80++ CM6802A/B
80+ CM6800/A
Low Cost CM6805A/B

80+ to 85+

CM6802
Hard Switching PFC
Dual Switch Forward

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September 30th, 2007

80++ CM6802A/B

80+ CM6800/A

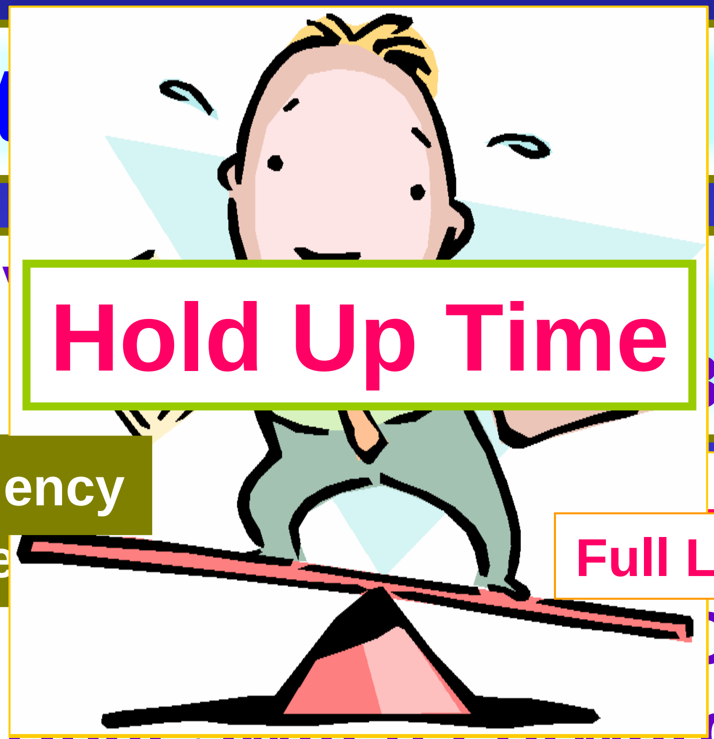
Low Cost CM6805A/B

380V

85+ t spec.

Vin = = 100Vac

82 5 85 85



Hold Up Time

Light Load Efficiency

Light Load Efficie

Load Efficiency

Full Load Efficiency

228V

80++ CM6802A/B

80+ CM6800/A

Low Cost CM6805A/B

Present possible R/D 85+ Solutions:

