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



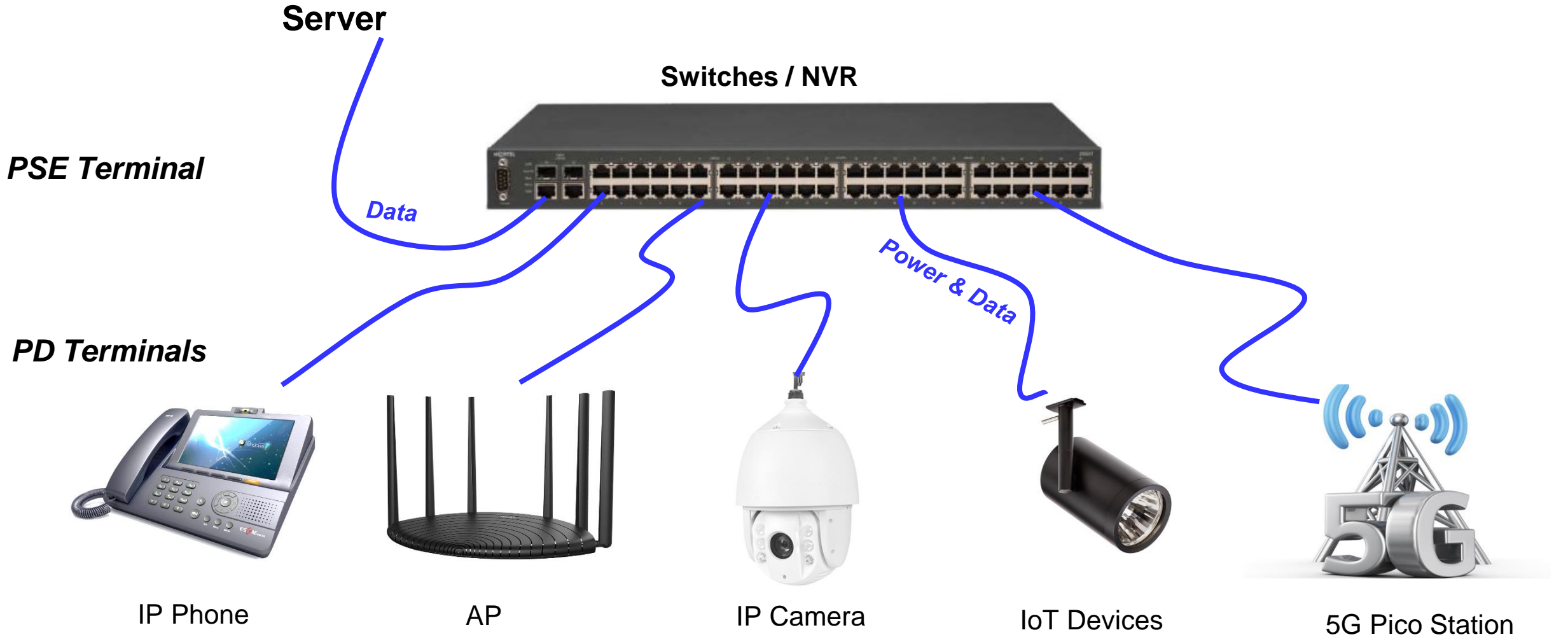
✓ Low Cost

✓ 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)

Standard	802.3 af				802.3 at	802.3 bt			
Class	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Type	1	1	1	1	2	3	3	4	4
PSE Output power	15.4W	4W	7W	15.4W	30W	45W	60W	75W	90W
PSE Output Voltage	44V – 57V				50V – 57V	50V/52V – 57V			
PD Input Power	13W	3.84W	6.49W	13W	25.5W	40W	51W	62W	71.3W
PD Input Voltage	37V – 57V				42.5V – 57V	41V – 57V			

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

at. PoE Power Ratings



2009

30W

IEEE 802.3at (POE+)

Standard	802.3 af				802.3 at	802.3 bt			
Class	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Type	1	1	1	1	2	3	3	4	4
PSE Output power	15.4W	4W	7W	15.4W	30W	45W	60W	75W	90W
PSE Output Voltage	44V – 57V				50V – 57V	50V/52V – 57V			
PD Input Power	13W	3.84W	6.49W	13W	25.5W	40W	51W	62W	71.3W
PD Input Voltage	37V – 57V				42.5V – 57V	41V – 57V			

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

bt. PoE Power Ratings



2018

90W

IEEE 802.3bt (POE++)

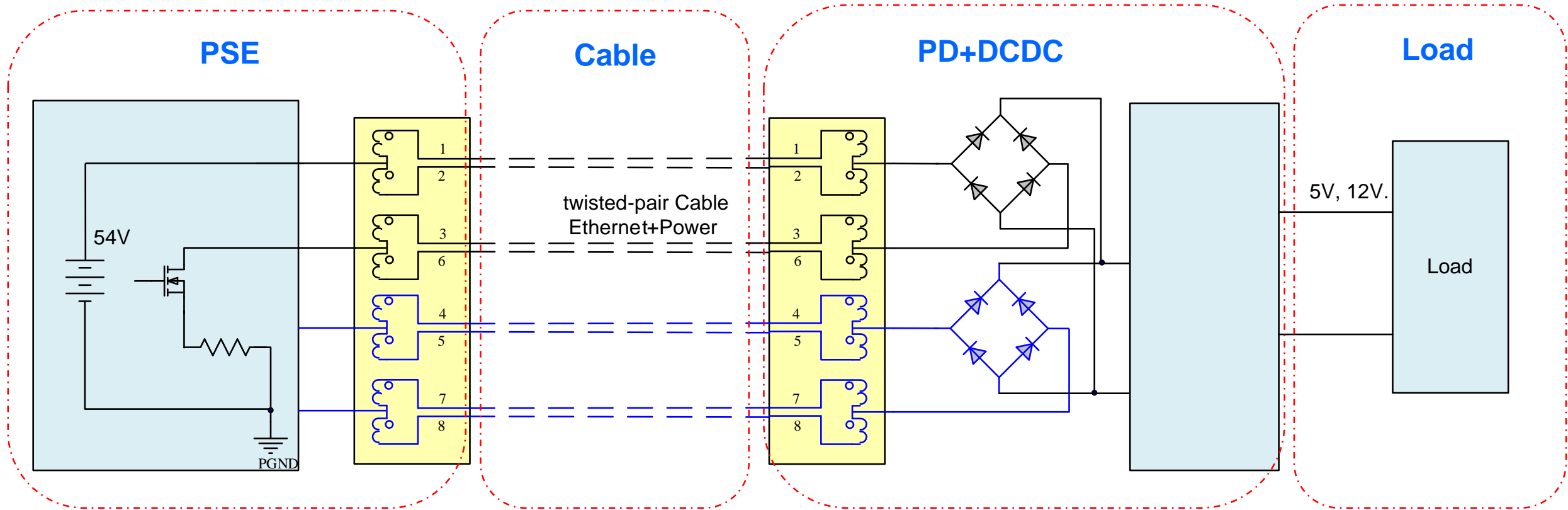
Standard	802.3 af				802.3 at	802.3 bt			
	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Class	1	1	1	1	2	3	3	4	4
Type	1	1	1	1	2	3	3	4	4
PSE Output power	15.4W	4W	7W	15.4W	30W	45W	60W	75W	90W
PSE Output Voltage	44V – 57V				50V – 57V	50V/52V – 57V			
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PD Input Voltage	37V – 57V				42.5V – 57V	41V – 57V			

IEEE802.3bt include Typ3 and Type 4 PoE, which supports class 5~8 and 802.3at.



PoE Protocol- Structure

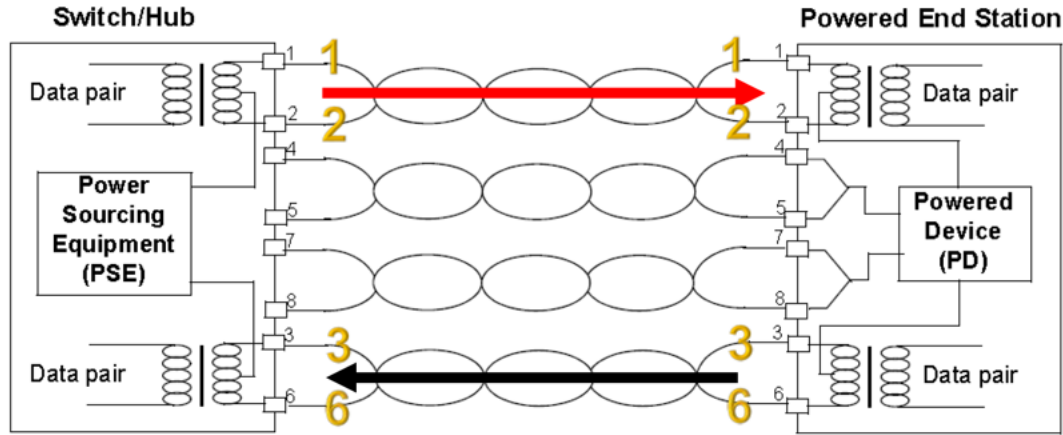
➤ Power Structure



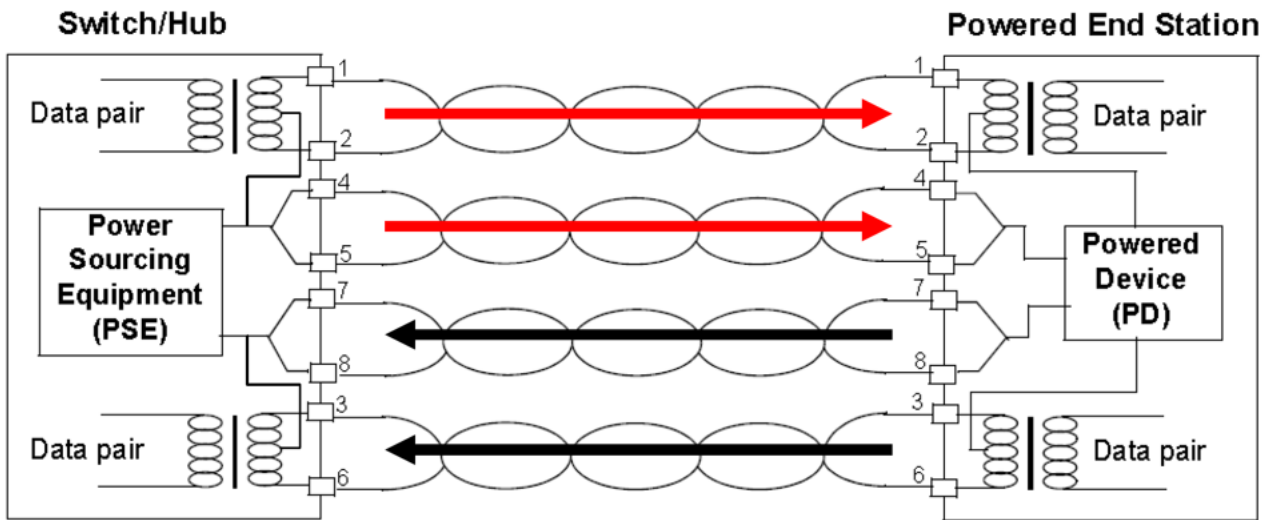
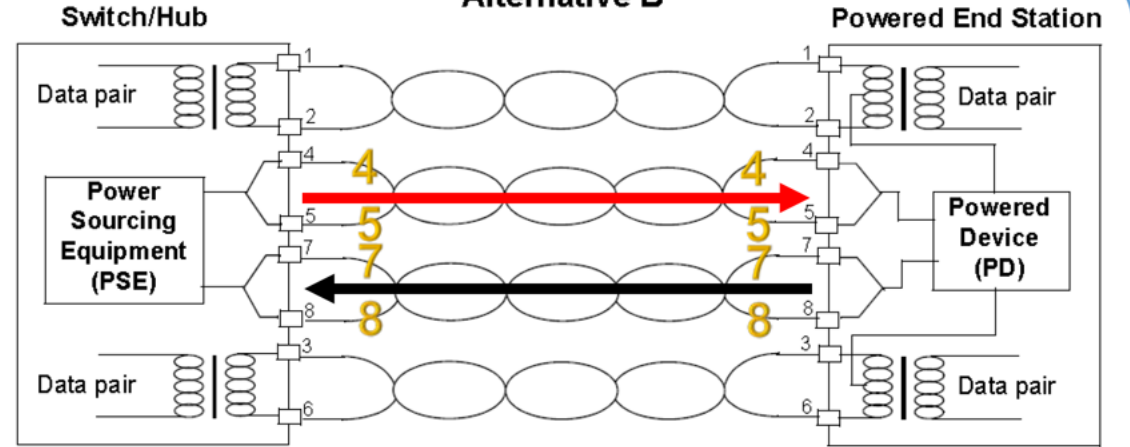
A PoE system always includes this 4 portions.

