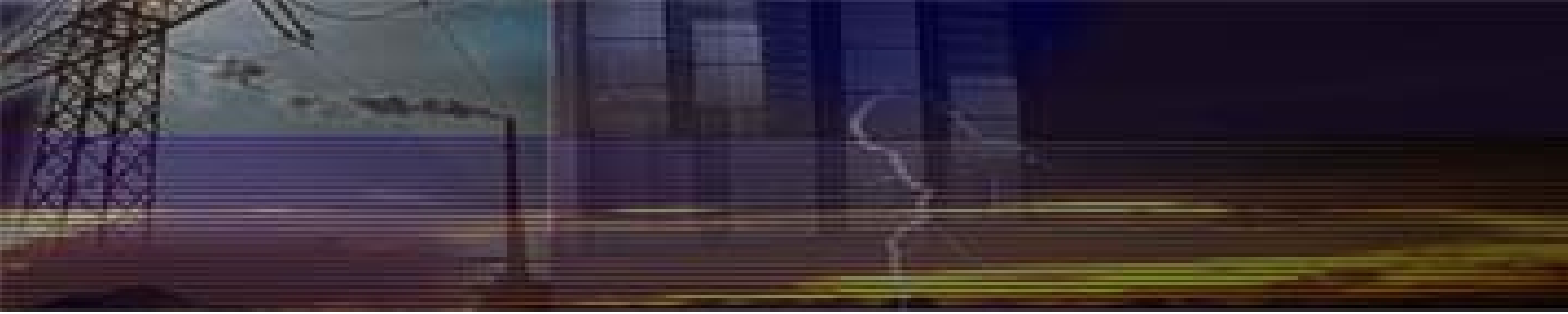


Qspeed™ semiconductor

Super-Efficient Power Semiconductors

Jason Hsu 許元豪, Sr. Application Engineer

Content

- Qspeed Semiconductor Introduction

- The Advantage of Qspeed Diode in CCM PFC
  - Q Series Diode
  - X Series Diode

- Why Can Qspeed Diode Compete Against SiC Diode
  - Qspeed Unique High Technology in Silicon Process
  - Fatal Defect in SiC Wafer

- Future Product Roadmap

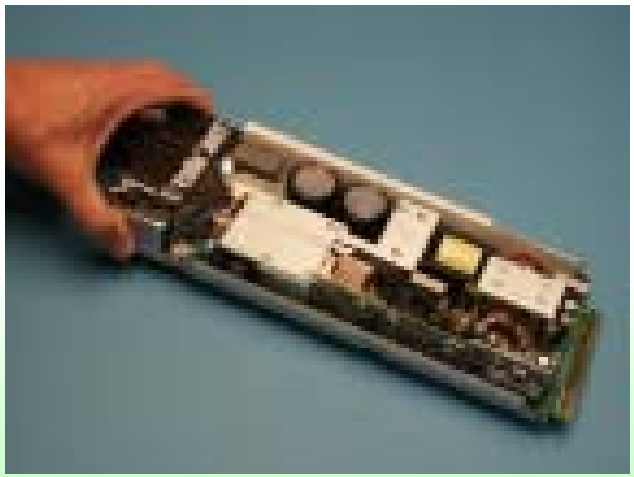
1. Qspeed Semiconductor Introduction

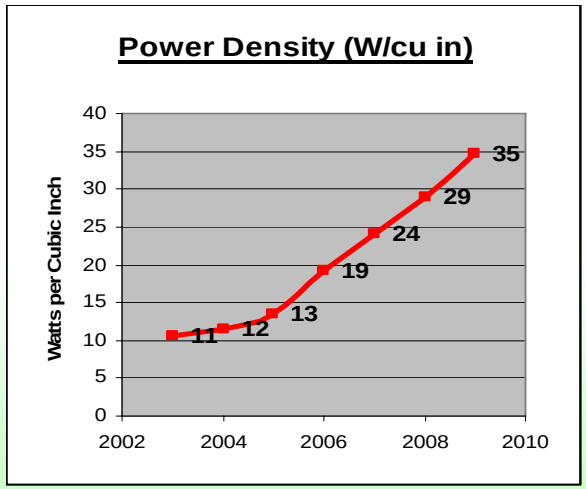
Qspeed Semiconductor – Locations/logistics

- Headquarters in Silicon Valley (Santa Clara)
- Fab in Japan, assembly in Manila
- Logistics in Taipei (Q3 2006)
- Sales office in Taipei

The Power Density Race Is Accelerating

- Power Density = Output Power ÷ Size
  - Example: 550 Watts ÷ 52 cubic inches = 11 Watts per Cubic Inch
- In 2003 the blade server power supply shown below offered 550 Watts of energy in 52 cubic inches for PD = 11 W/in^3
- In 2005 the same space was used to deliver 700 W for 13 W/in^3
- This year 2007 power supply companies must deliver 1000 W in same space -24 W/in^3
- R&D groups around the world now working to achieve 40 W/in^3

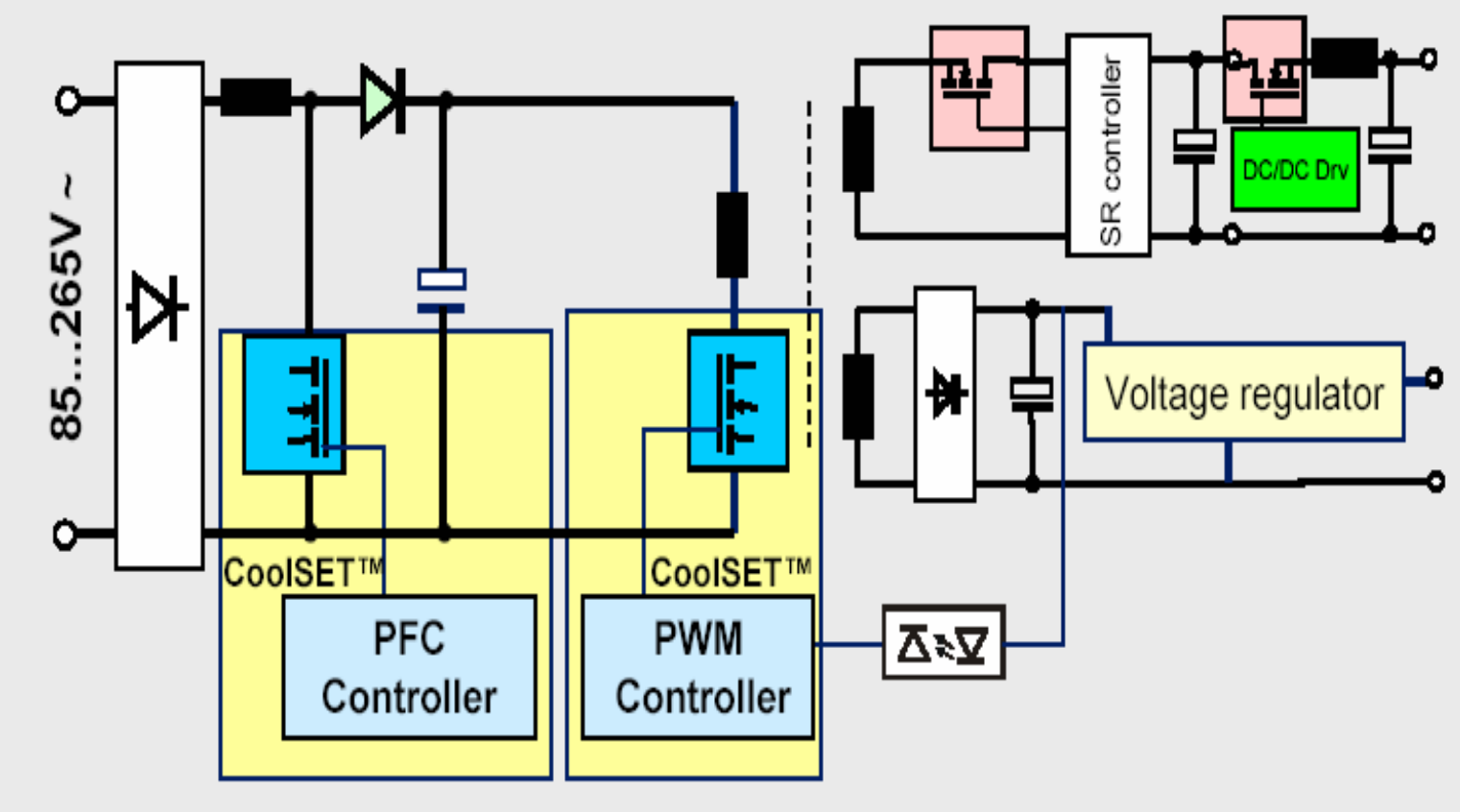




2. The Advantage of Qspeed Diode in CCM PFC

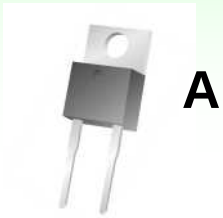
- Q Series Diode
- X Series Diode

SMPS Function Block

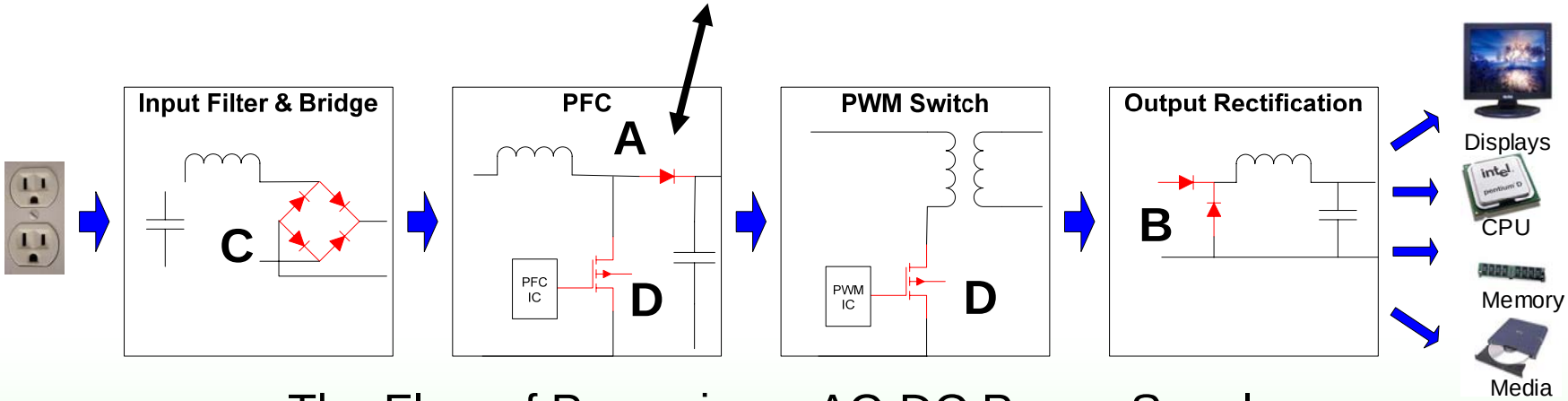


Power Semi's are the Key to Energy Efficiency

The largest cause of energy loss in a power supply is due to the power semiconductor components. Qspeed Semi will address these component needs, with the Q-Series PFC Rectifier being just the first…