CM6802

CM6807 & CM6900

CM6565

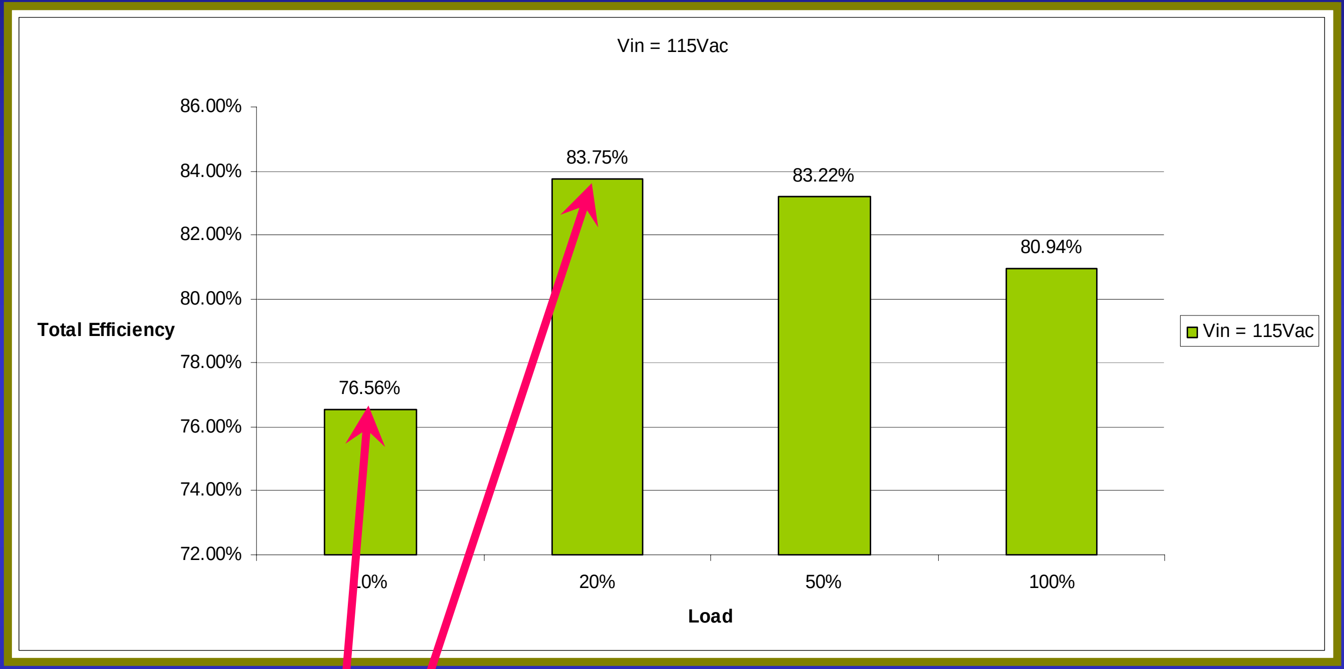
- PFC/PWM combo (CM6802): F[illegible]al Forward Topology
- Interleaved PFC + Dual Forward/Half Bridge Topology
- Single PFC + Half Bridge + SR
- ~~Single PFC + Active Clamp~~ Reliability Issue and Bad Reputation

SR: Synchronous Rectification

80++ CM6802A/B
80+ CM6800/A
Low Cost CM6805A/B

Archetypal CM6800/A (PFC PWM Controller)