POE Protocol- Connection

Alternative A



Alternative B

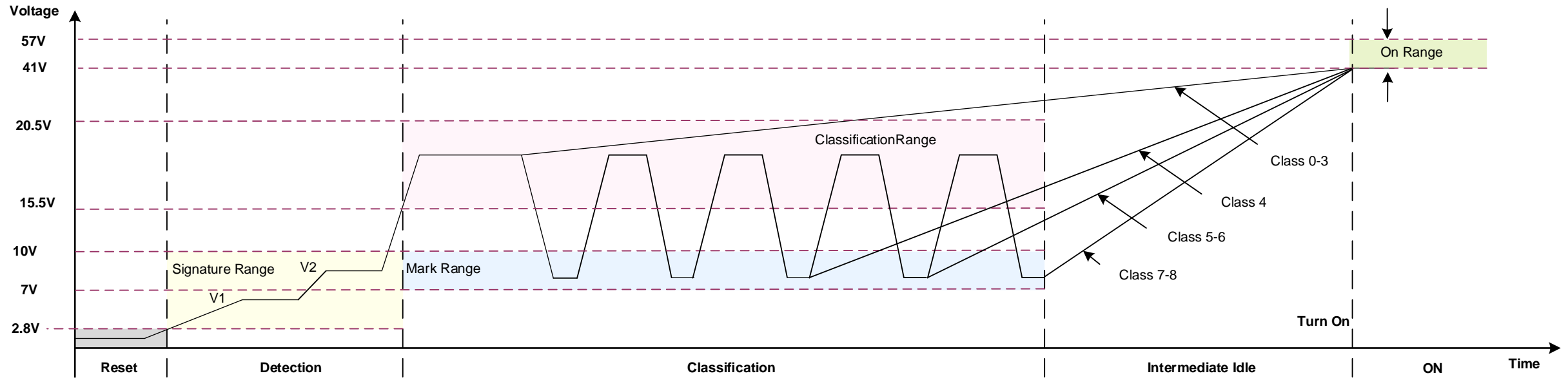


Note:

- 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?

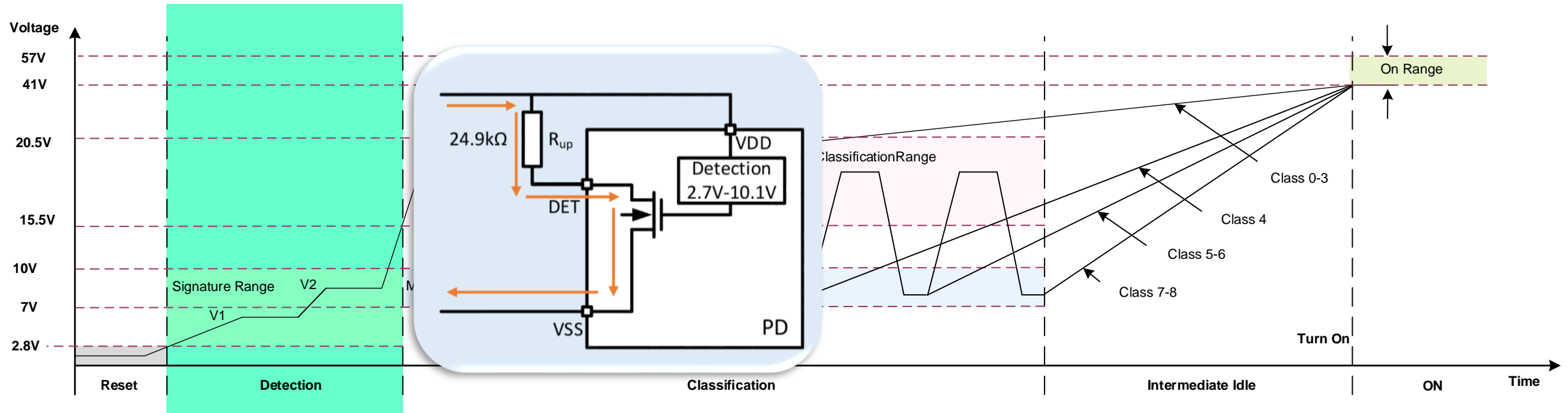


Power on



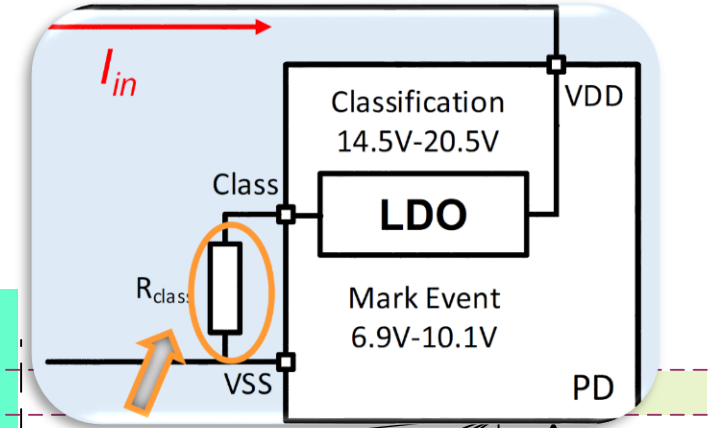
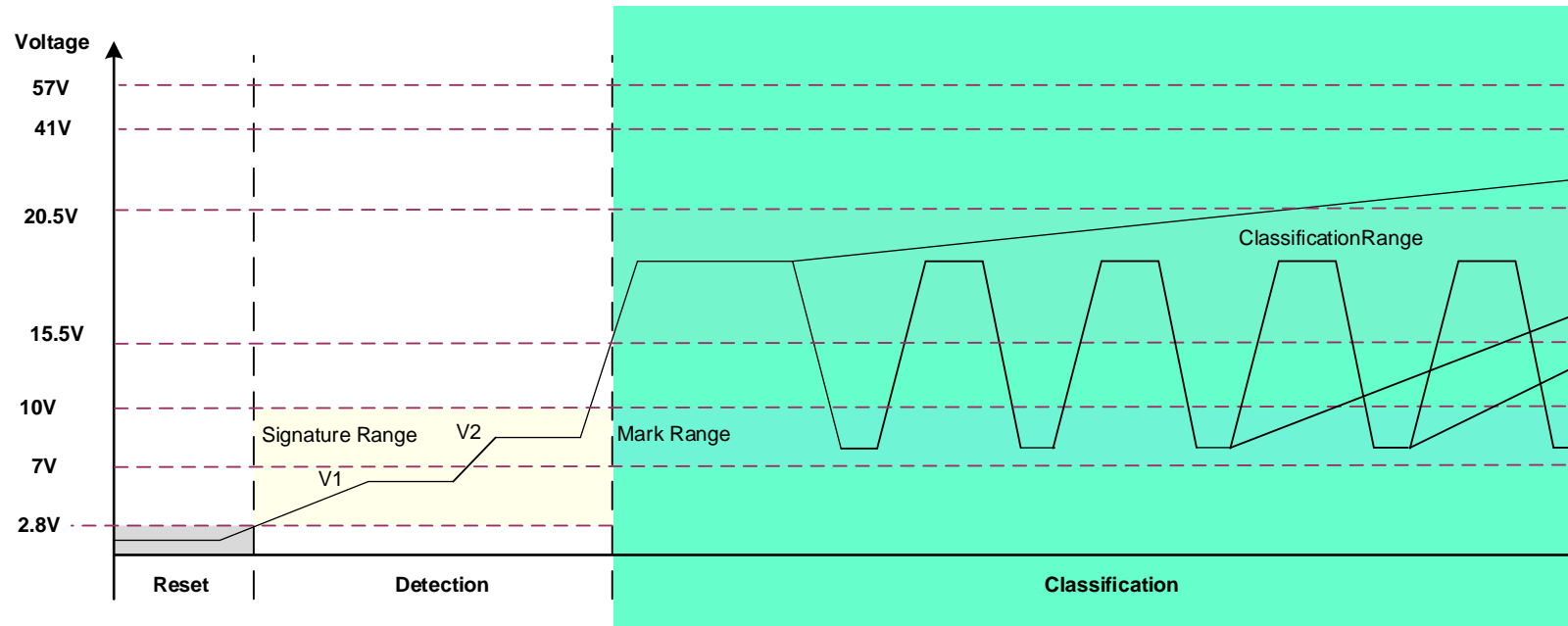
Stabilize and monitor

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.

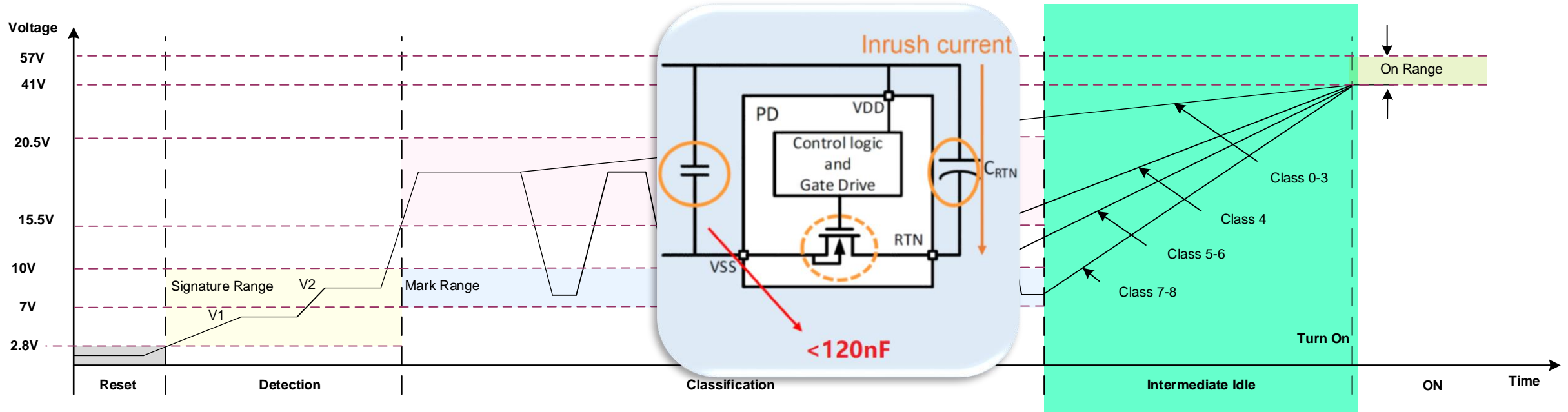
POE Protocol- Classification



PD Class	Class Cycles	1, 2 Cycle Current(mA)	3, 4, 5 Cycle Current(mA)
0	1	1~4	-
1	1	9~12	-
2	1	17~20	-
3	1	26~30	-
4	2 or 3	36~44	36~44
5	4	36~44	1~4
6	4	36~44	9~12
7	5	36~44	17~20
8	5	36~44	26~30