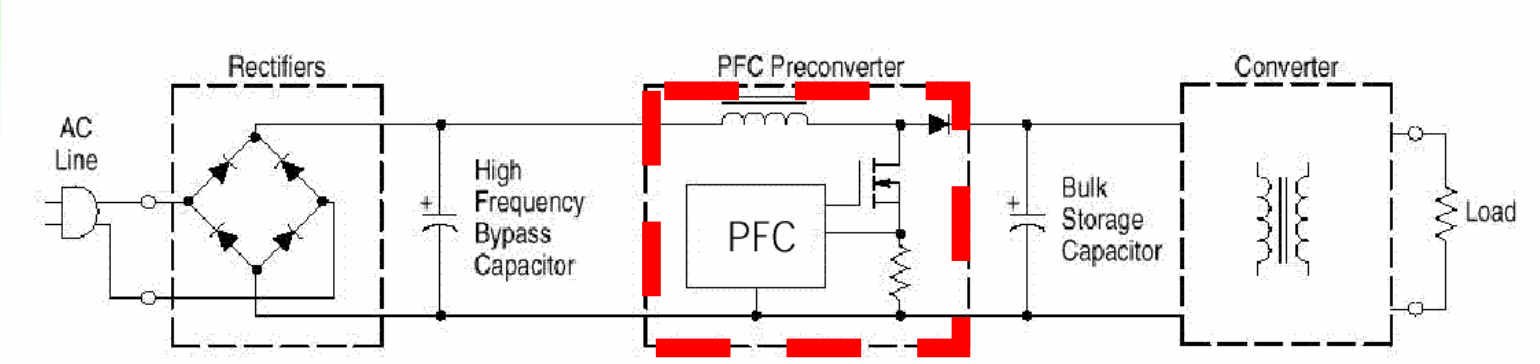


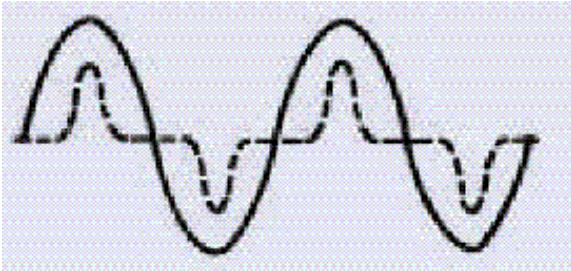
The Q-Series PFC Rectifier



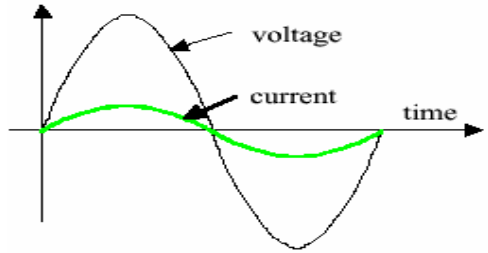
The Flow of Power in an AC-DC Power Supply
From Wall to Load

Why Should We Need PFC ? 1/2





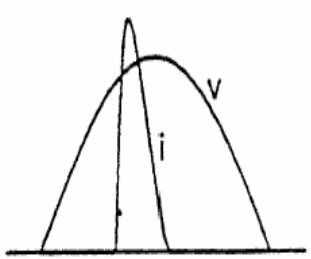
$K_d < 1, K_\theta \approx 1$



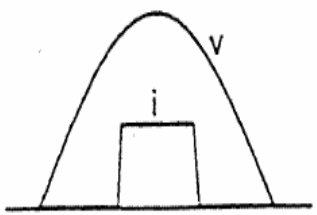
$k_d = 1, \quad k_\theta = 1$

Why Should We Need PFC ? 2/2

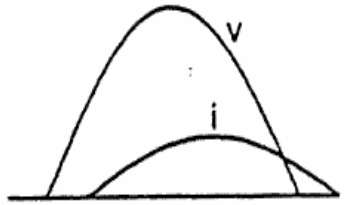
$$PF = \frac{\text{Average Power}}{\text{Apparent Power}} = \frac{\text{Avg}[v(t)i(t)]}{V_{rms} I_{rms}} = \frac{V_{rms} I_{rms(1)} \cos ?}{V_{rms} I_{rms}} = \frac{I_{rms(1)}}{I_{rms}} \cos ? = K_d K_?$$



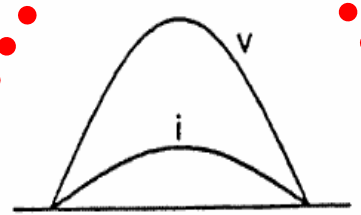
$k_d < 1,\ k_\theta < 1$



$k_d < 1,\ k_\theta = 1$



$k_d = 1,\ k_\theta < 1$



$k_d = 1,\ k_\theta = 1$

To reduce electrical **costs**

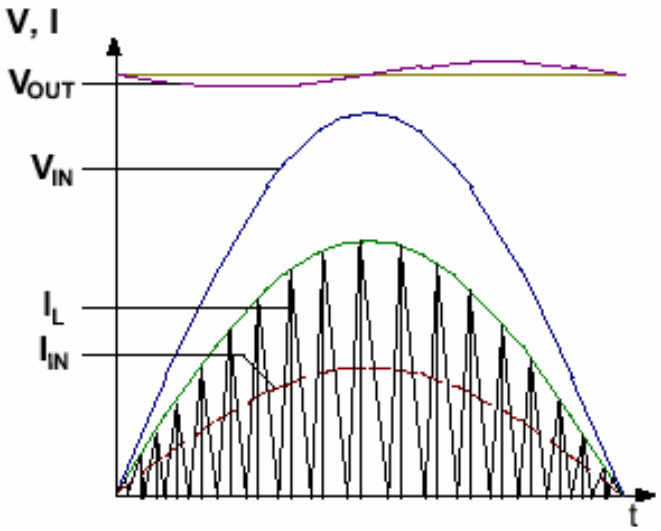
To reduce load **losses** of the distribution system

To increase system's **capacity**

To maintain a better voltage **regulation**

Control Methods for Active Power Factor Correction

Discontinuous Current Mode DCM
usually variable frequency

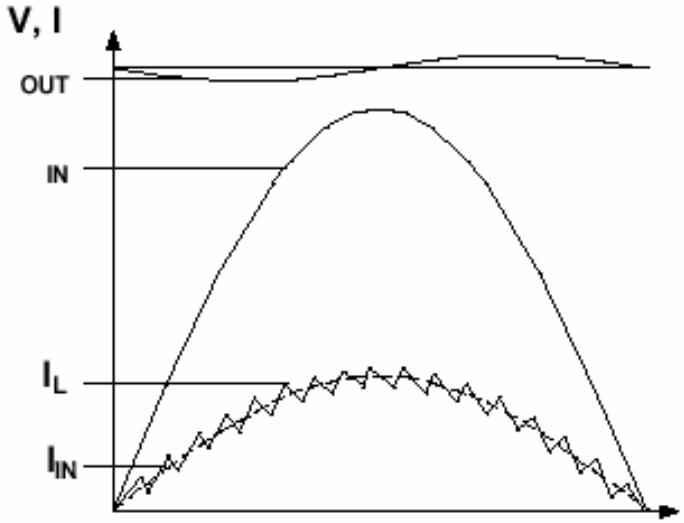


Charakteristics:

Advantage
no reverse recovery losses of diode
simple control method

Disdvantage
difficult smoothing of peak currents
instable operation at light load

Continuous Current Mode CCM
usually constant frequency

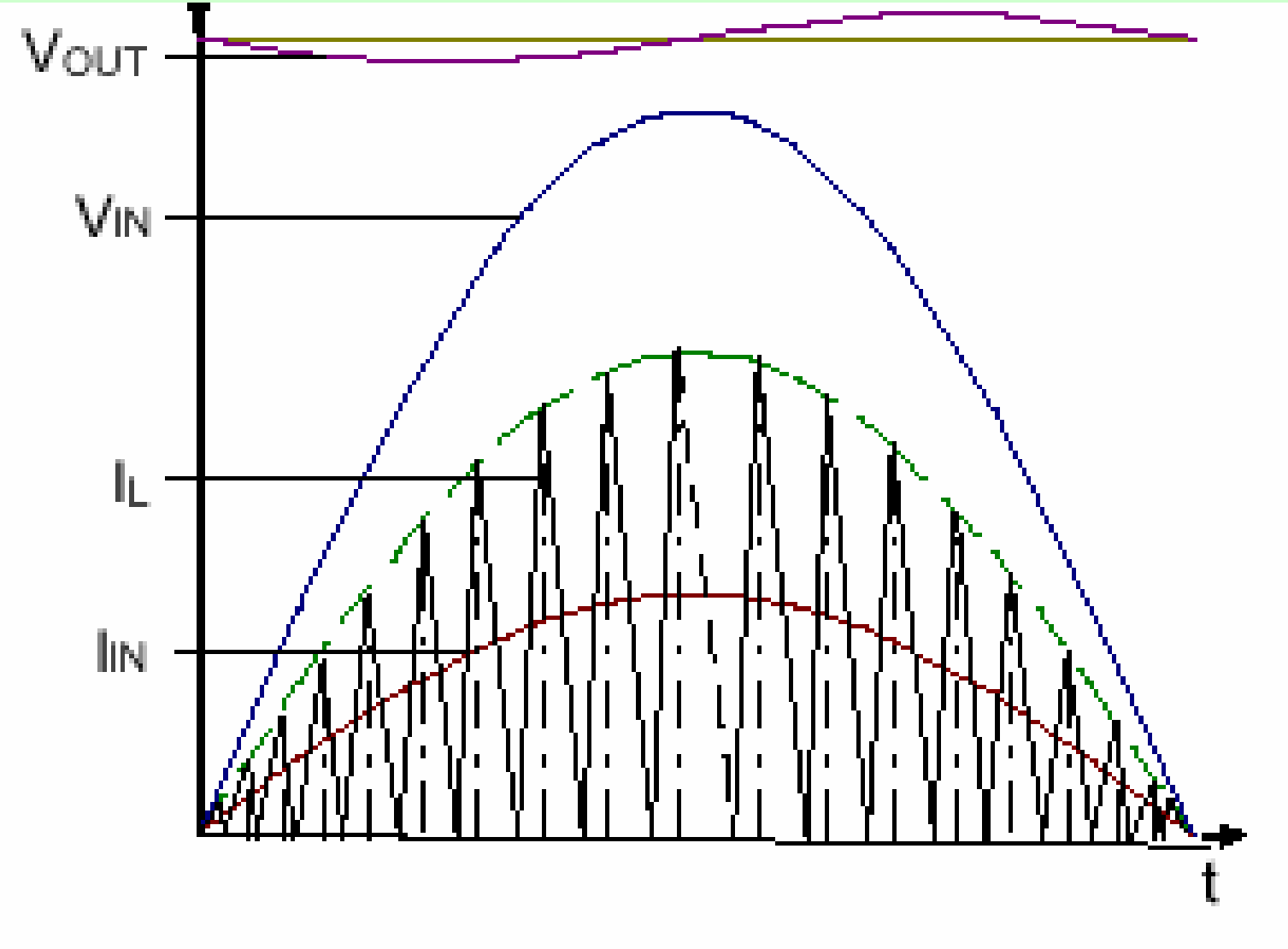


Charakteristics:

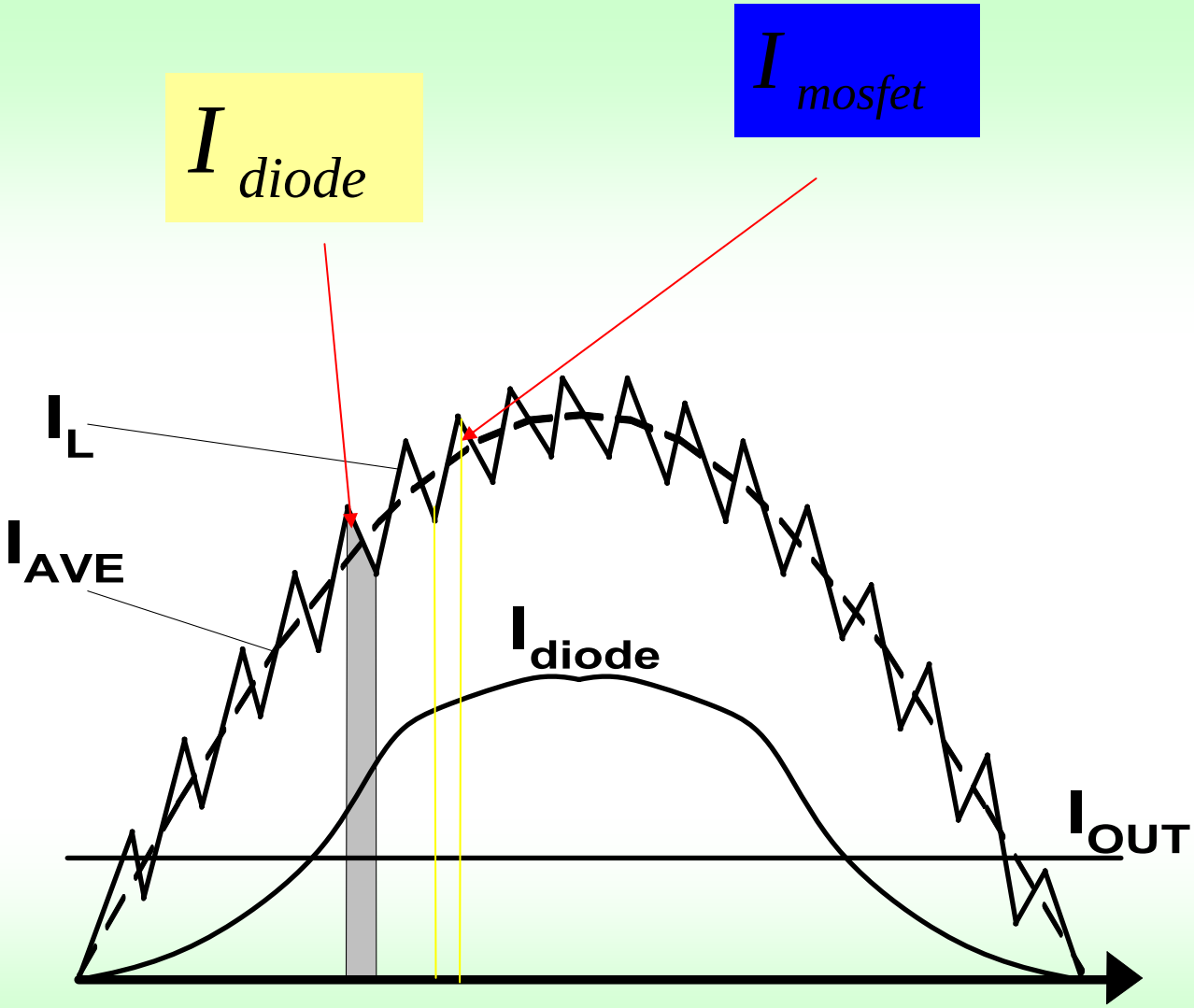
Advantage
easy smoothing of peak currents
stable operation at light load