Archetypal CM6802 (PFC PWM Controller)

80+ Power Supply Efficiency
80++ Power Supply Efficiency



At Full Load:

- Turn Ratio = 10 with D ~ 33%
- Low Volt Schottky Diodes for both 5V and 3.3V
- Better Magnetic Materials (Sundest Core)
- Better MOSFETs

At Light Load: (CM6802 Key Features)

- Change PFC Boost from 380V to 304V

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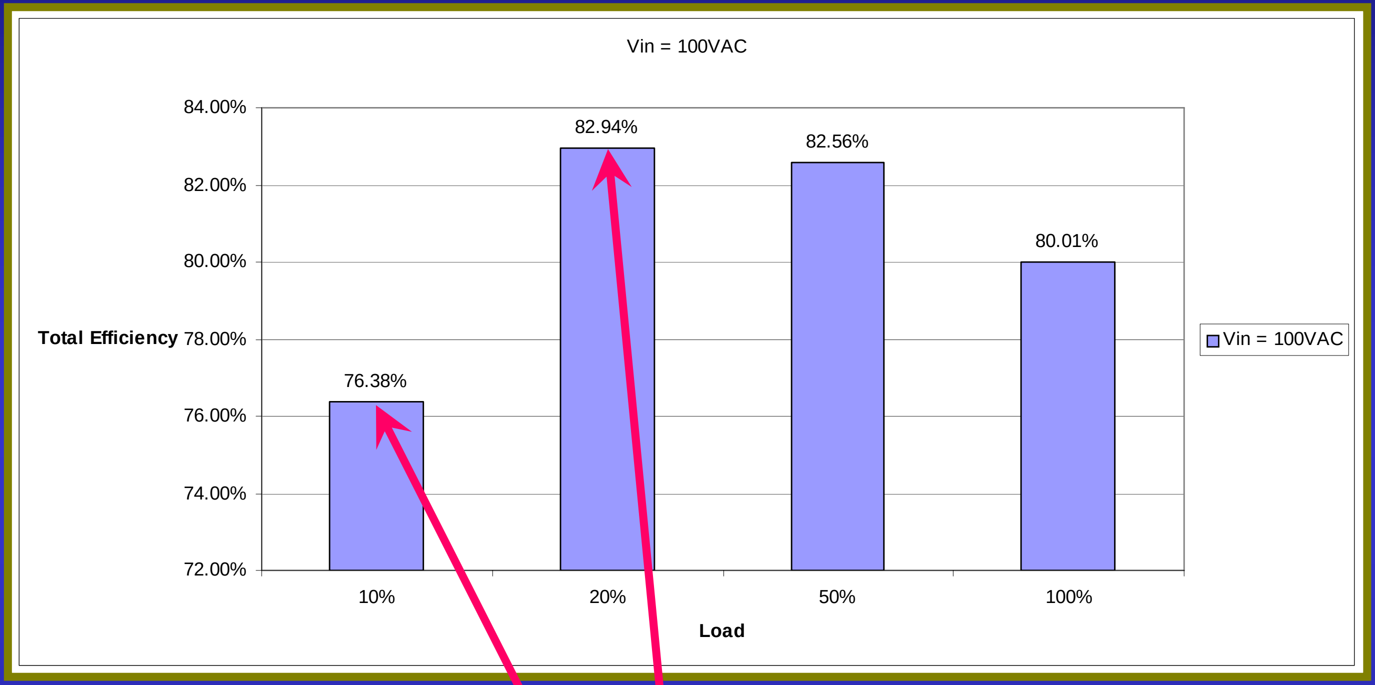
80++ CM6802A/B