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

POE Protocol- Power On

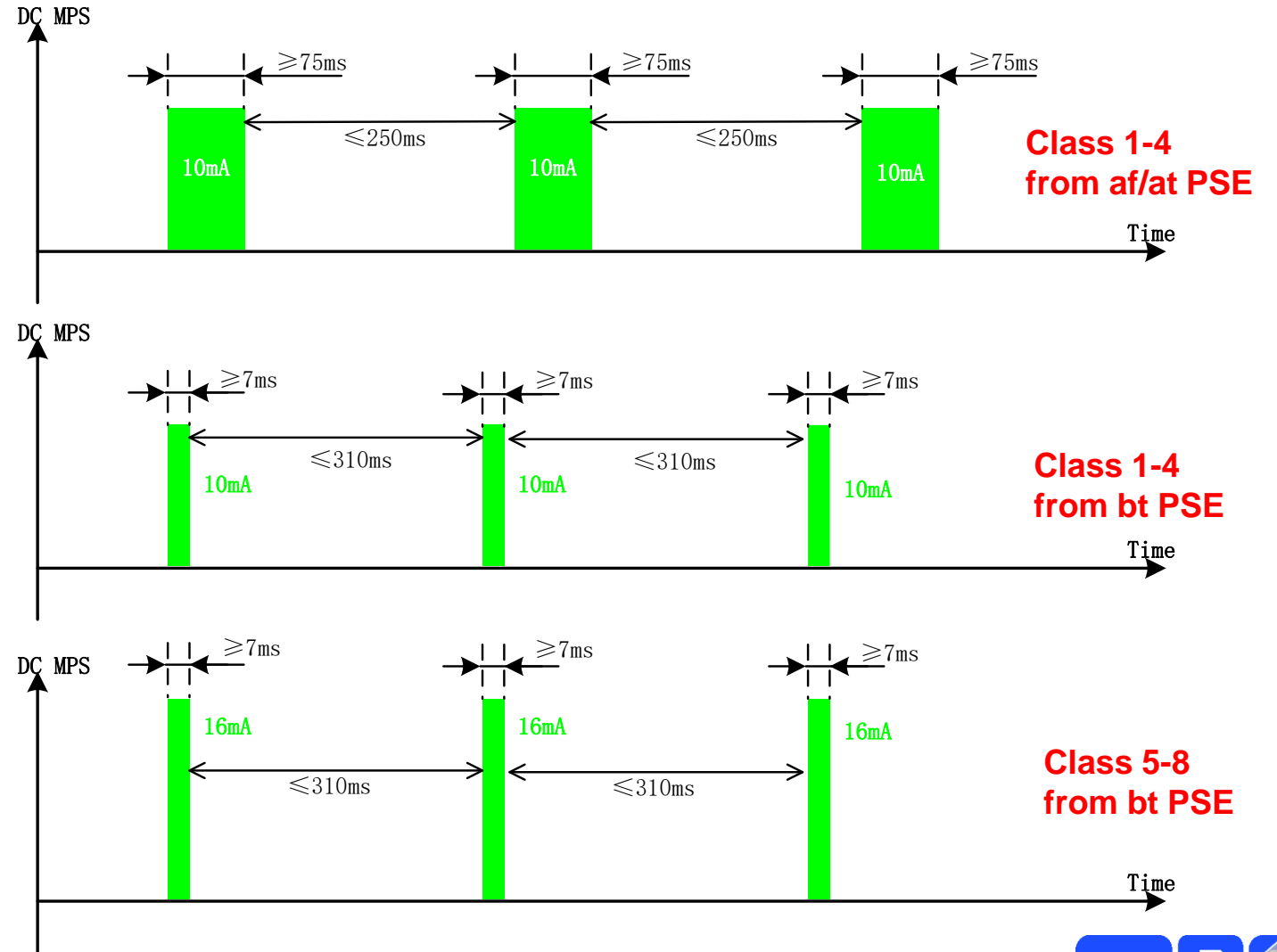


1. The PD input capacitor is $<120nF$, need a hot-swap MOSFET to isolate the big output capacitor.
2. After power on, the hot-swap MOSFET limits the current to charge output capacitor.

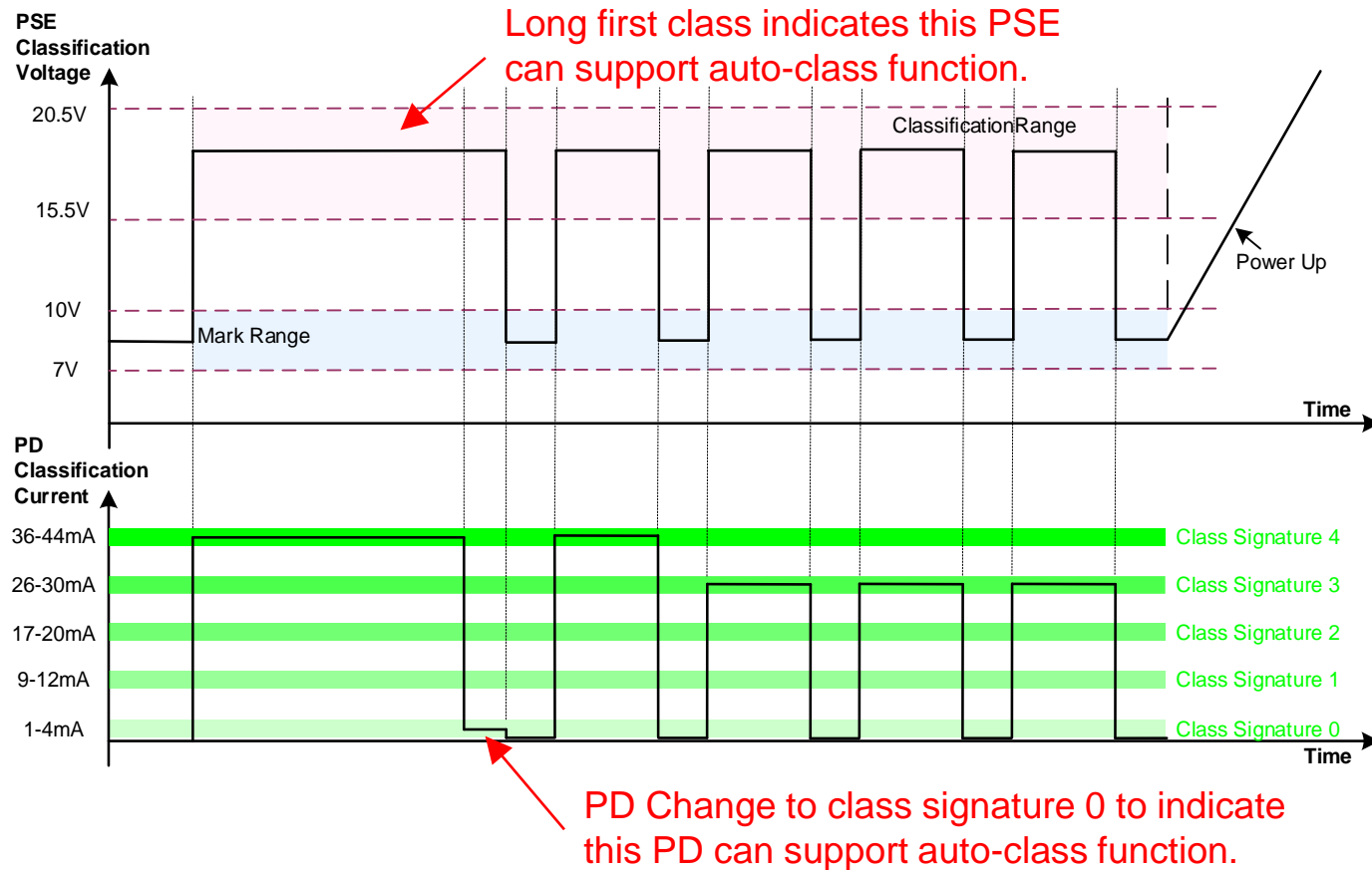
POE Protocol- Maintain Power Signature



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

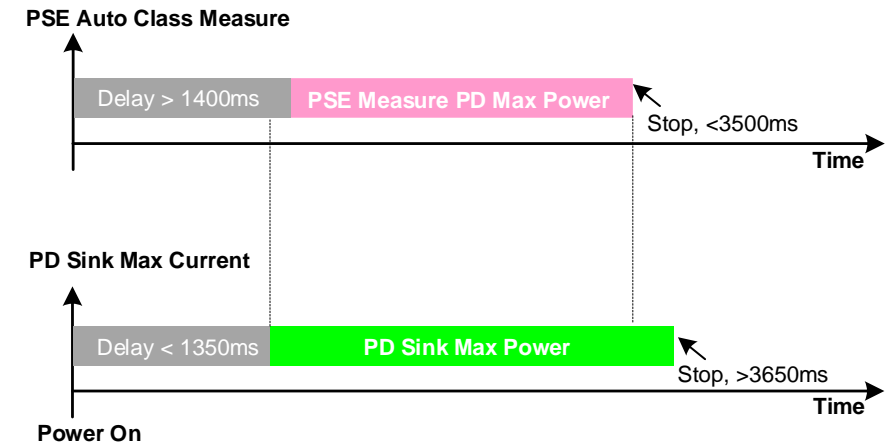


POE Protocol- IEEE 802.3bt Auto Classification



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.



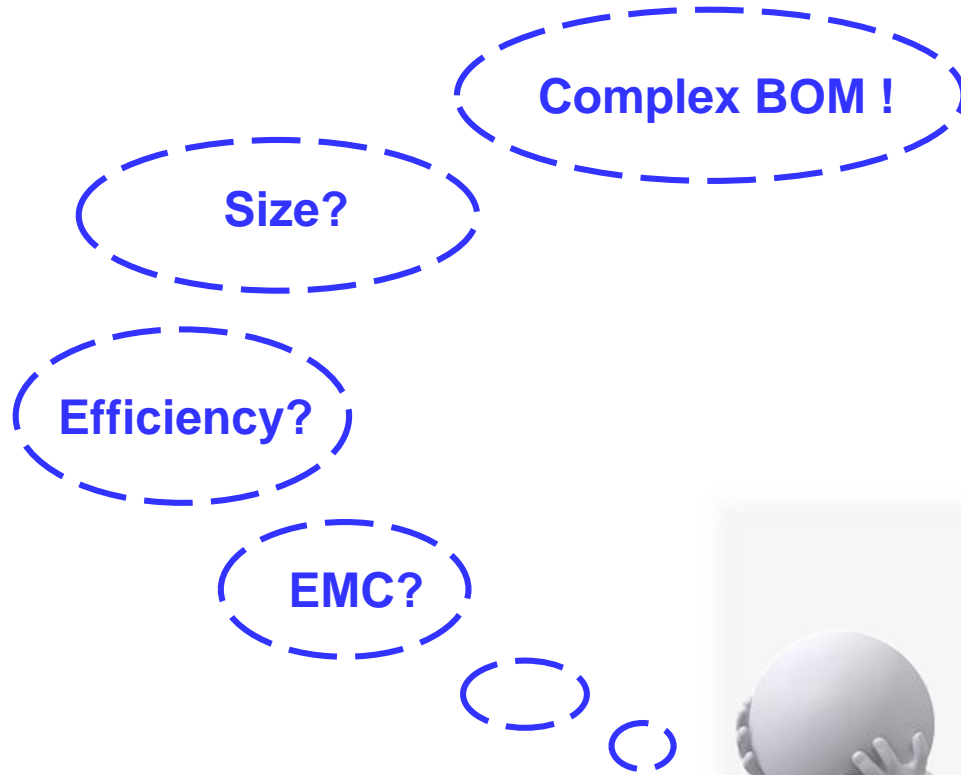
Auto Class Measure Time



Content

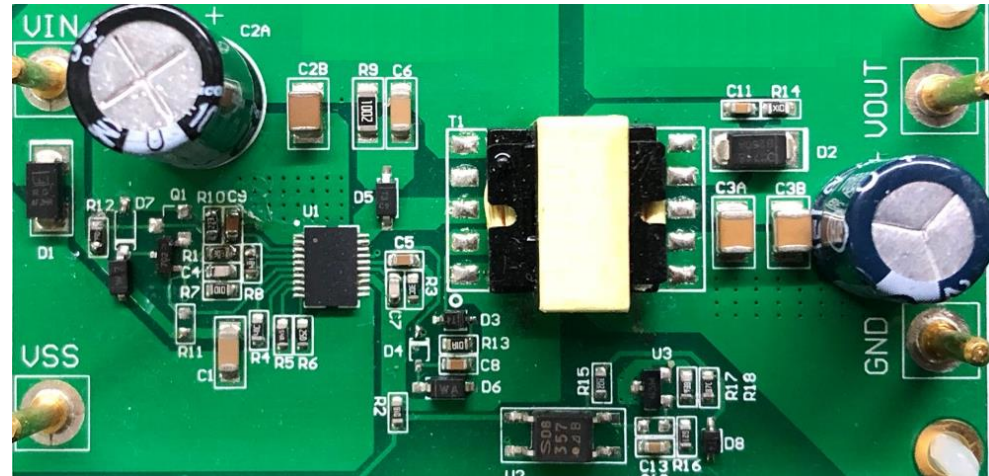
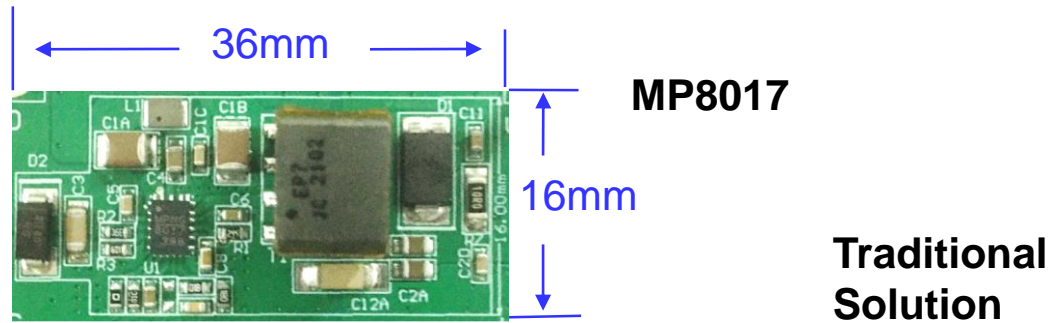
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 - C. MPS PSE Solution