Disadvantage
reverse recovery losses of diode
complex control method

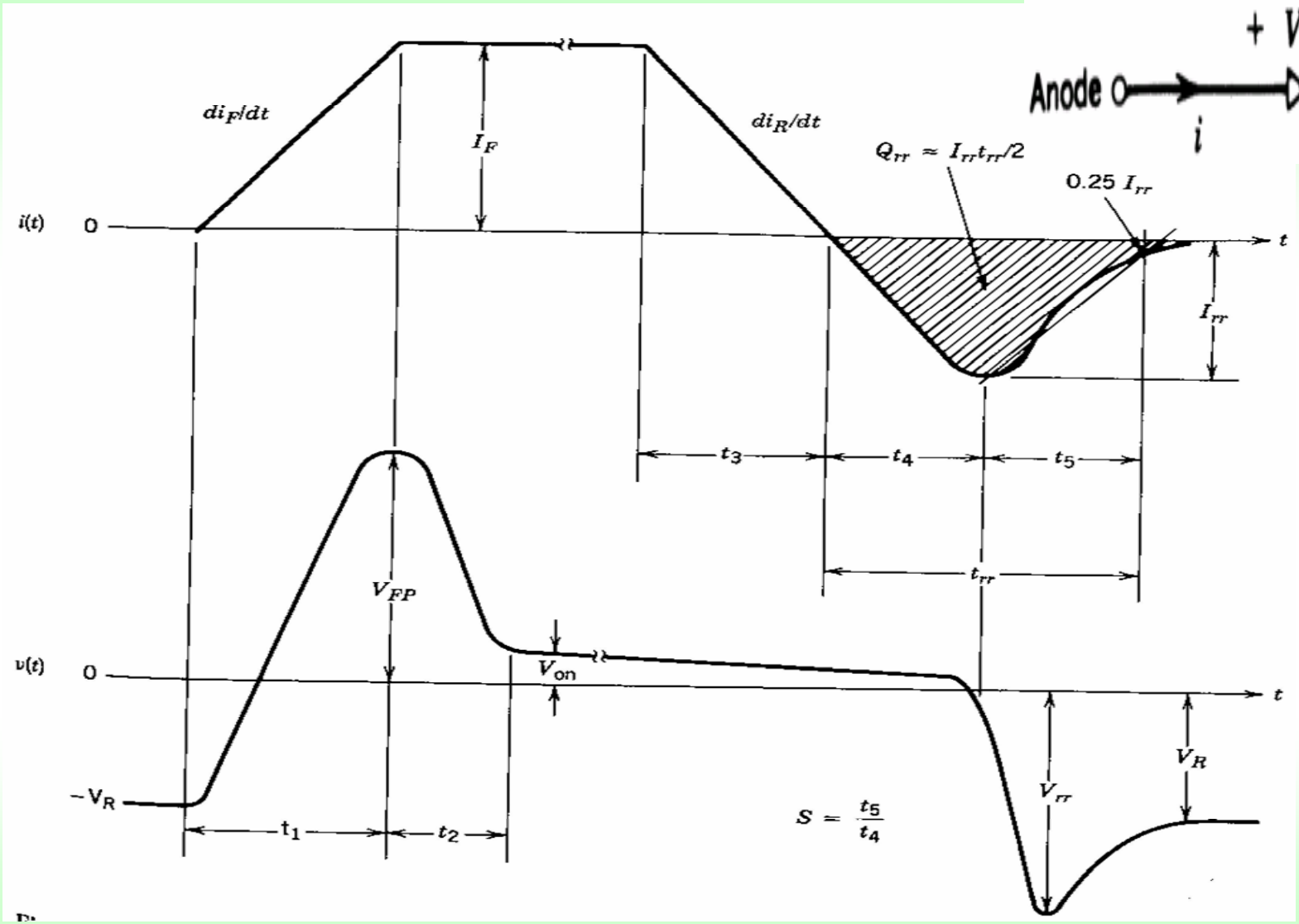
DCM PFC Inductor Current



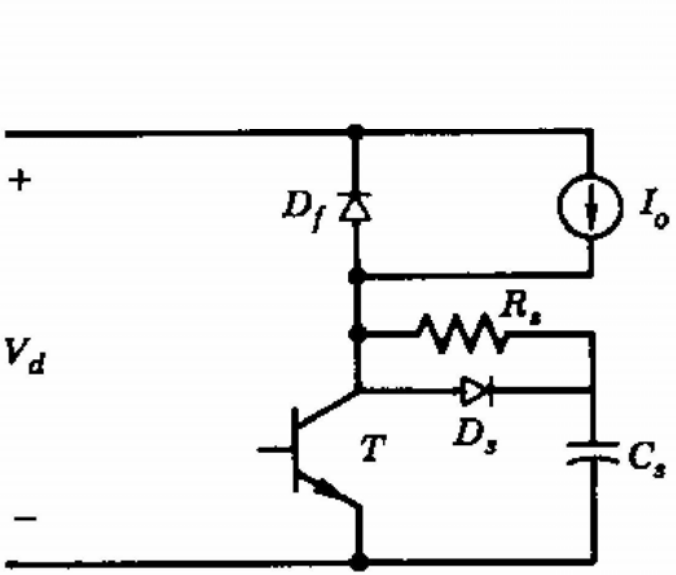
CCM PFC Inductor Current

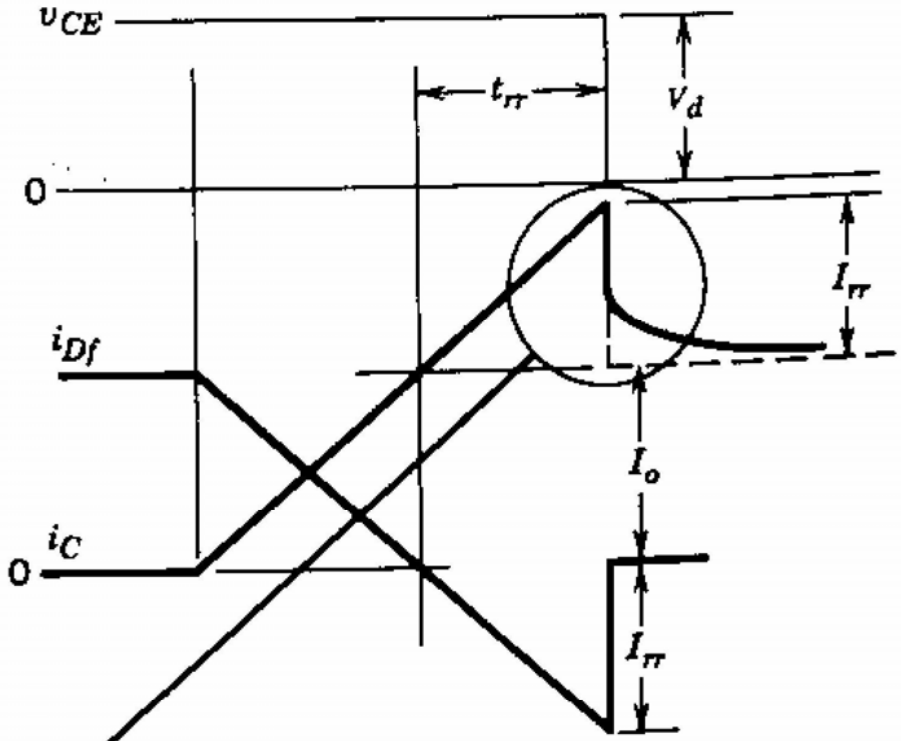


Power Diode Switching Behavior

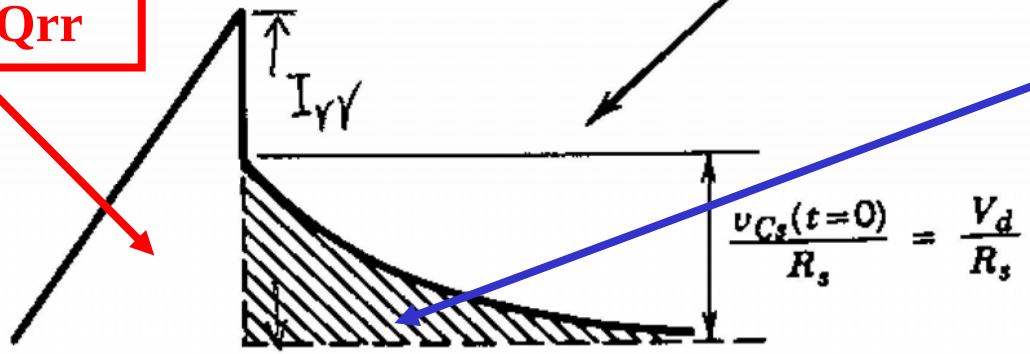


Additional Switching Current Spike Caused by Diode Qrr



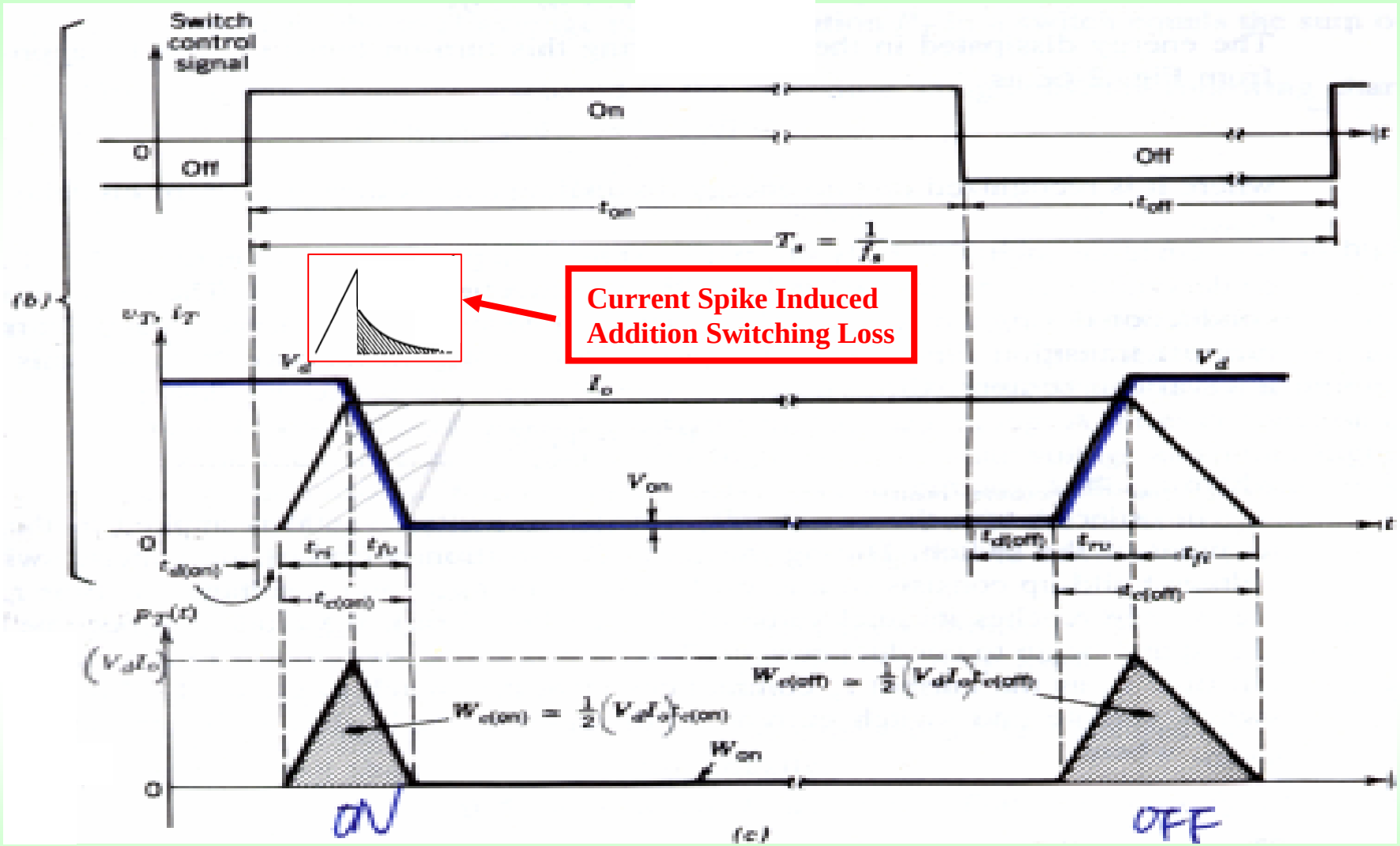


Current Spike Induced by Qrr

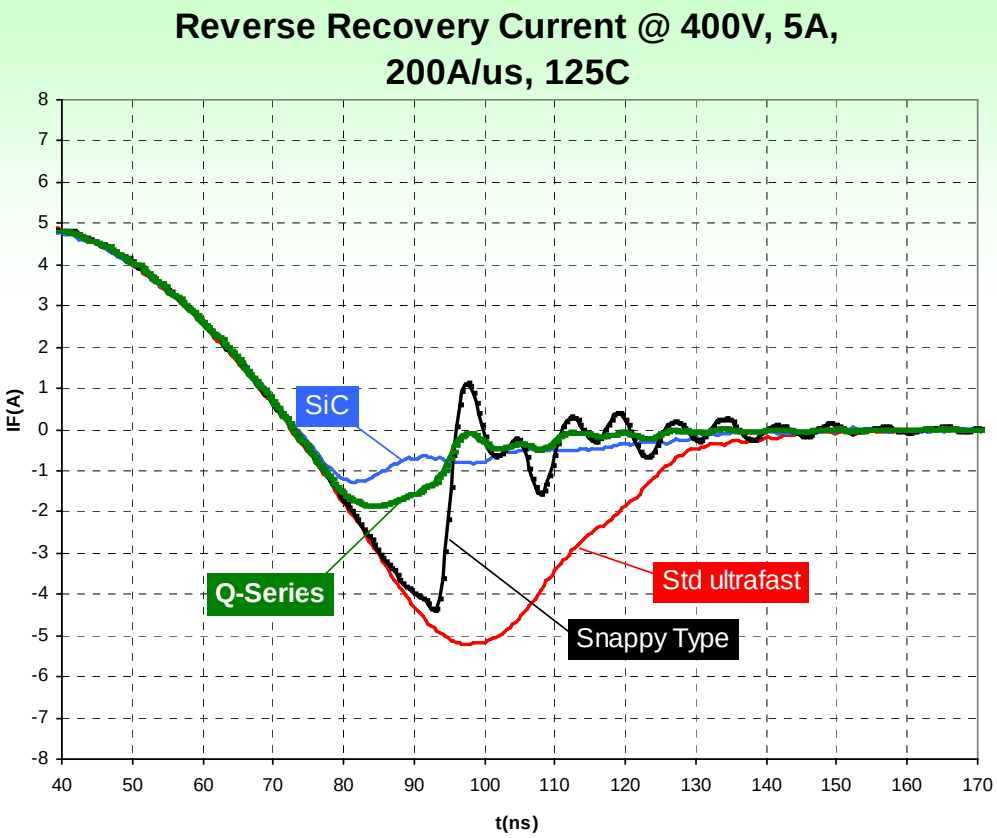


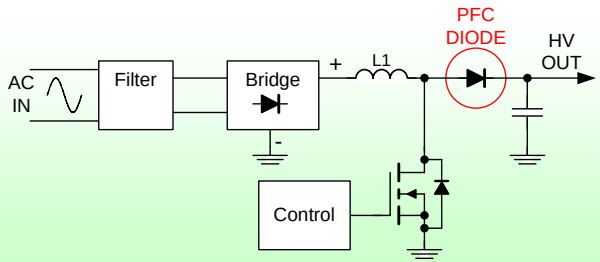
Current Spike Induced by RCD Snubber

Power MOSFET Switching Behavior