80+ CM6800/A

Low Cost CM6805A/B

Archetypal CM6802 (ZVS-Like PFC-PWM Controller)

80++ Power Supply Efficiency



At Full Load:

- DC to DC 3.3V
- Turn Ratio = 10 with D ~ 33%
- Low Volt Schottky Diodes for both 5V and 3.3V
- Better Magnetic Materials (Sundest Core)
- Better MOSFETs

At Light Load: (CM6802 Key Features)

- Change PFC Boost from 380V to 304V
- DC to DC 3.3V remove the 600mW by the Mega Amp

80+ to 82 85 82

80++ CM6802A/B

80+ CM6800/A

Low Cost CM6805A/B

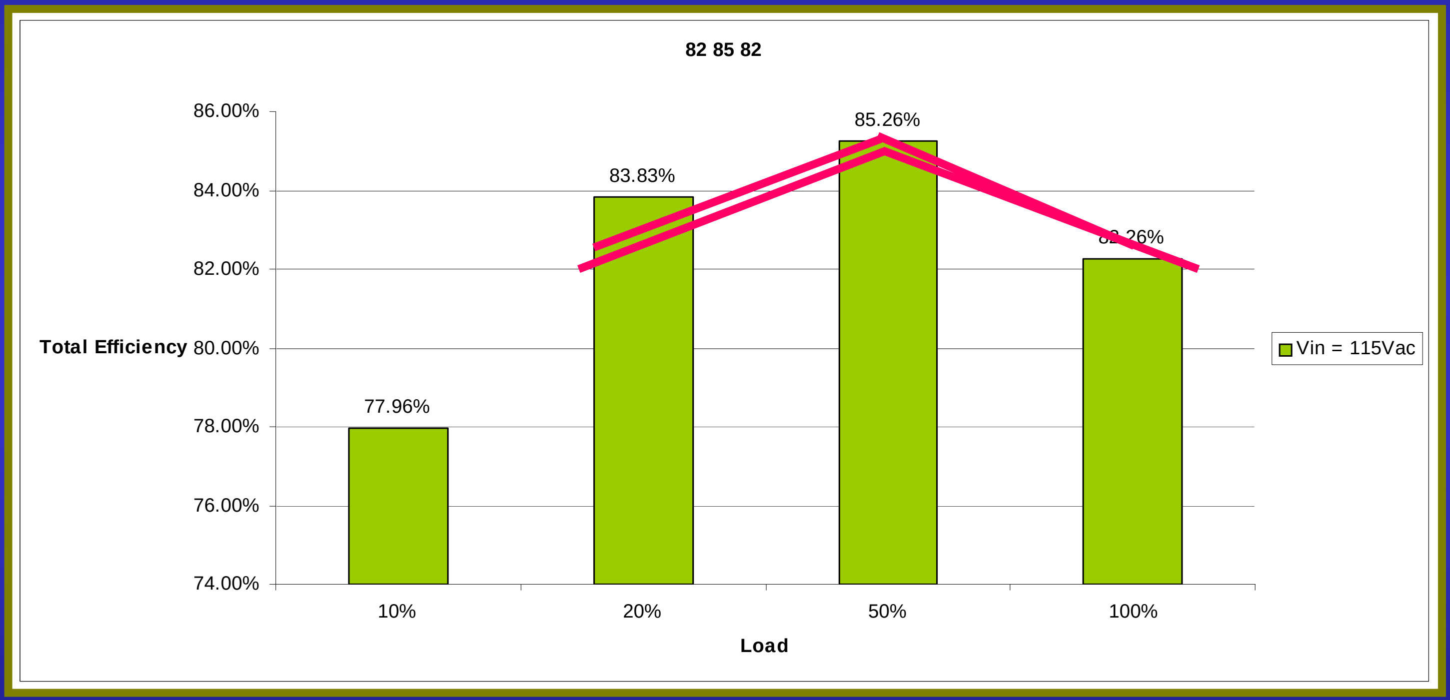
Archetypal CM6802 (ZVS-Like PFC-PWM Controller)

82 85 82 Power Supply Efficiency

80+ to 82 85 82

Power Supply Volume Production Ready

Now



At Full Load:

- DC to DC 3.3V: It improves 2.04% at 50% load and 1.32% at 100% load

At Light Load:

- CM6802: Improve 2% light load
- DC to DC 3.3V due to remove ~ 600mW from Mega Amp Current