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**

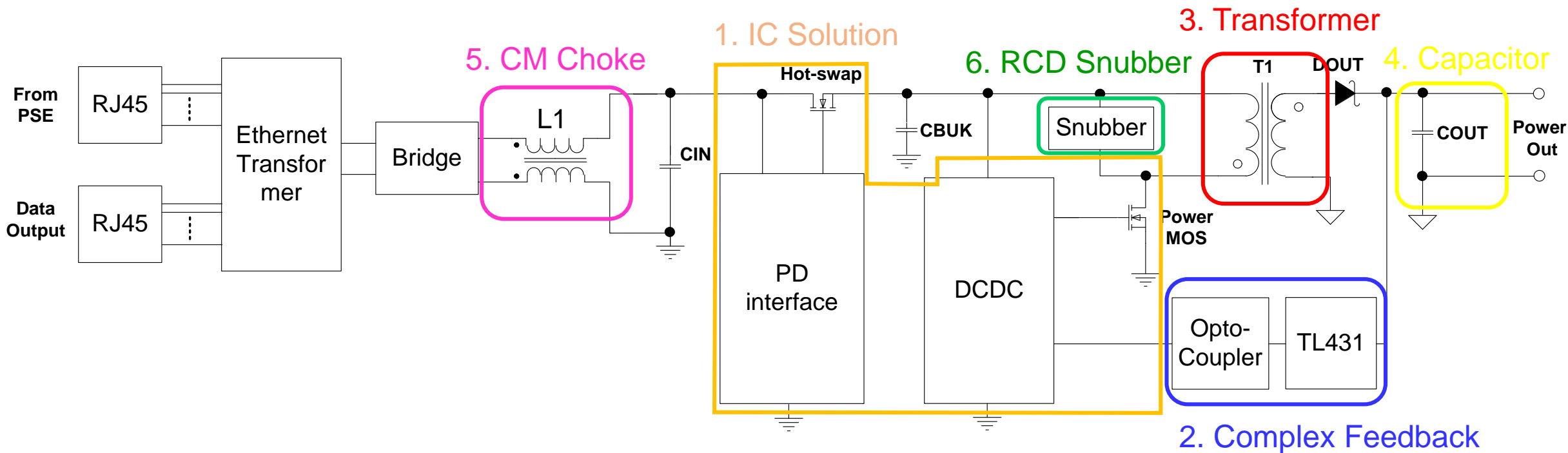
✓ **EP7 Transformer for 12W**

✓ **Small Input/Output Capacitor**

✓ **Good EMI without Common Choke**

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

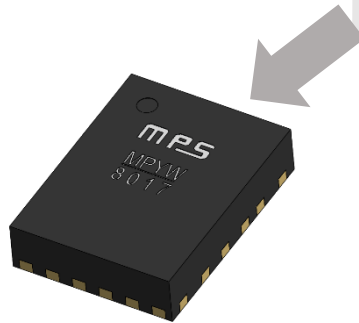
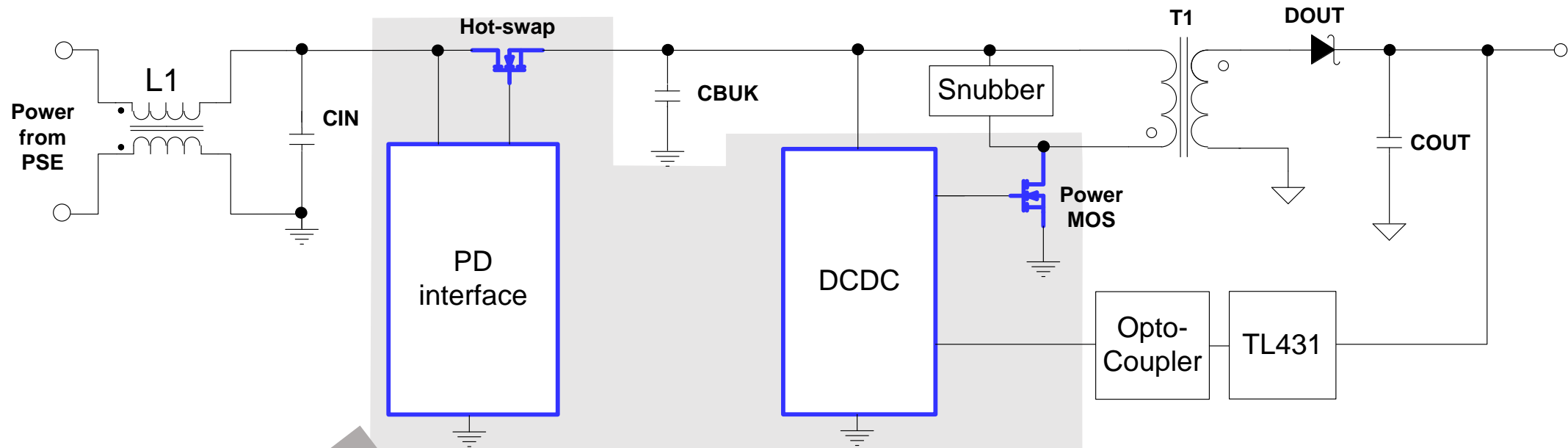
2, Design a Compact Solution



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

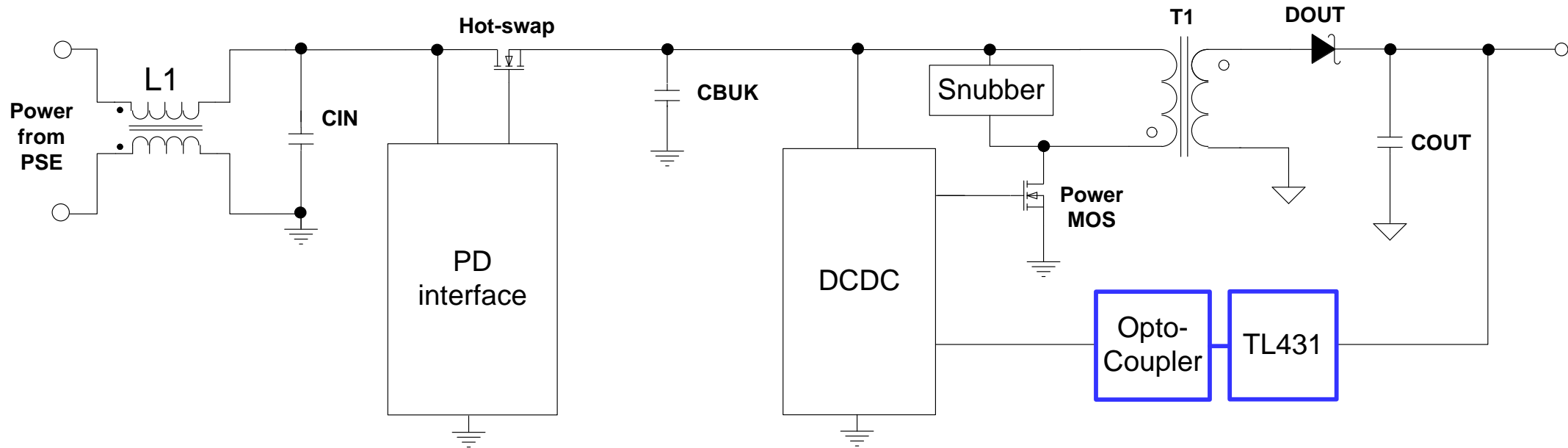
Pain Points

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?

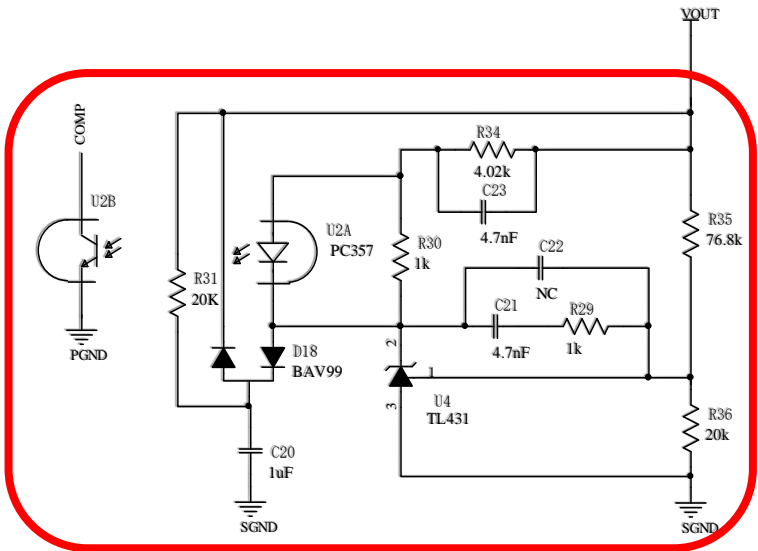


Pain Points

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.

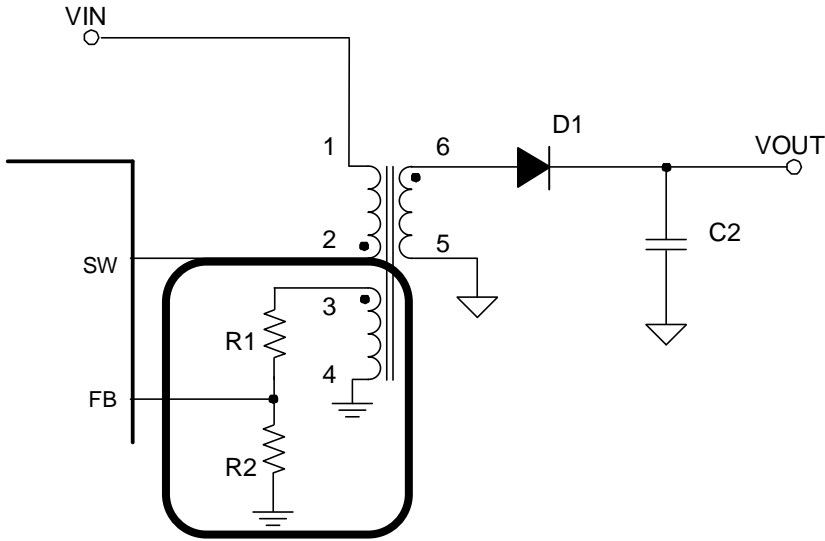
2.2, Does the Converter offer PSR feedback?