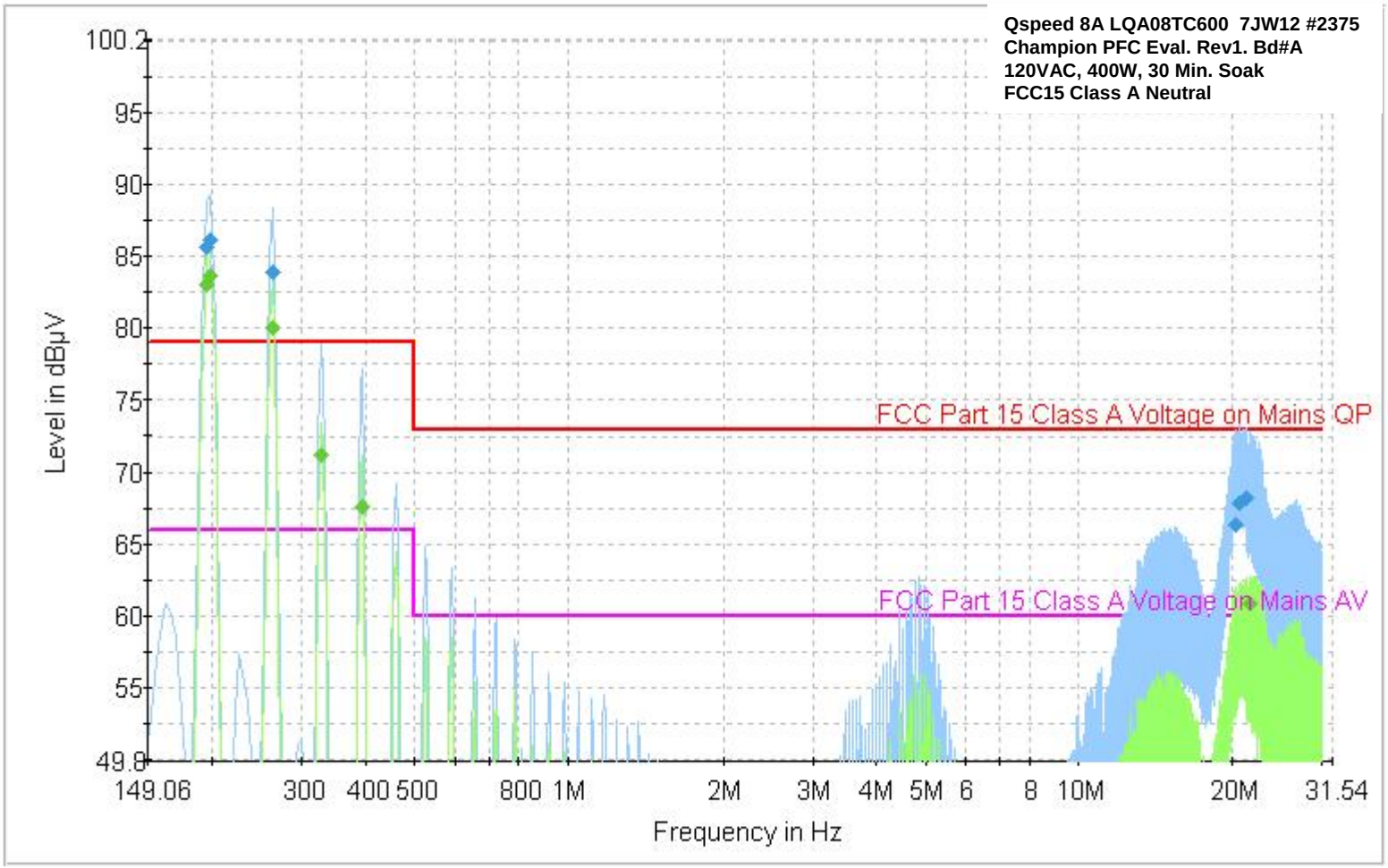
PFC Diode Reverse Recovery ➔ Efficiency



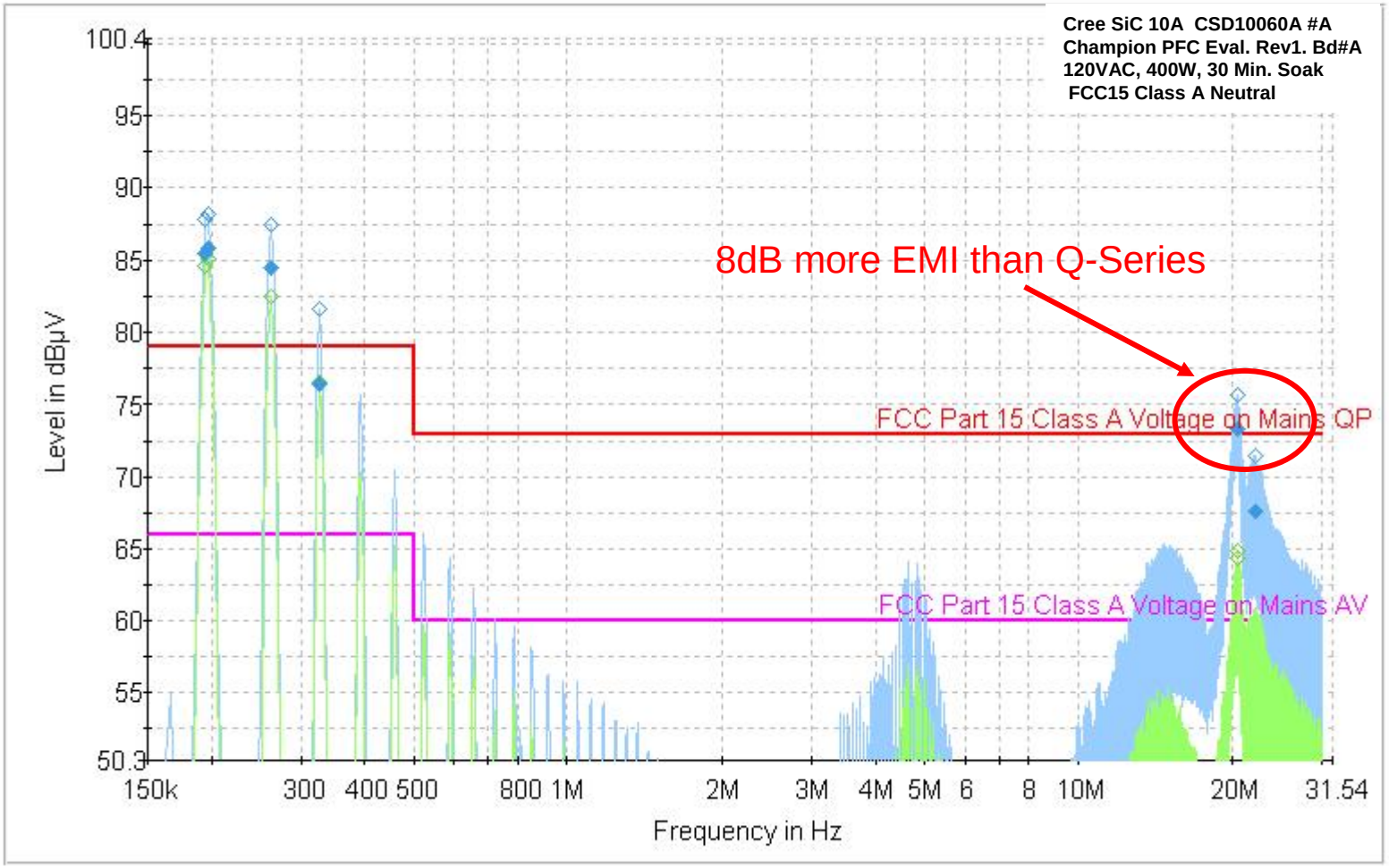


- **The area under the zero line represents energy and charge stored in the diode (Qrr). Less is better.**
- **This "reverse recovery energy" flows through the FET during turn on causing low efficiency.**
- **Compared to traditional ultrafast diodes, Q-series Rectifiers:**
  - **Reduce the temp of the PFC FET by 5 to 10˚C.**
  - **Improve efficiency up to 2%**
  - **Improve power density up to 10%.**
  - **Generate less noise**

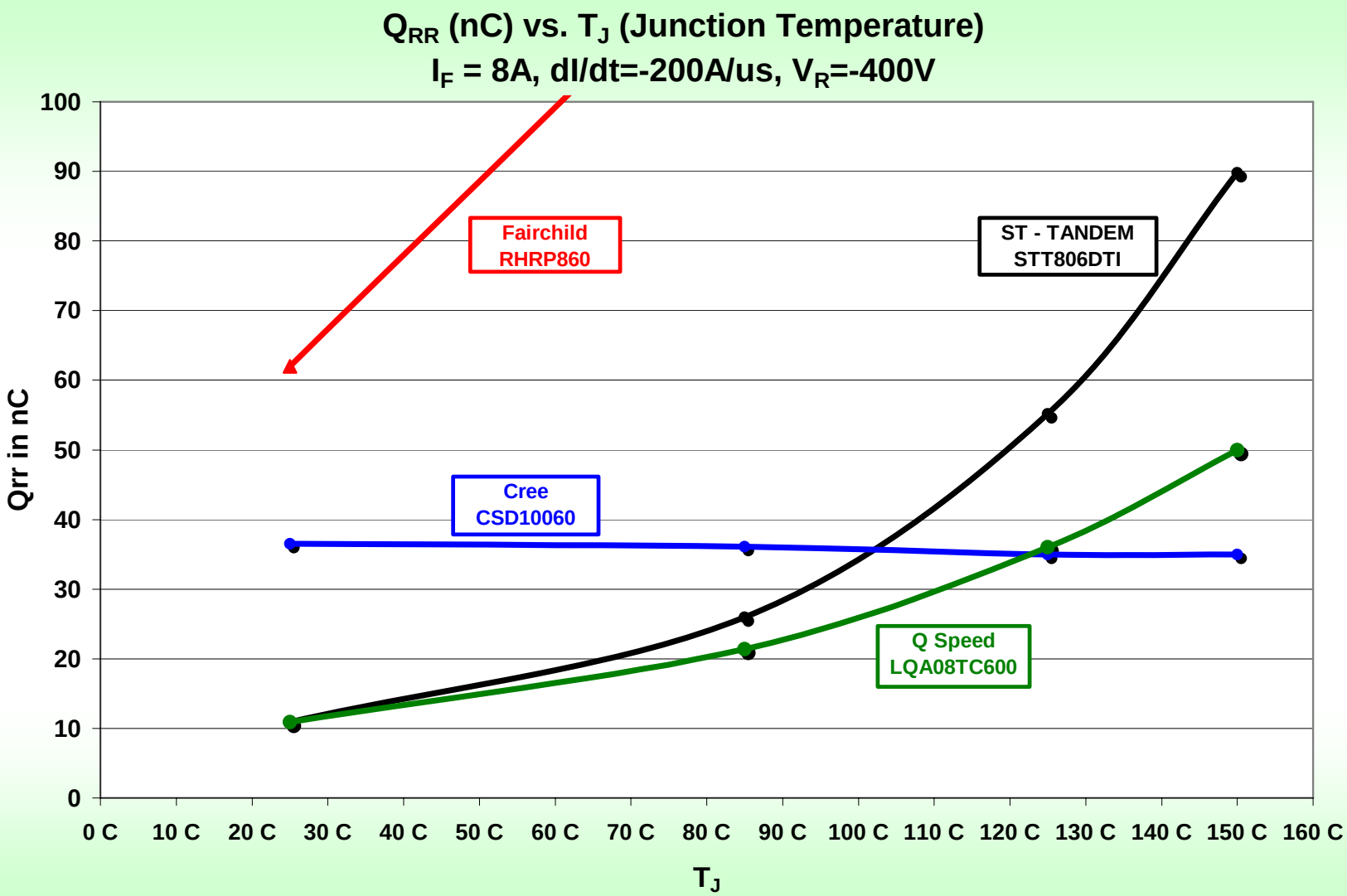
Q-Series has lowest EMI of all UF rectifiers:



…including SiC:

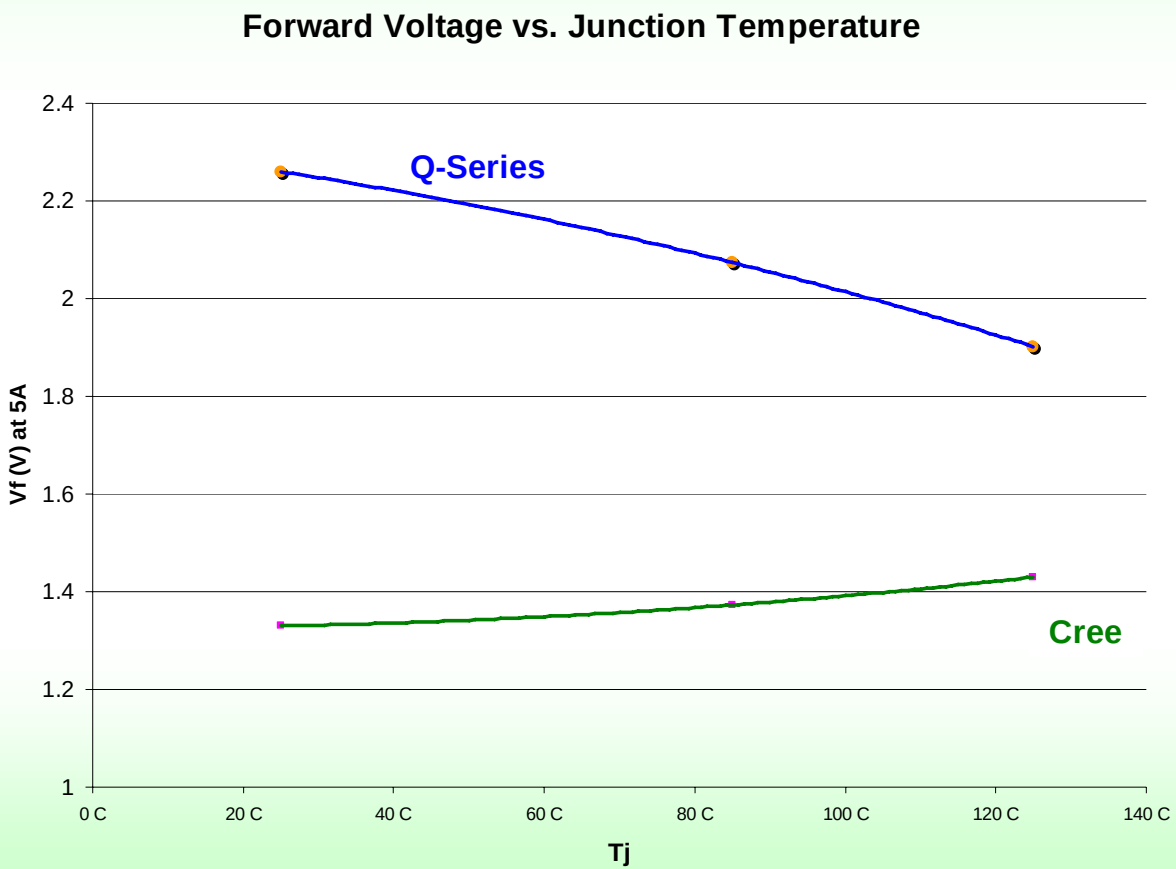


Qrr v.s. Tj for Various Technologies:



Q-Series Forward Losses Improve with Temperature

- So the losses versus temperature tend to balance…



Q-Series Diode Test Example – (1)

温升对比（50 度高温）

	D7（PFC 升压二极管）	Q1（PFC MOS 管）
APT15DQ60K	103.9	106.7
CSD06060	81.2	86.6
LQA08TC600	92.2	87.9

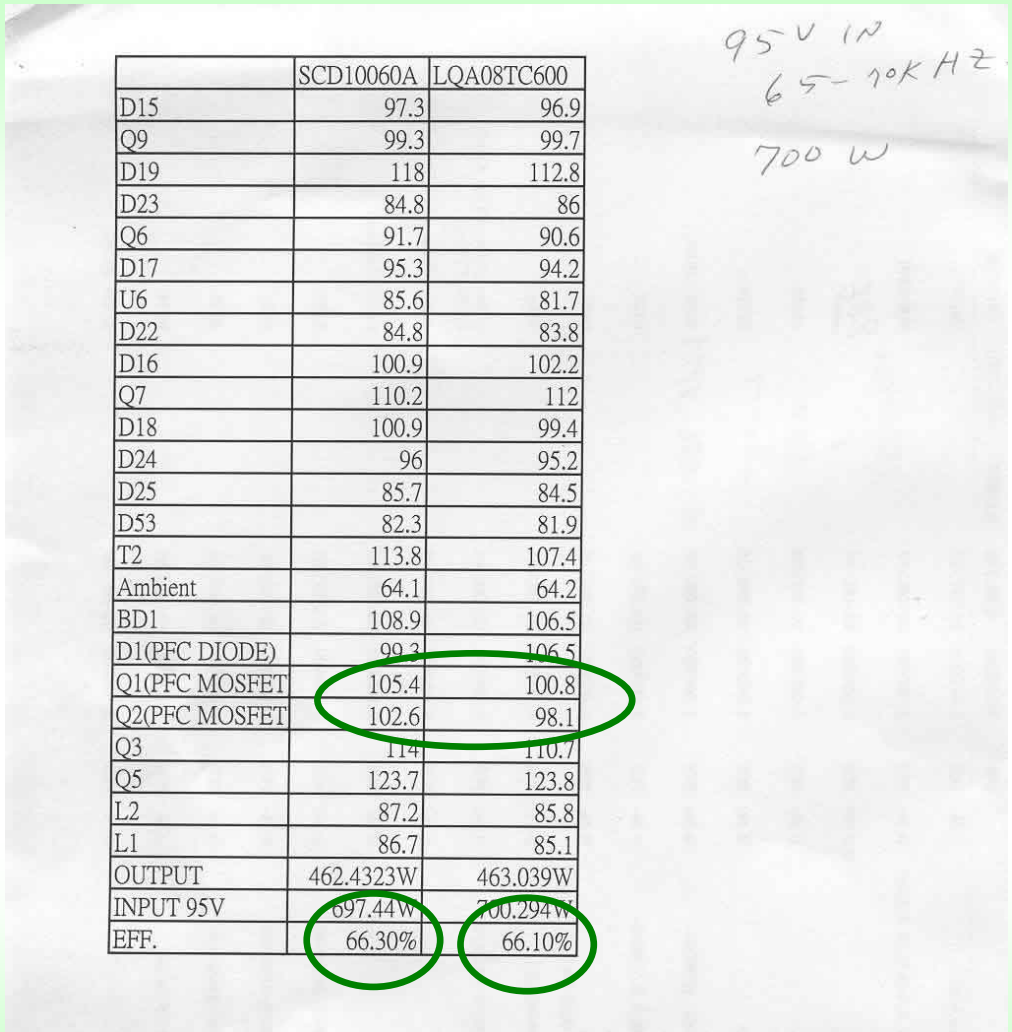
输入 90VAC，输出 700W，老化 2 小时测试温度

频率对输入功耗的影响

	83K	135K
APT15DQ60K	722.5	731.5
CSD06060	716.2	717.8
LQA08TC600	718	720

输入 90VAC，开机瞬间测试，输出 600W，主要测试 D7（PFC 升压二极管）的改变对开关损耗的影响。

Q-Series Diode Test Example – (2)



95V IN
65-70KHZ
700 W

	SCD10060A	LQA08TC600
D15	97.3	96.9
Q9	99.3	99.7
D19	118	112.8
D23	84.8	86
Q6	91.7	90.6
D17	95.3	94.2
U6	85.6	81.7
D22	84.8	83.8
D16	100.9	102.2
Q7	110.2	112
D18	100.9	99.4
D24	96	95.2
D25	85.7	84.5
D53	82.3	81.9
T2	113.8	107.4
Ambient	64.1	64.2
BD1	108.9	106.5
D1(PFC DIODE)	99.3	106.5
Q1(PFC MOSFET	105.4	100.8
Q2(PFC MOSFET	102.6	98.1
Q3	114	110.7
Q5	123.7	123.8
L2	87.2	85.8
L1	86.7	85.1
OUTPUT	462.4323W	463.039W
INPUT 95V	697.44W	700.294W
EFF.	66.30%	66.10%

- Customer test report comparing SiC diode from Cree with Qspeed:
  - Efficiency is within 0.2%
  - MOSFETs run 4.5˚C cooler with Qspeed
  - Almost all other components run cooler with Qspeed
- This customer was paying $4.00 for Cree SiC diodes. Qspeed would be <<$2.00.