80++ CM6802A/B

80+ CM6800/A

Low ... A/B

Performance Gain

80+ to 82 85 82

Saving

1. Efficiency Goes up ~ 1.5% to 2% — US$???

2. Electrical Stress on the Power Device Reduced — US$ 0.25

3. Hold-Up tim — US$ 0.35

4. EMI filter is — US$???

With CM6802,
There is no cost difference
To migrate from 80+ to 82 85 82

5. Monotonic Output is easy — US$???

6. No Load Consumption Drops ~ 0.3 W — US$???

Total Saving greater than US$ 0.60

80+ to 82 85 82

With CM6802,

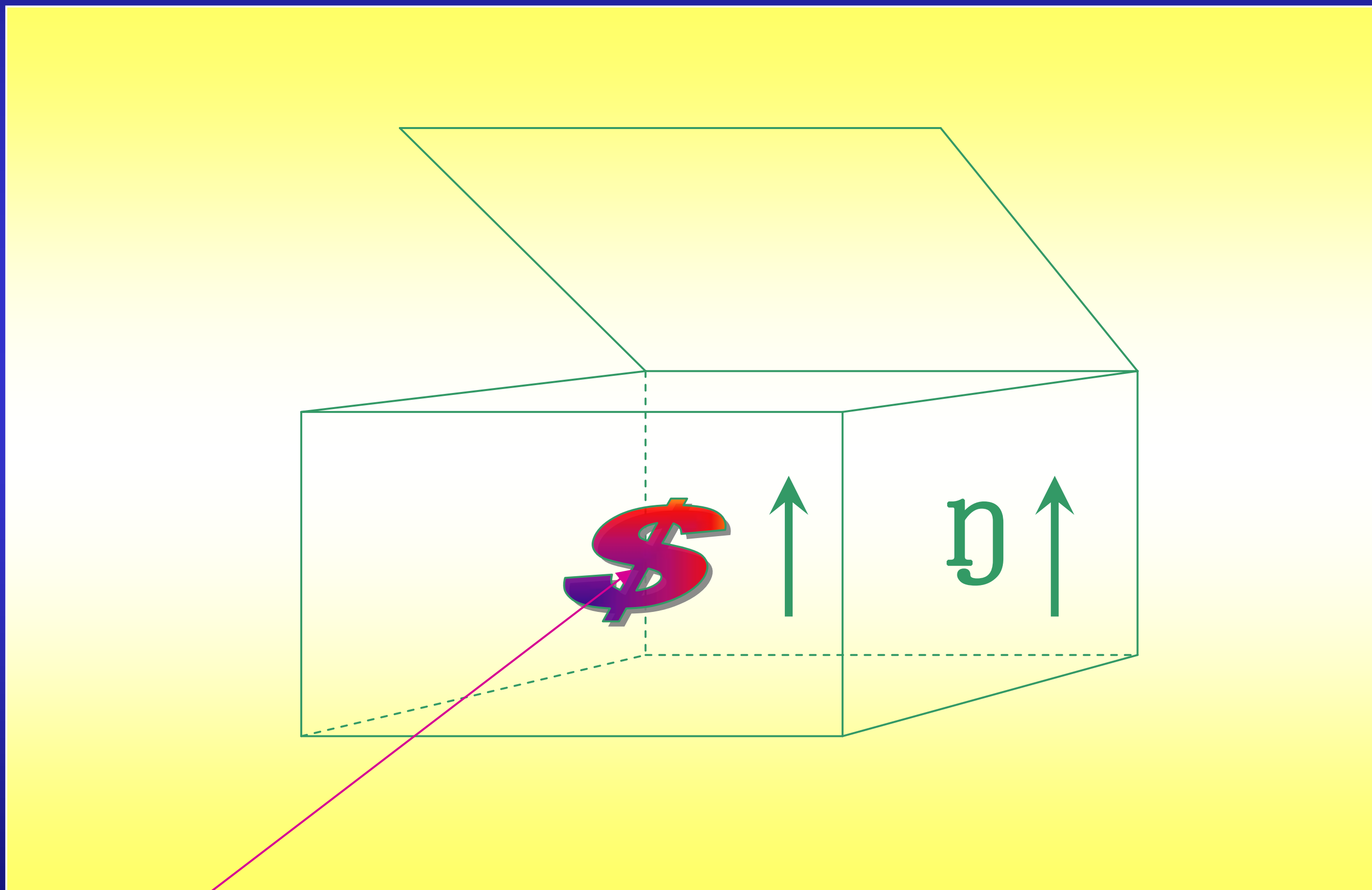
There is no cost difference

To migrate from 80+ to 82 85 82

82 85 82 to 85 85 85

80++ CM6802A/B
80+ CM6800/A
Low Cost CM6805A/B

Efficiency is proportional to cost



Efficiency is limited by the cost!