Traditional SSR Feedback



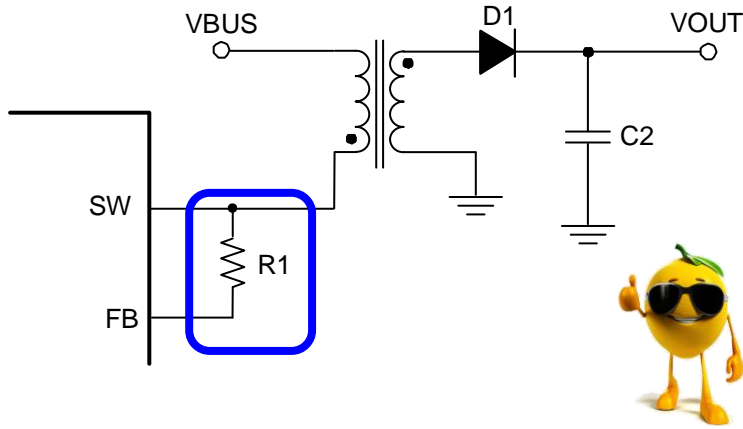
Complex TL431 / Opto-coupler

Traditional PSR Feedback



Aux-winding + FB divider resistors

MP8017 SW Feedback



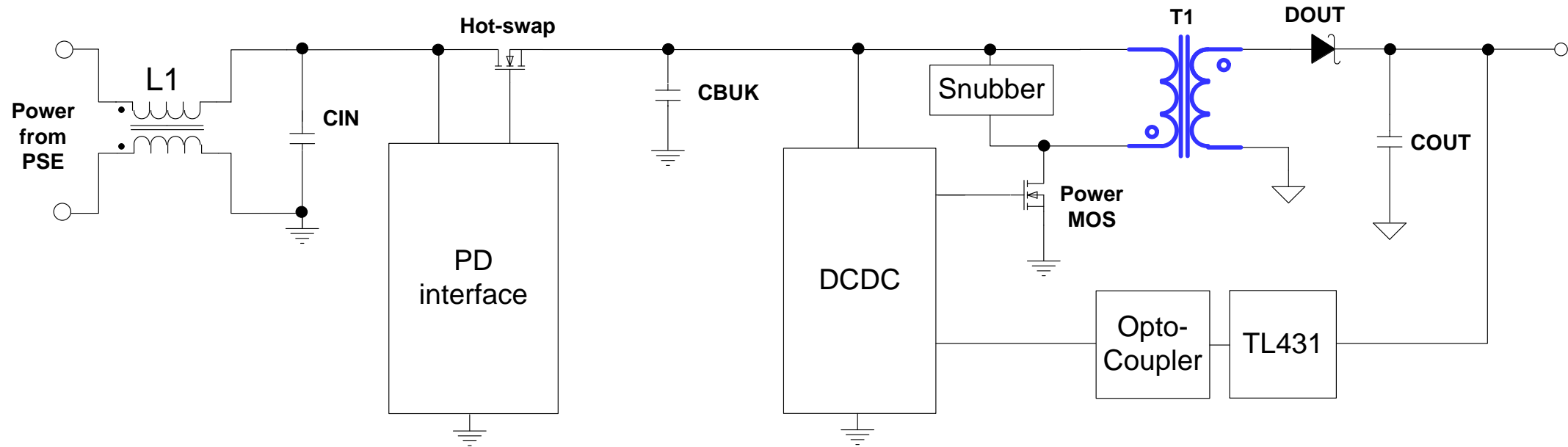
Only one resistor



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

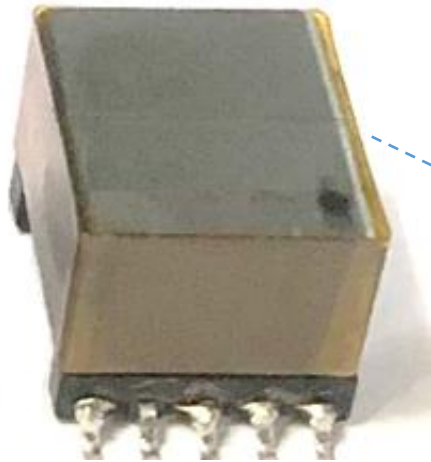


Pain Points

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

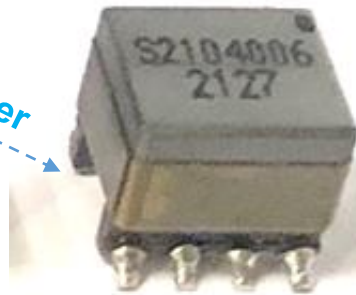
2.3, How to reduce the Transformer Size

EP13 Transformer



17.7x13.5x12.3mm

EP7 Transformer



9.5x8.9x11mm

MP8017 12W

Size is 300% smaller

MP8017 Advantages:

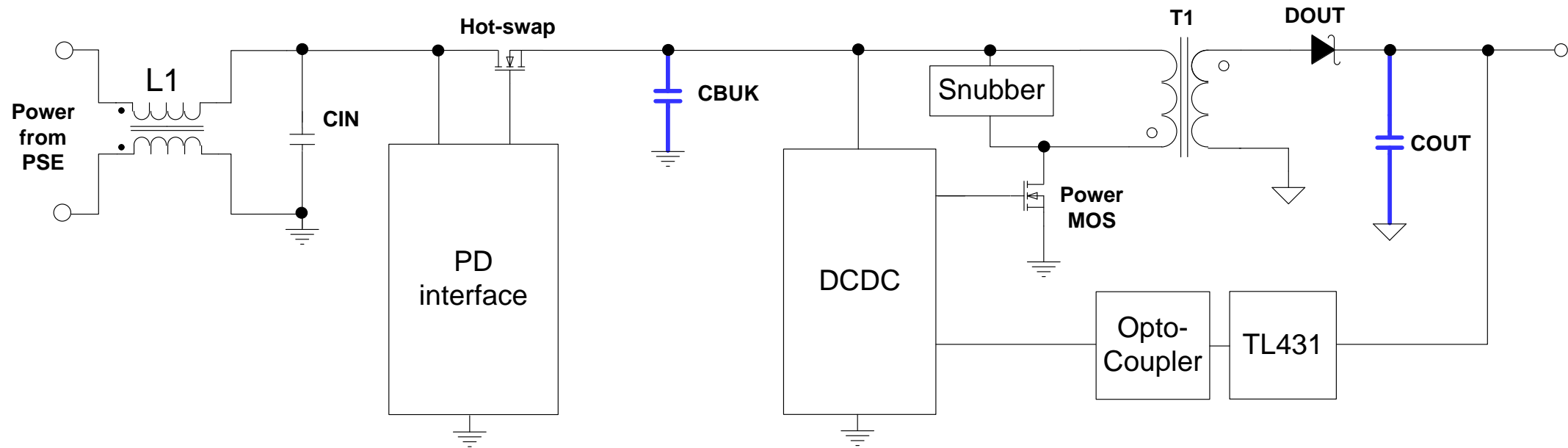
- ✓ Fewer winding without aux-winding.
- ✓ Fewer winding turns with up to 650KHz frequency.

Fewer Winding

High Frequency
250KHz → 650KHz

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

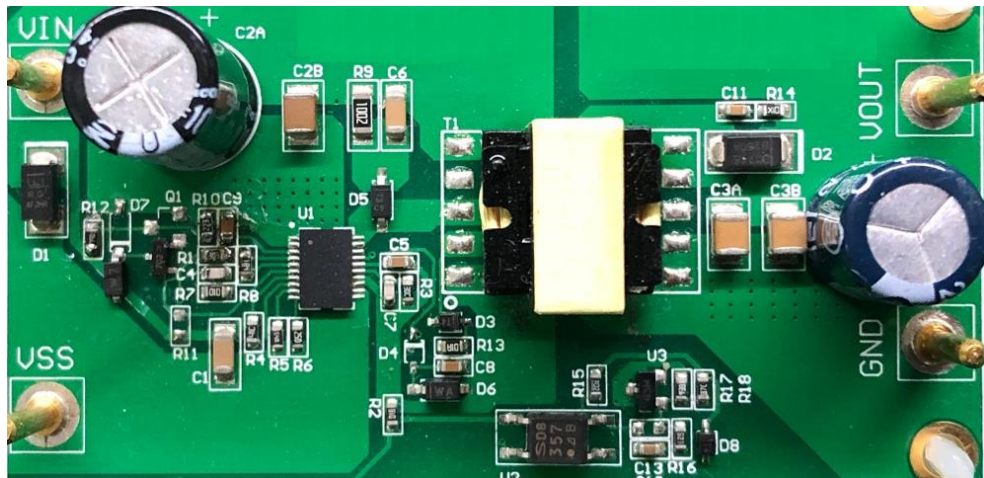
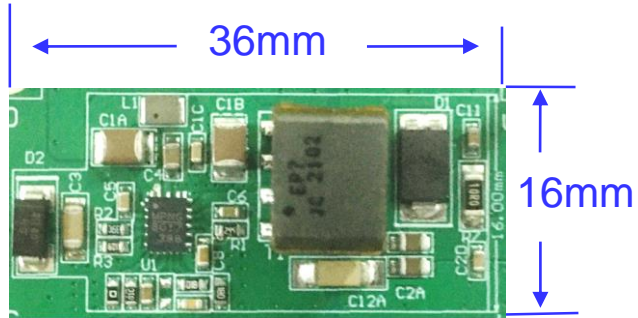
2.4, How to reduce Input/Output Cap.



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

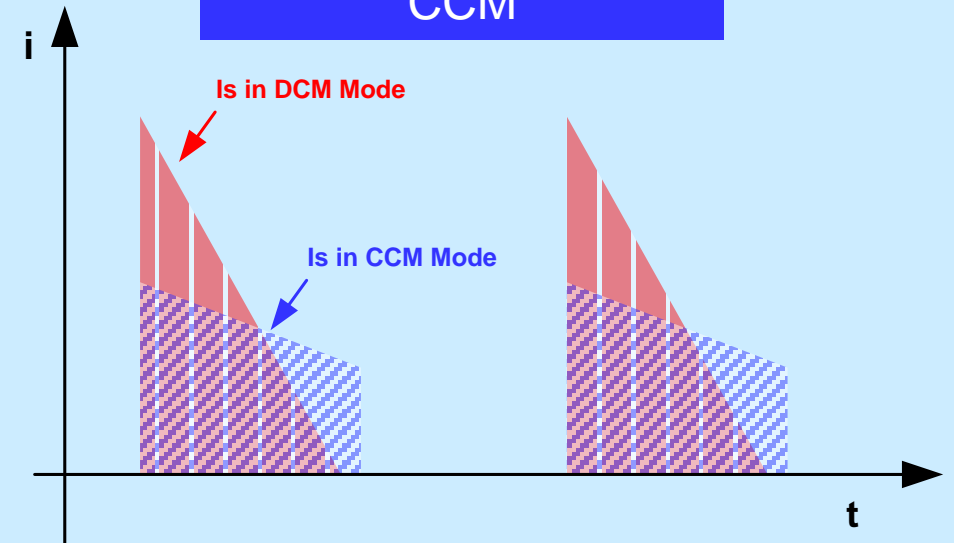
VIN ripple

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

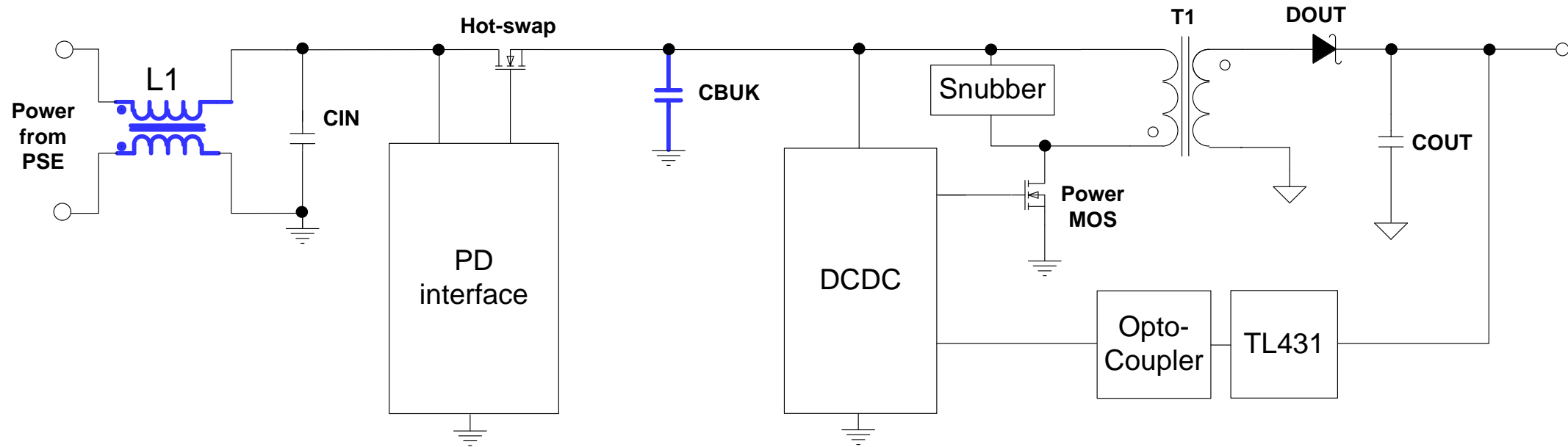
VOUT ripple

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

CCM



2.5, Hard to Pass EMI test?