Q-Series Diode Test Example – (4)

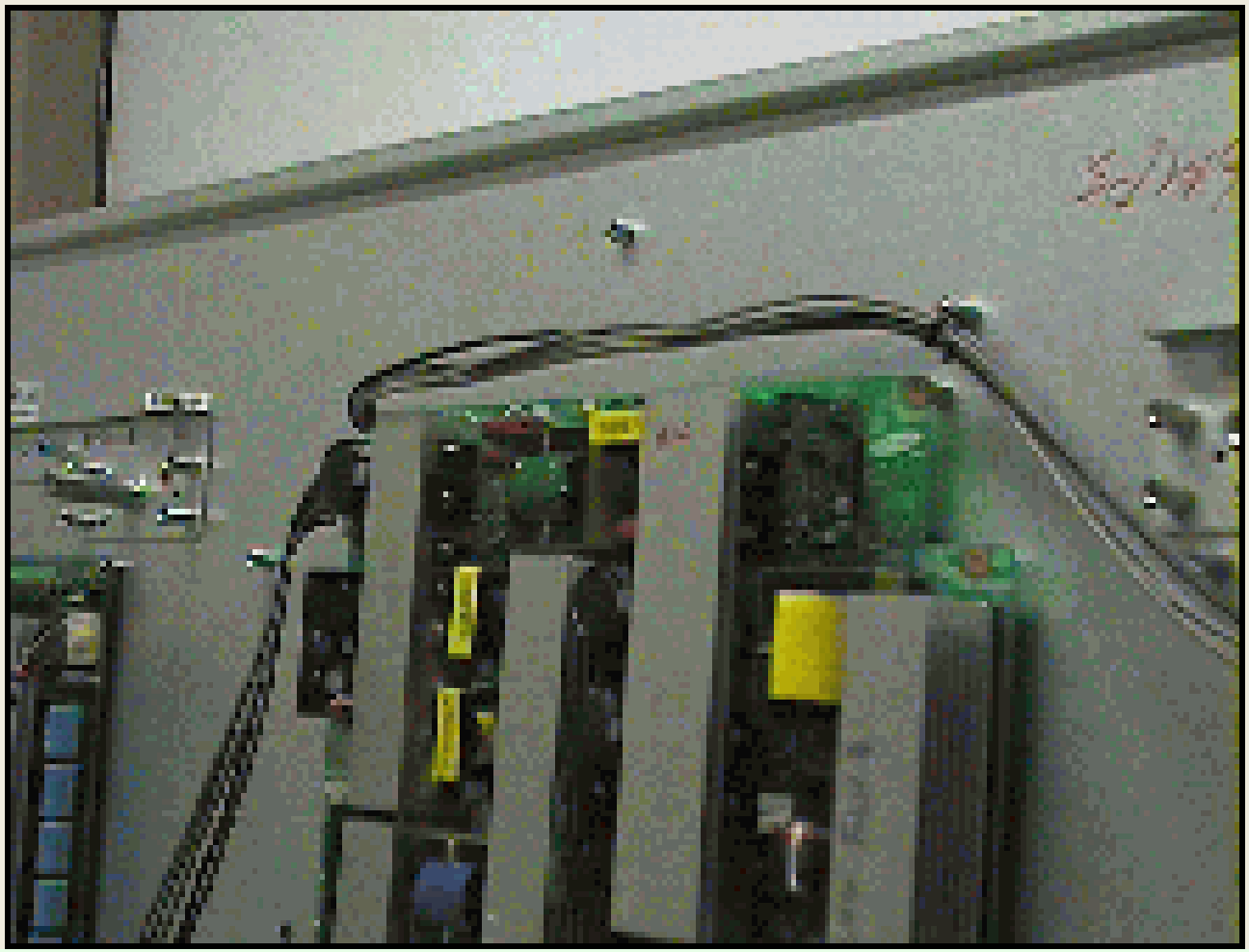
1KW Power Supply @ the following conditions

- PS2 Mechanical Size
- 90VAC/50HZ Line Input
- 67 KHz Synchronized Frequency in PFC and PWM,
- **4 pcs** SPW20N60C3 in PFC Stage (no snubber circuit)
- Tamb = 25 degreeC

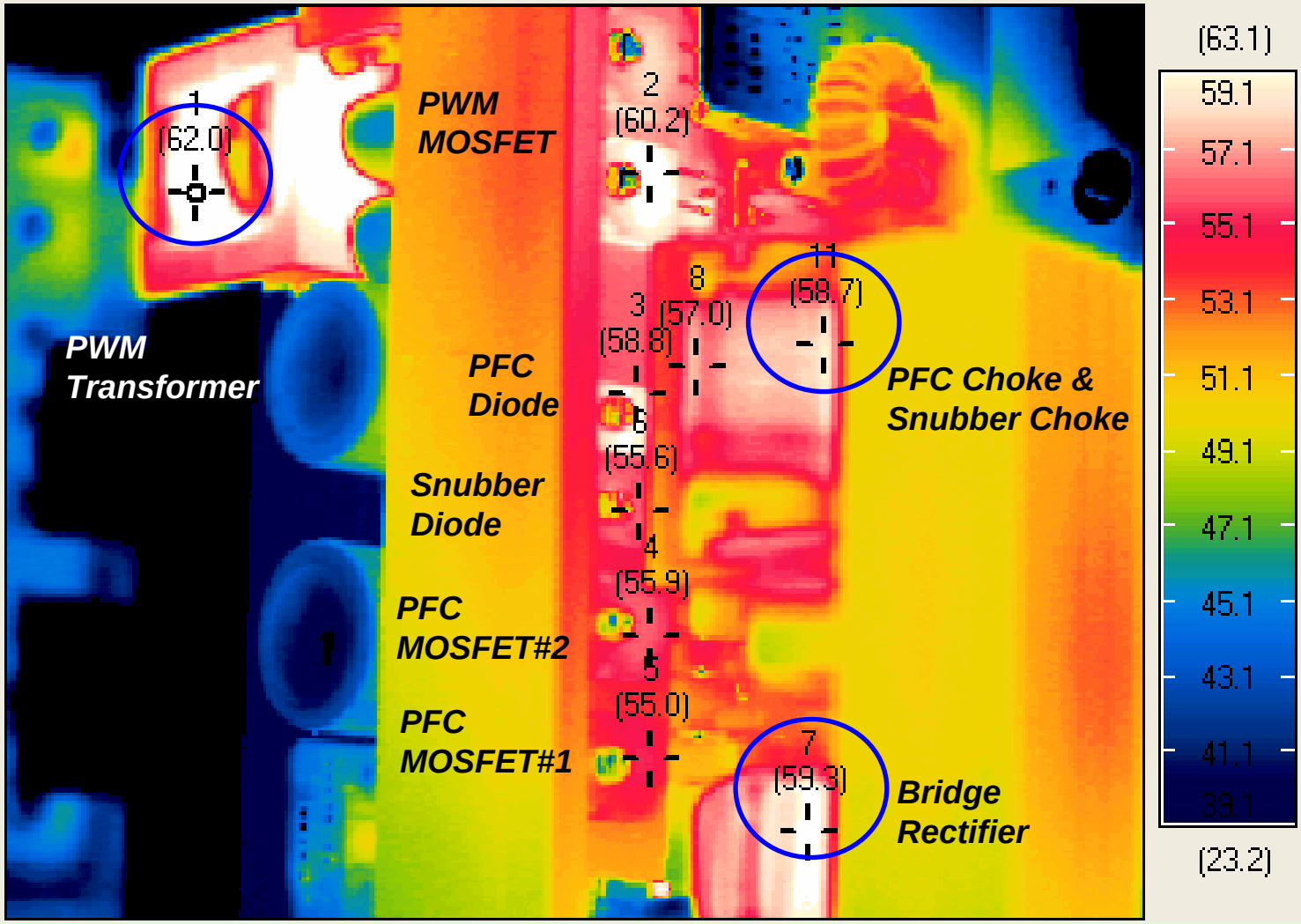
	LQA08TC600	RHRP1560
Tcase, diode	**73**℃	**92**℃
Tcase, FET	**71**℃	**93**℃

Reduce PFC MOSFET to **3 pcs** SPW20N60C3

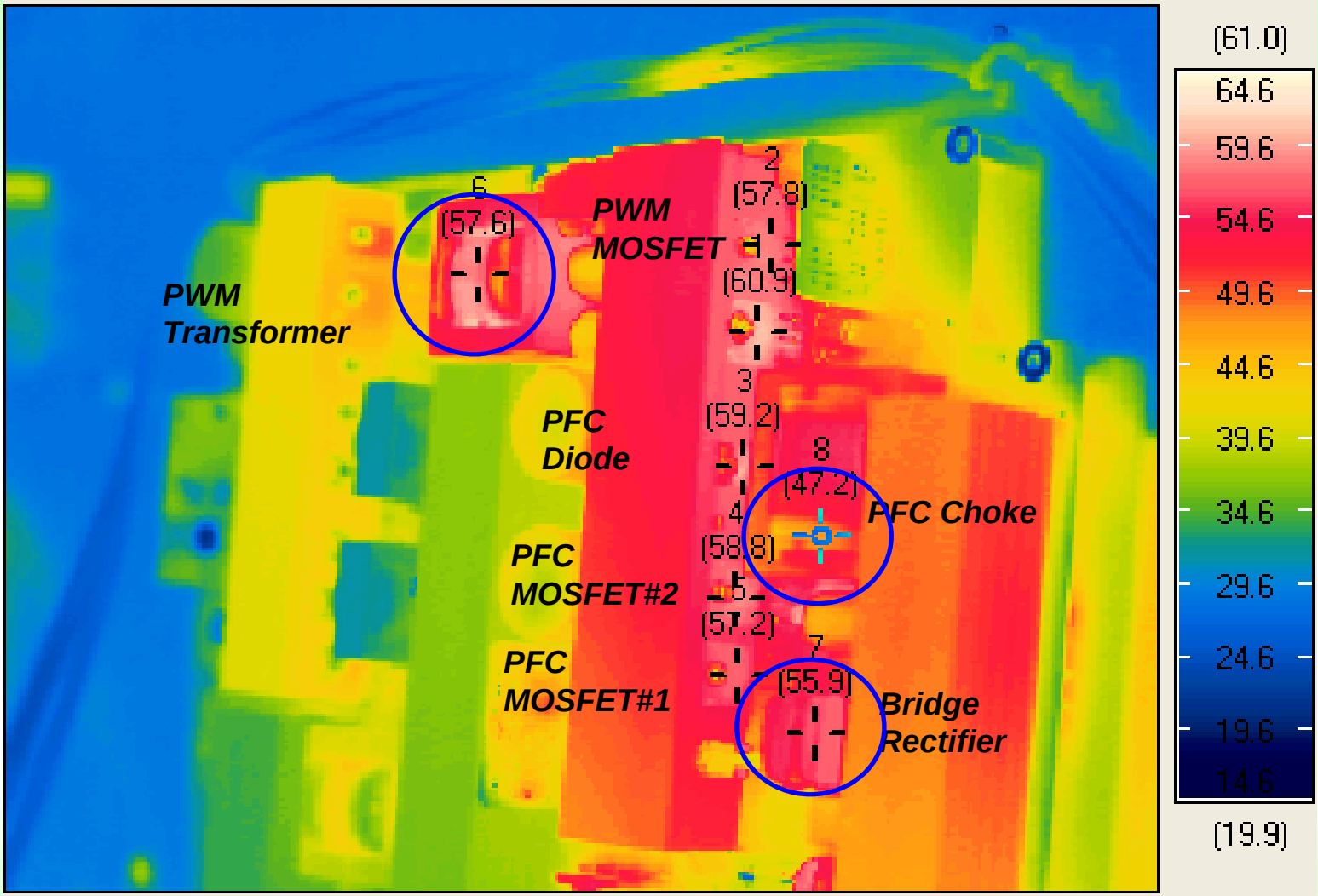
Q-Series Diode Test Example – (5)



50” PDP Power Board



STTH12R06 + Lossless ZVS Sbubber



LQA08TC600 without Any Snubber

X-Series Rectifiers

- Designed to be a direct drop-in replacement for ST "Tandem" ultrafast rectifiers
- Similar VF characteristics, but better than ST at 25˚C
- Similar Qrr values
- Much softer recovery
  - Straightforward replacement
  - Fewer noise problems
  - Can eliminate snubbing
- **Cost: Significantly Lower**
- Sampling Q1, 2007