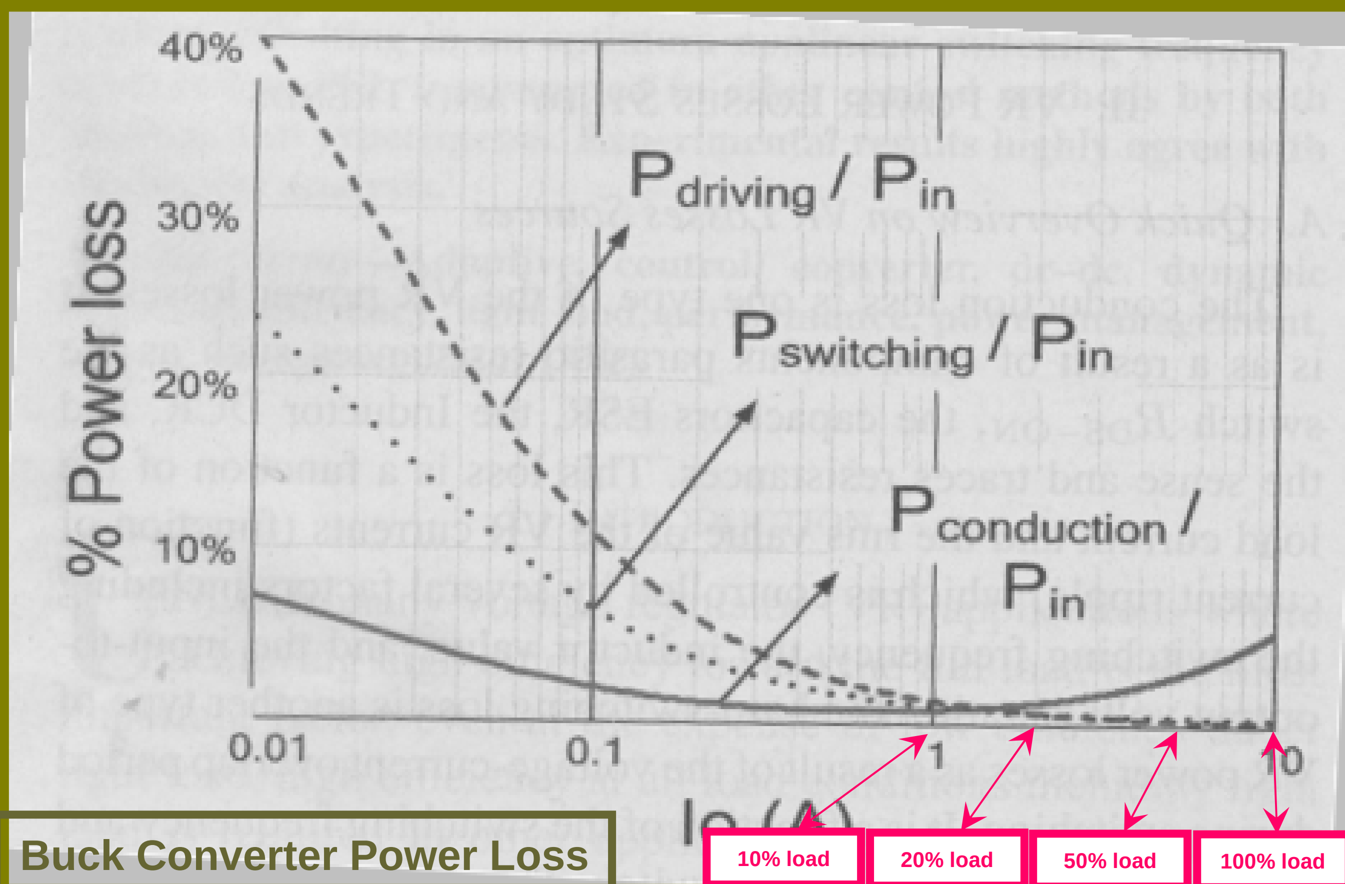
82 85 82 to 85 85 85

80++ CM6802A/B
80+ CM6800/A
Low Cost CM6805A/B

We know that…

Effici … ortional to cost

Reduce Vin
To reduce Switching Loss!