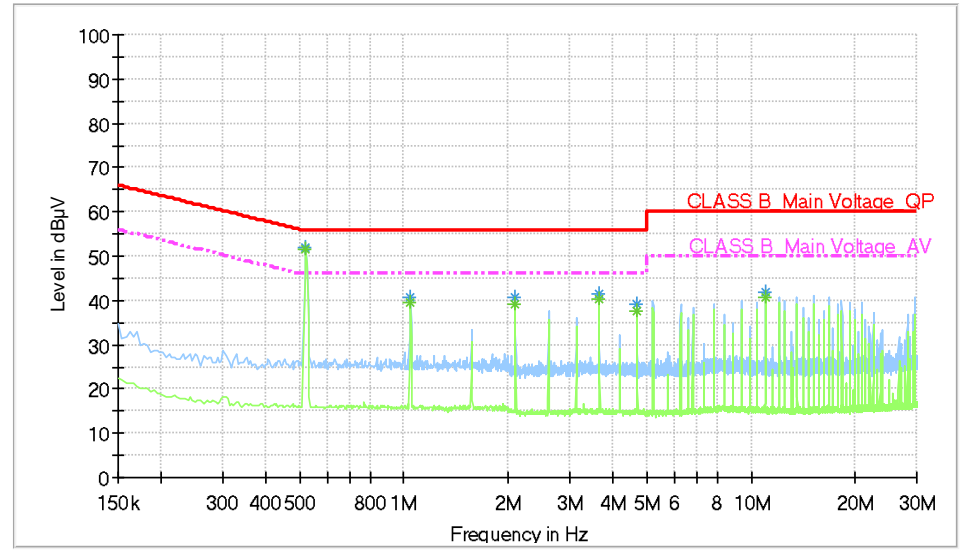
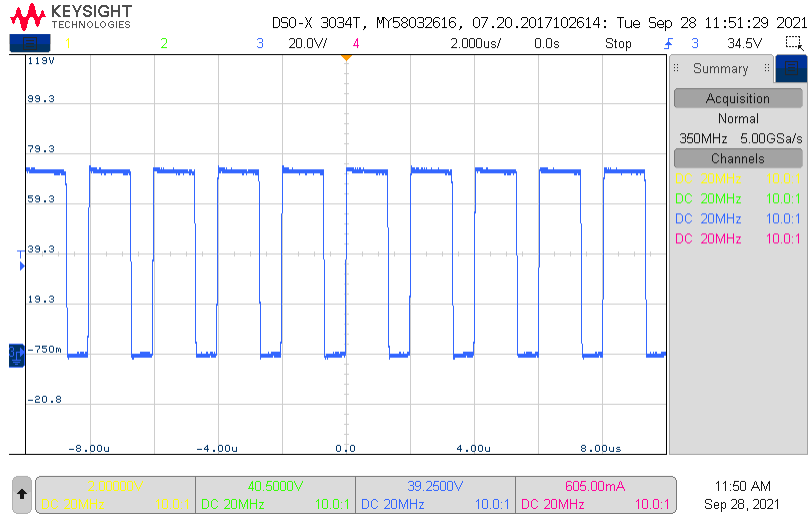


Pain Points

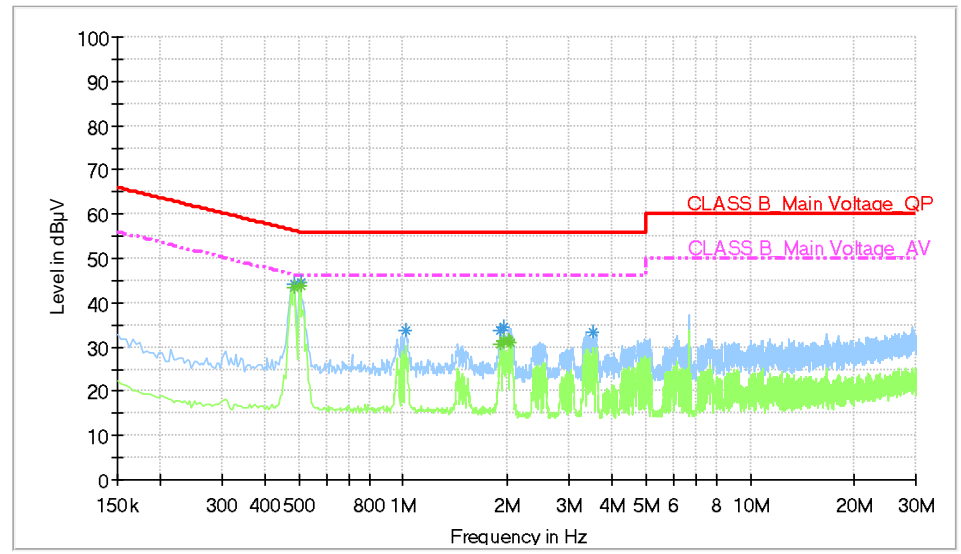
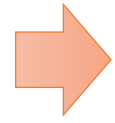
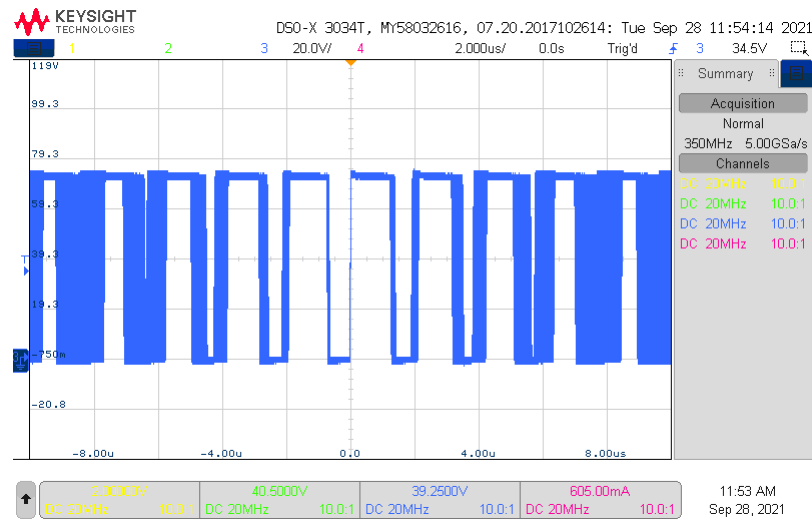
- 1. Hard to tune EMC performance.
- 2. CM choke increases cost and solution size.

2.5, Hard to Pass EMI test?

No Frequency Dither



MP8017 Frequency Dither



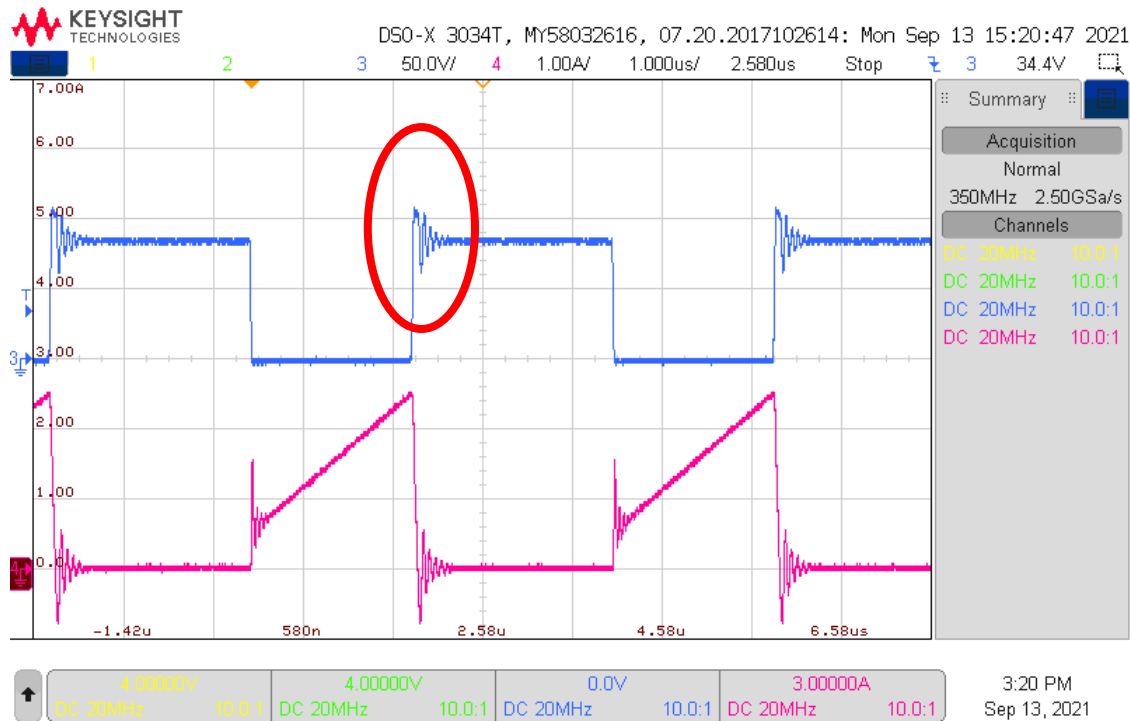
MP8017 Advantages:

- ✓ 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

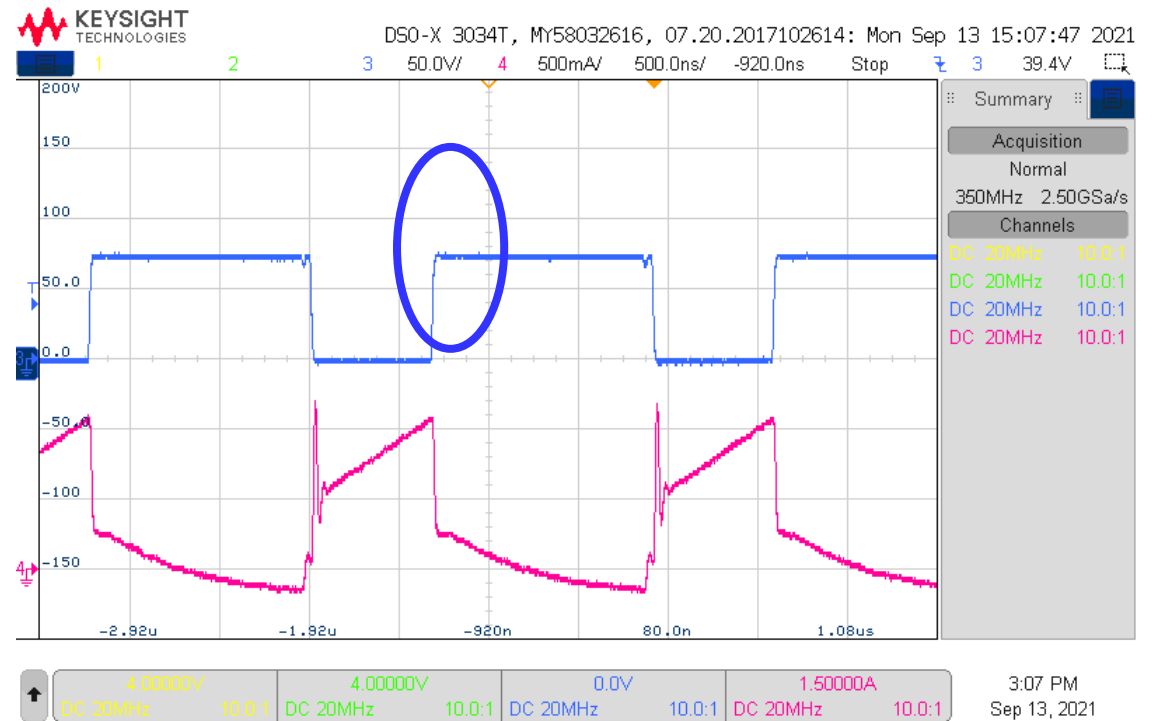


2.5, Hard to Pass EMI test?

Normal SW



MP8017 SW

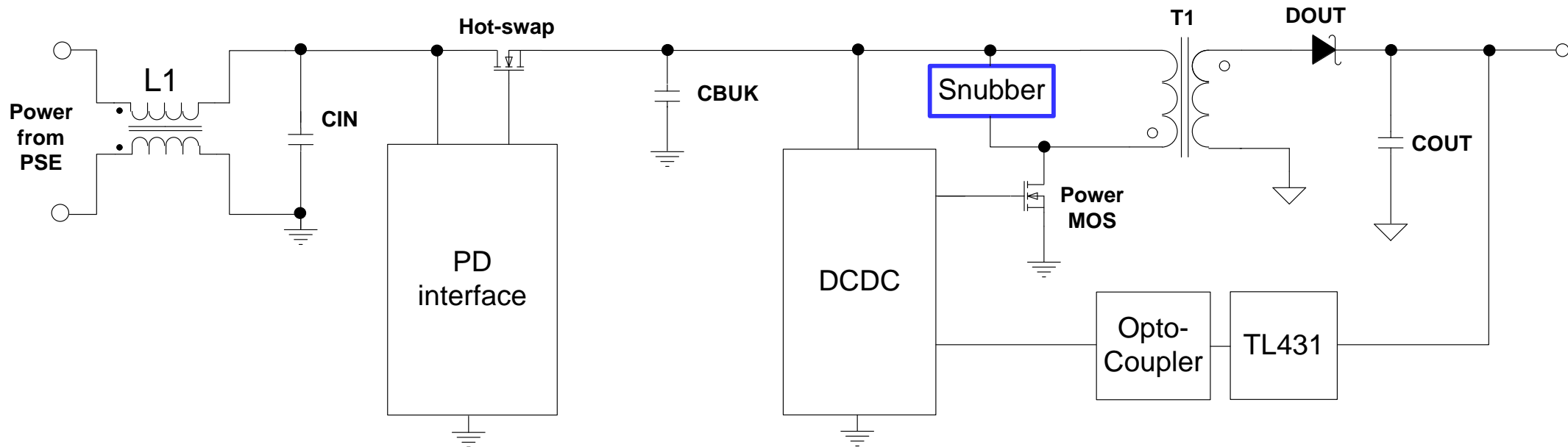


MP8017 Advantages:

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



2.6, Advance Snubber Design.