Direct Replacement with Qspeed Rectifiers

	Currently using:	Replace with:	Result:
1	Silicon Carbide Rectifiers	Q-Series	Same efficiency, much lower cost (simple drop-in direct replacement)
2	Tandem with snubbers	Q-Series*	+0.5% efficiency, lower cost (*no snubber required)
3	Tandem w/o snubbers	X-Series	Same or higher efficiency, lower cost (simple drop-in direct replacement)
4	Std ultrafast with snubbers	Try X-Series* or Q-Series*	+2% efficiency, lower cost (*no snubber required)
	Std ultrafast w/o snubbers	Don't bother	The super-cheap market is unprofitable, and will decline soon

Qspeed PFC Product Family

- Products targeted to match the needs of the power level and topology:

Power level	**75-150W**	**125-200W**	**200-400W**	**400-800W**	**600-1kW**	**800-1.5kW**
Operating mode	**DCM**	**DCM**	**CCM or DCM**	**CCM**	**CCM**	**CCM**
600V **Q-Series**			3A  LQA03TC600	5A  LQA05TC600	8A  LQA08TC600	15A  LQA15AC600
600V **X-Series**	1A  LXA01T600	4A  LXA04T600	6A  LXA06T600	8A  LXA08T600	15A  LXA15T600	20A  LXA20T600

4. Future Product Roadmap

The proof is in our customers

- Customers who are already in mass production with Qspeed products:

DANAM

SUNGHO ELECTRONICS

SAMSUNG

Seventeam

CWT CHANNEL WELL TECHNOLOGY

Deer Right Power

Tsintin

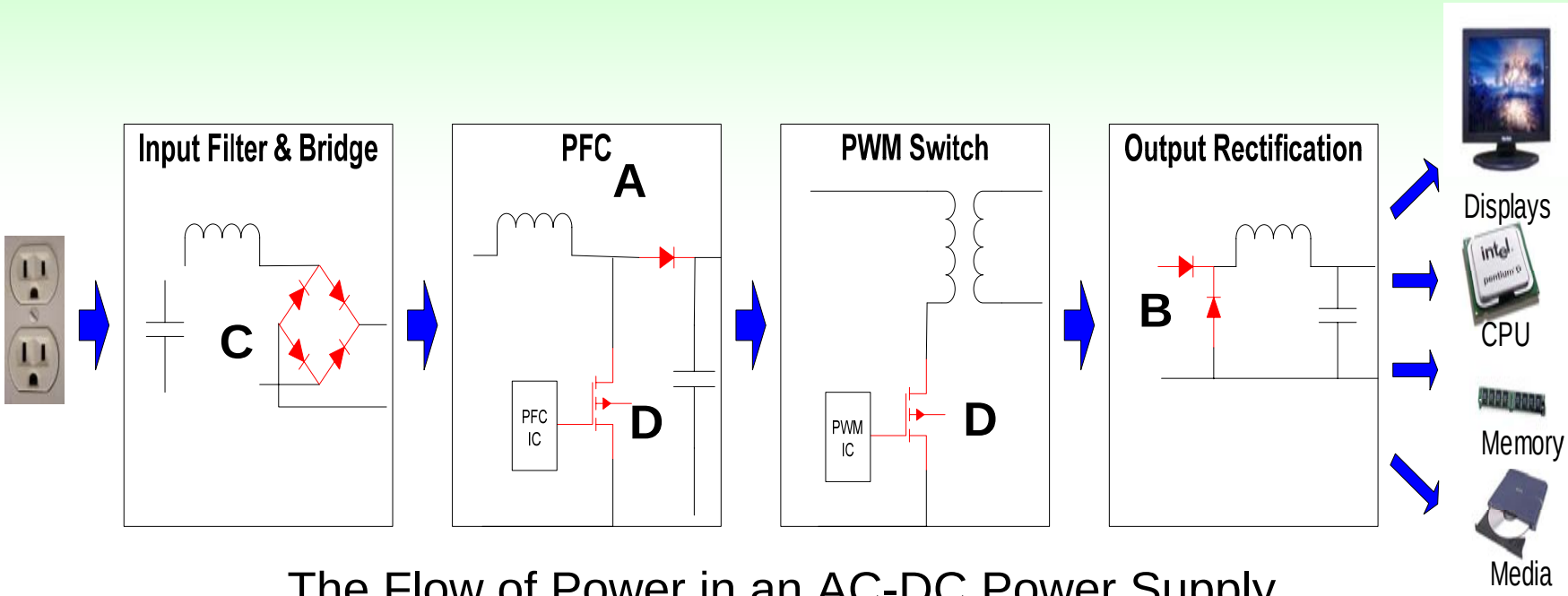
深圳千田電子有限公司
SHENZHEN TSIN TIN ELECTRONICS CO., LTD.

TOPOWER

東莞市長安宇佳電子實業
YUJIA PLASTIC & ELECTRONI

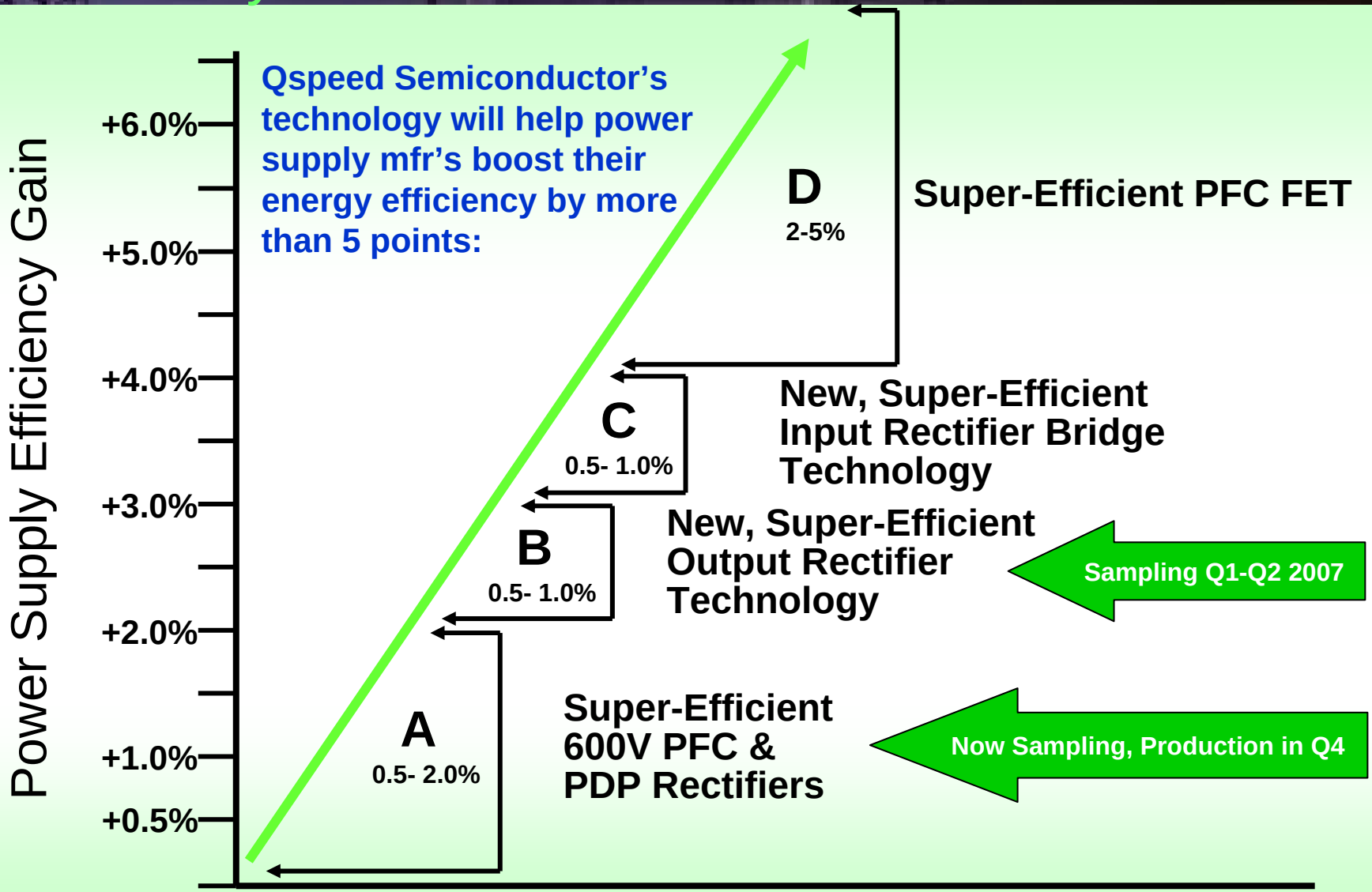
Huntkey 航嘉

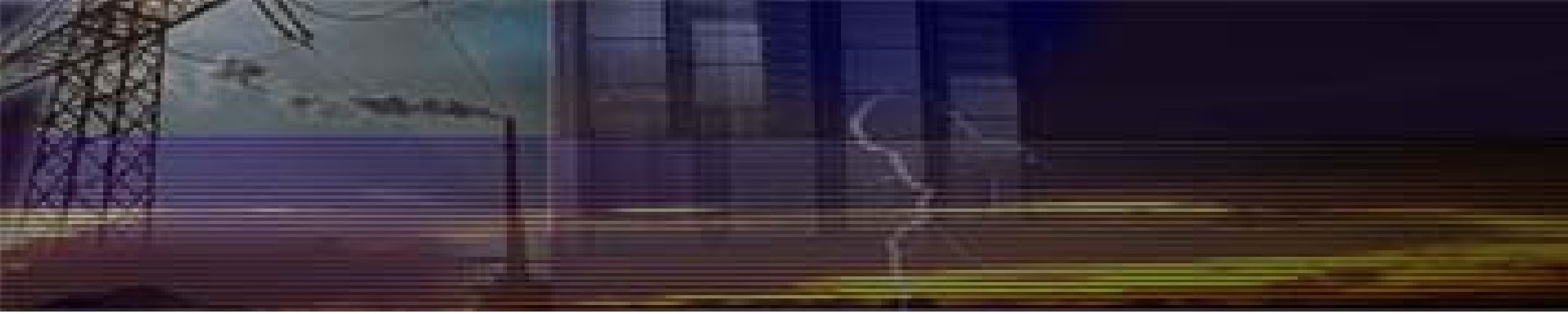
Qspeed Semiconductor's Product Roadmap



The Flow of Power in an AC-DC Power Supply
From Wall to Load

Qspeed Semiconductor's Impact on Power Efficiency





End of Presentation – Thank You!

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