Buck Converter Power Loss

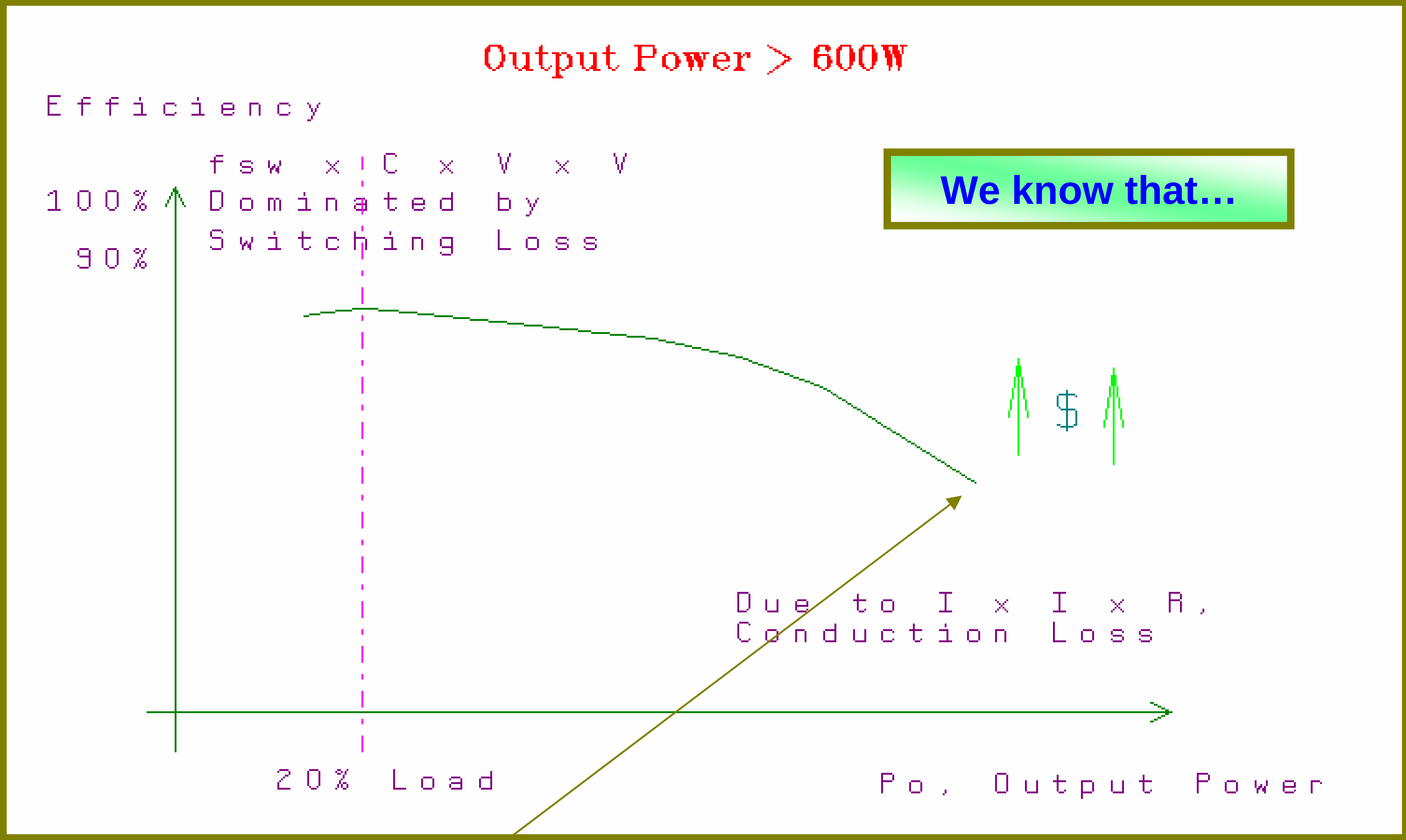
82 85 82 to 85 85 85

80++ CM6802A/B

80+ CM6800/A

Low Cost CM6805A/B

Efficiency is proportional to cost



We know that…

We can focus on improving the full load efficiency!