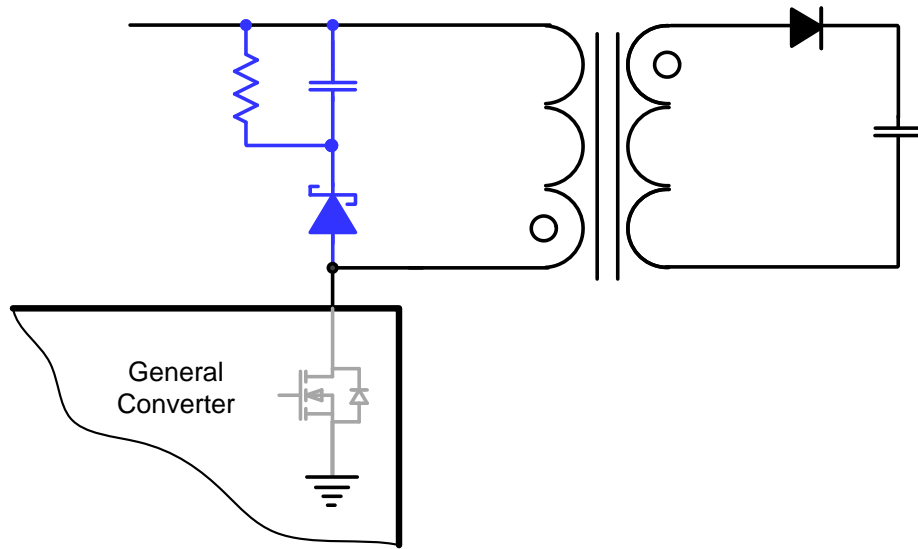


Pain Points

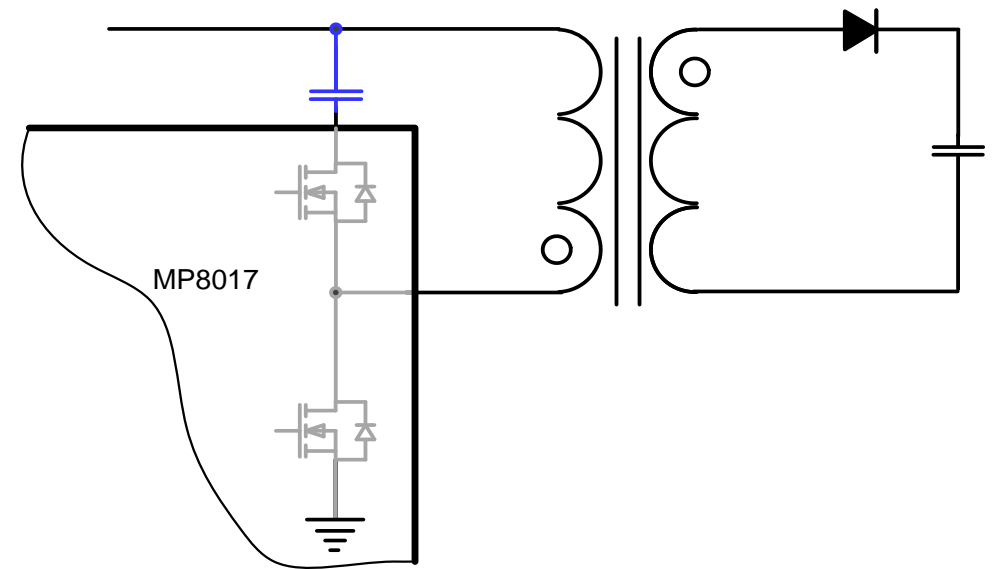
1. RCD clamp circuit increases layout area.
2. RCD clamp circuit consumes leakage inductance energy. which decreases efficiency and increases temperature.
3. Hard to layout in small loop.

2.6, Advance Snubber Design.

General Converter



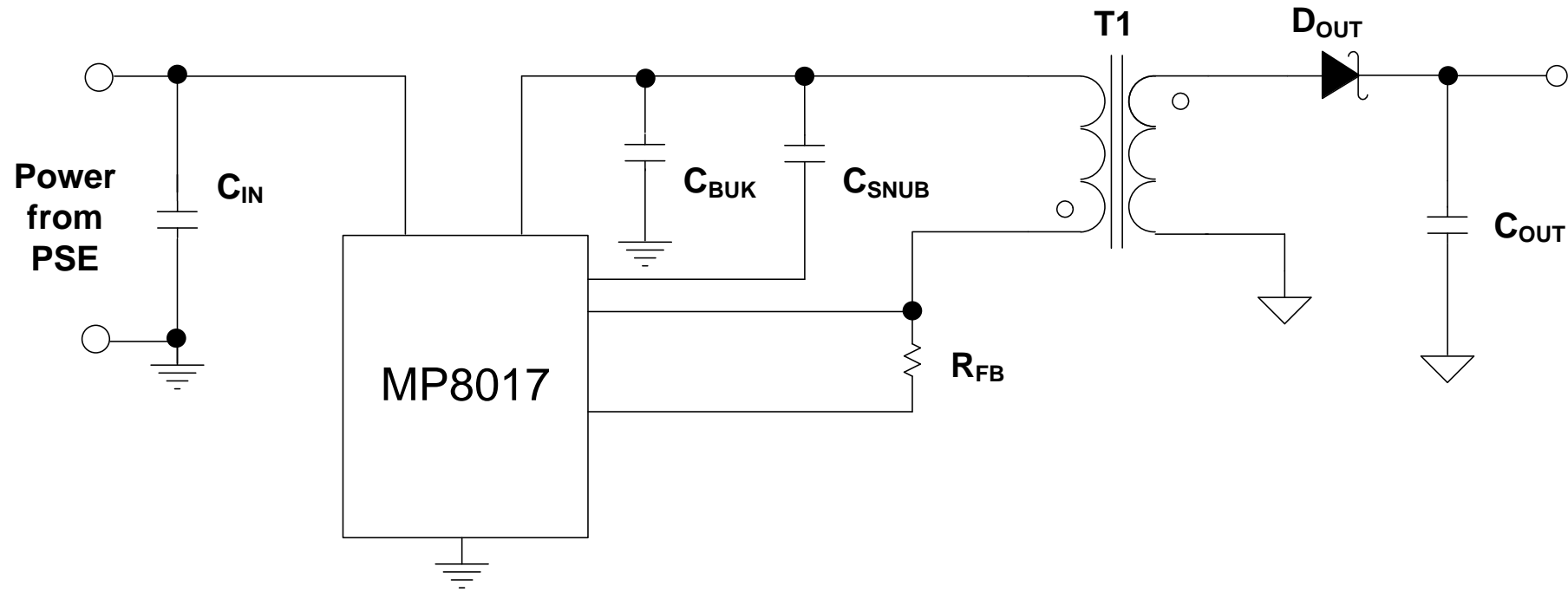
MP8017



MP8017 Advantages:

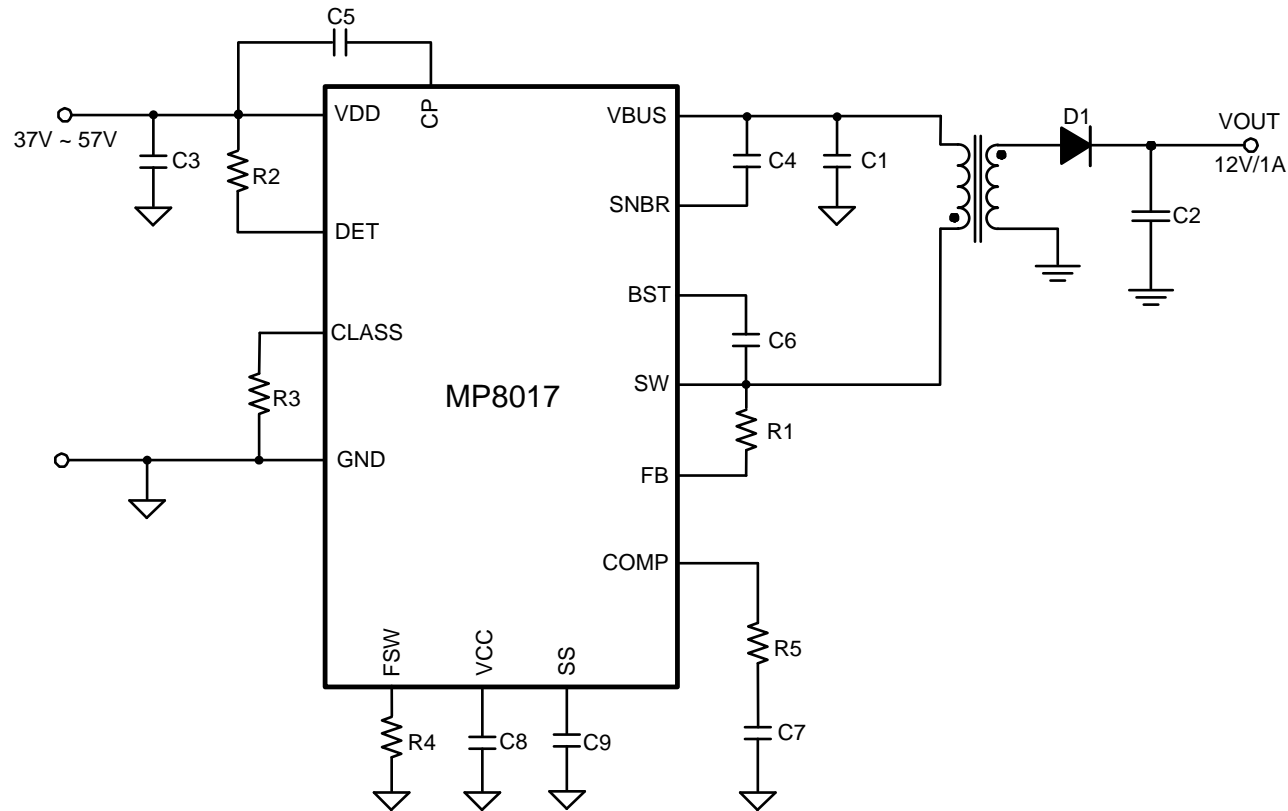
- ✓ Snubber only need a C instead of RCD.
- ✓ Leakage inductor energy can transfer to output, which improves efficiency.
- ✓ Smaller loop for highly impact solution.

MP8017 Ultra Miniature Design

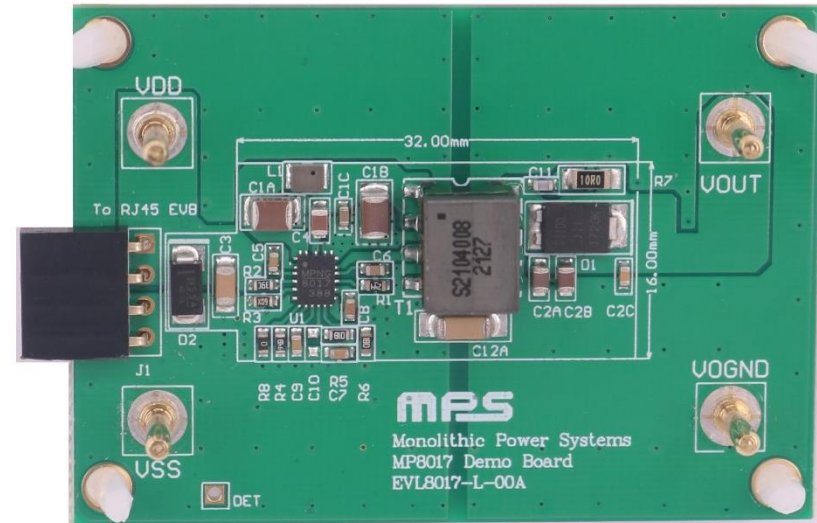


MP8017 Ultra Miniature Design

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.



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3.1, IEEE802.3at PD solution- MP8009

FEATURES

High Integration

- PD controller + PD FET + flyback controller

Flexible Design

- Support both flyback and active clamp forward
- Support both PSR flyback and SSR flyback
- Frequency dithering for EMI optimization

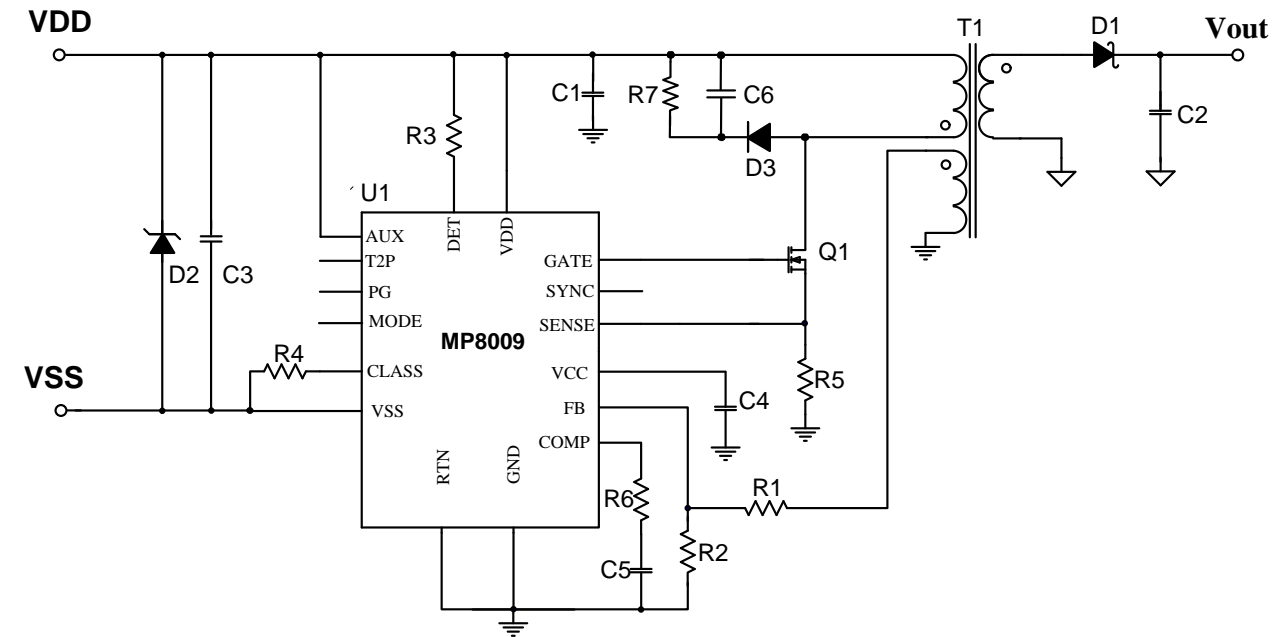
Compatible with 802.3at

- Ethernet Alliance Certified

Small Package

- QFN28-4mmx5mm

Application Circuit



PSR-Flyback simplify the design w/o opto-coupler.

3.2, IEEE802.3bt PD solution- MP8030

FEATURES

High Integration

- All in One Design:
- ✓ PD controller + PD FET + forward controller
- ✓ Support class 1~8 all .BT power range

Flexible Design

- NMOS replacing diode for >70W adaptor ORing
- Support both flyback and active clamp forward
- Frequency dithering for EMI optimization

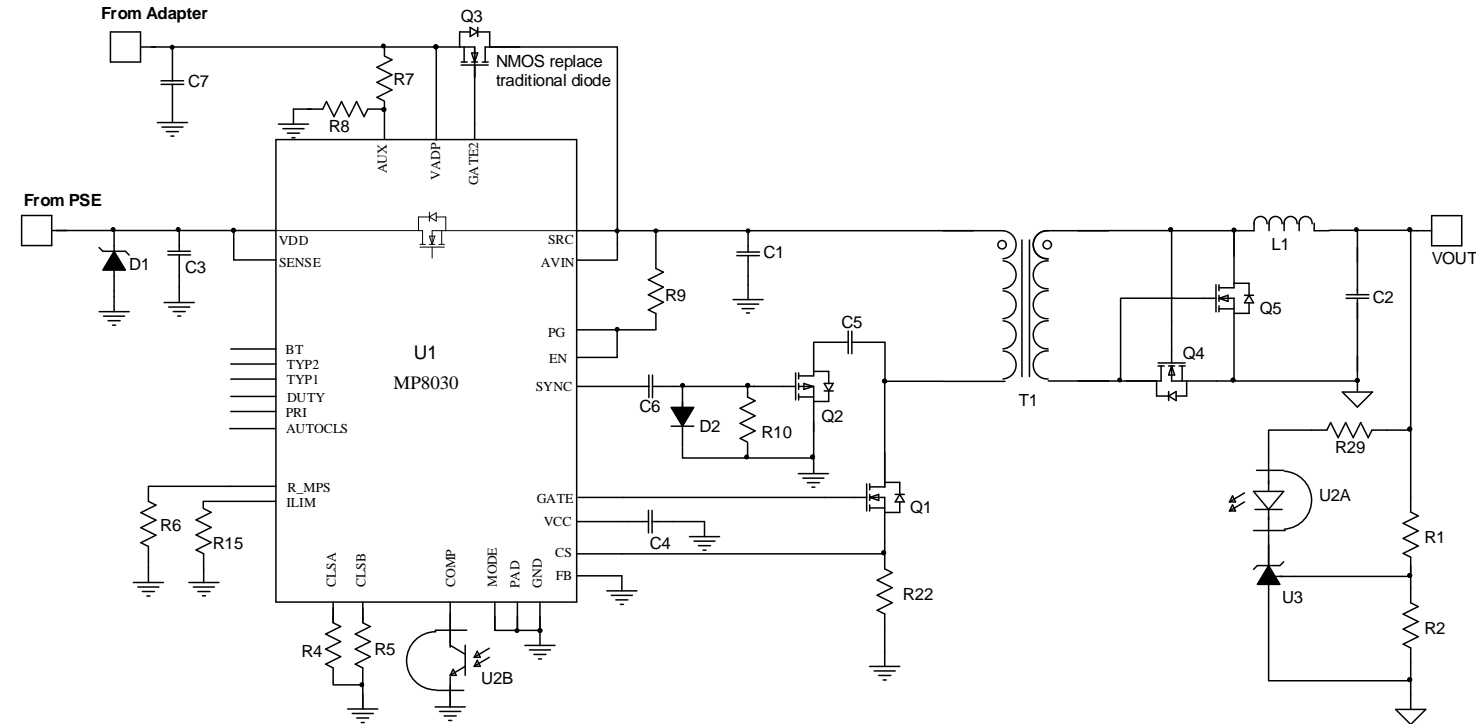
Compatible with 802.3bt

- Ethernet Alliance (EA Gen 2) Certified

Small Package

- QFN32-5mmx6mm

Application Circuit



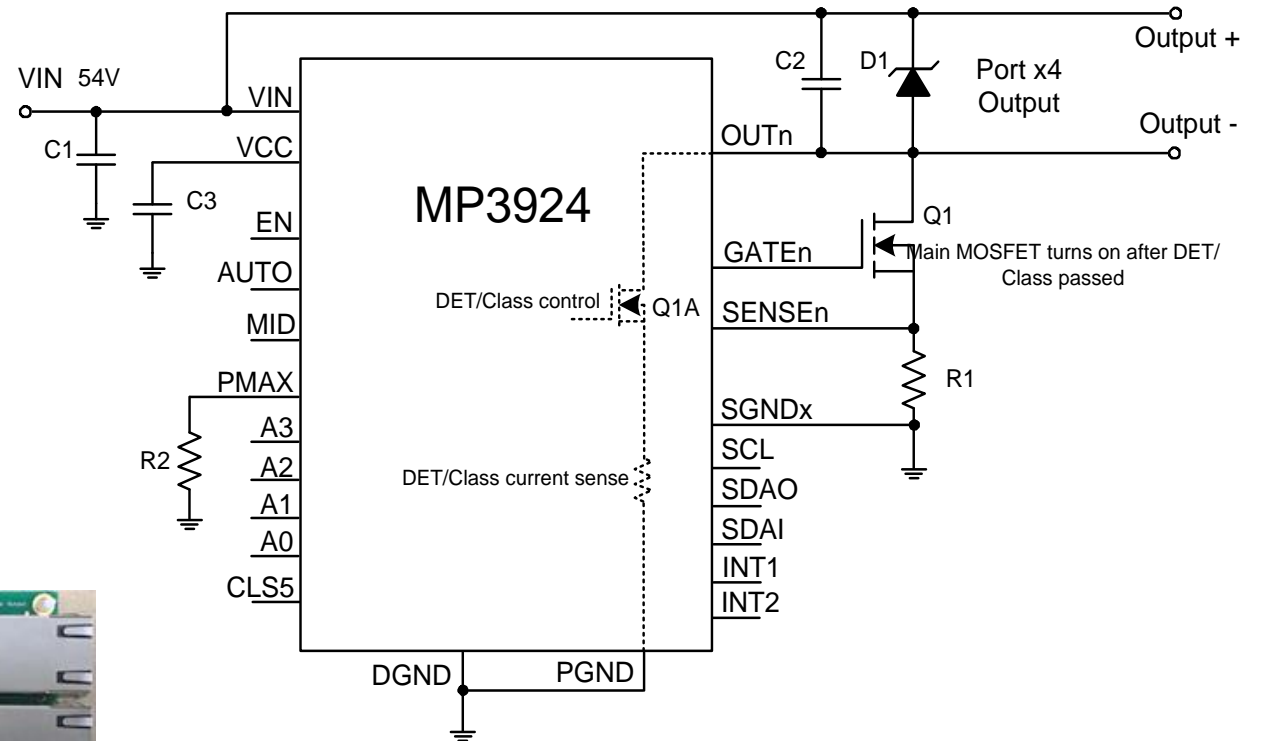
3.3, IEEE802.3at PSE solution- MP3924

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, Strong Design Support

Gold Design for PoE PD

➤ MPS support all power level **Golden Design**, can provide:

1. Schematic
2. PCB layout
3. BOM
4. Transformer Selection Guide
5. Test Report

➤ Golden Design List

Power Rating	PN	Vout(V)	Topology	Transformer	Efficiency
13W	MP8017	5V	Flyback	EP7	85.2%
	MP8017	12V	Flyback	EP7	86.6%
25W	MP8009	5V	Flyback	EFD20	91.0%
	MP8009	12V	Flyback	EP13	91.4%
51W	MP8030	5V	Forward	EP13	91.9%
	MP8030	12V	Forward	EP13	92.0%
71W	MP8030	5V	Forward	EFD20	92.2%
	MP8030	12V	Flyback	EFD25	93.2%

3.4, Strong Design Support

More Materials for PoE System

功率等级				
IEEE802.3bt 71.3W	MP8020 802.3bt 内部集成+外部 FET	MP6005 反激/正激控制器, 原边反馈/副边反馈	MP9928 60V 降压控制器	MP8030 802.3bt 全集成 PD+反激/正激控制 器, 原边反馈/副边反馈 推荐新设计
IEEE802.3at 25.5W	MP8003A IEEE 802.3at 内部集成 FET	MP3910 反激控制器, 副边反馈	MP9572 60V/2A 同步降压转换器	MP8009A 802.3at 全集成 PD+反激/正激控制 器, 原边反馈/副边反馈 推荐新设计
		MP6002 PWM 控制器	MP4562 60V/2A 非同步降压转换器	MP3924 IEEE 802.3af/at 4 口 PSE 控制器 推荐新设计
IEEE802.3af 13W	MP8001 IEEE 802.3af 内部集成 FET	MP6004 反激/降压转换器, 原边反馈	MP8017 全新一代 802.3af 全集成 PD+反激转换器, 原边 反馈/副边反馈 推荐新设计	
			MP8007H 802.3af PD 全集成 PD+反激/降压转换器	
			MP8004 802.3af 全集成 PD+反激控制器	



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