82 85 82 to 85 85 85

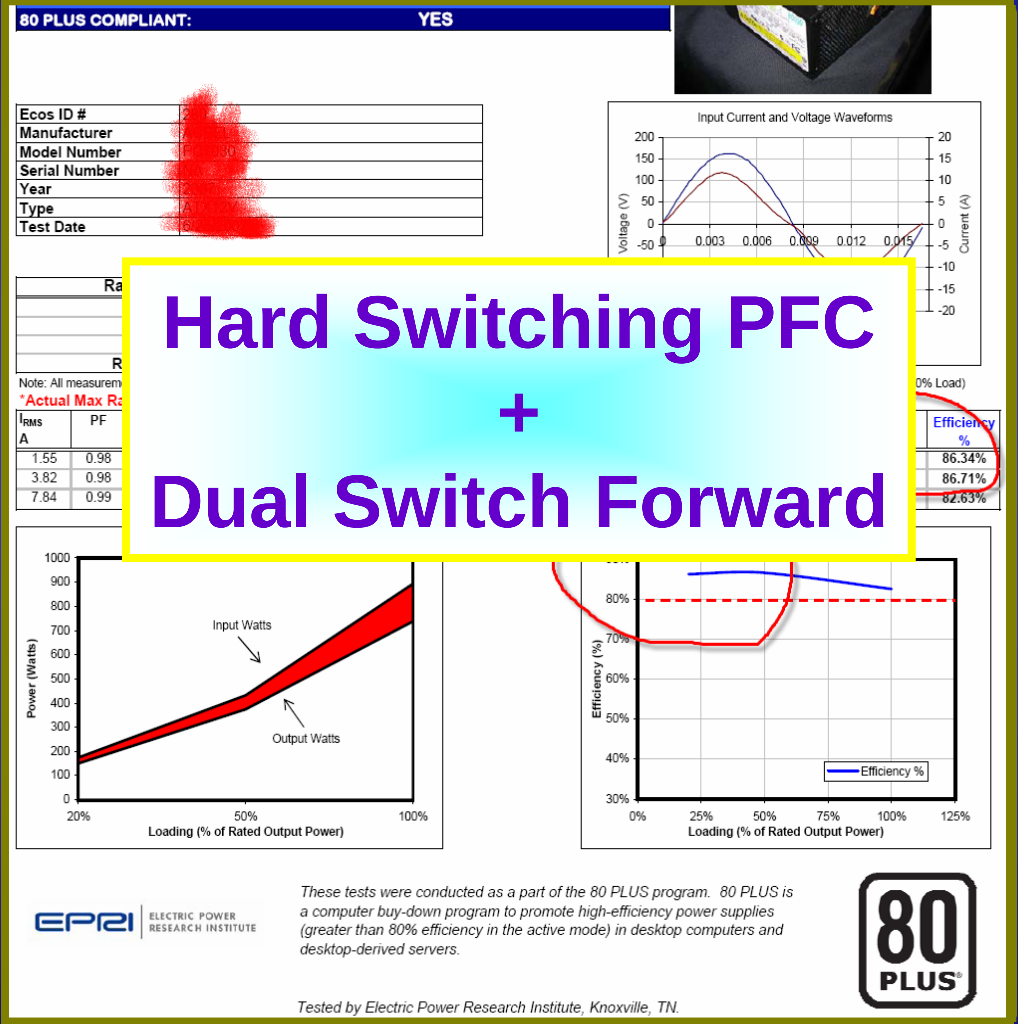
80++ CM6802A/B

80+ CM6800/A

Low Cost CM6805A/B

Efficiency is proportional to cost

Let us brute force it first!



Hard Switching PFC

+

Dual Switch Forward

- 750W: Efficiency ~ 86.71% @ 374W
- 850W: Efficiency ~ 85.58% @ 431W
- 1000W: Efficiency ~ 86.45% @ 498W
- 750W: Efficiency ~ 85.34% @ 378W
- 475W: Efficiency ~ 85.29% @ 240W
- 1000W: Efficiency ~ 85.24% @ 494W
- 850W: Efficiency ~ 85.25% @ 428W
- 560W: Efficiency ~ 85.08% @ 283W
- 1000W: Efficiency ~ 84.75% @ 507W
- 600W: Efficiency ~ 84.71% @ 302W
- 700W: Efficiency ~ 84.46% @ 352W

Efficiency is not limited by the topology!

82 85 82 to 85 85 85

Where to start the project?
What is our priority?

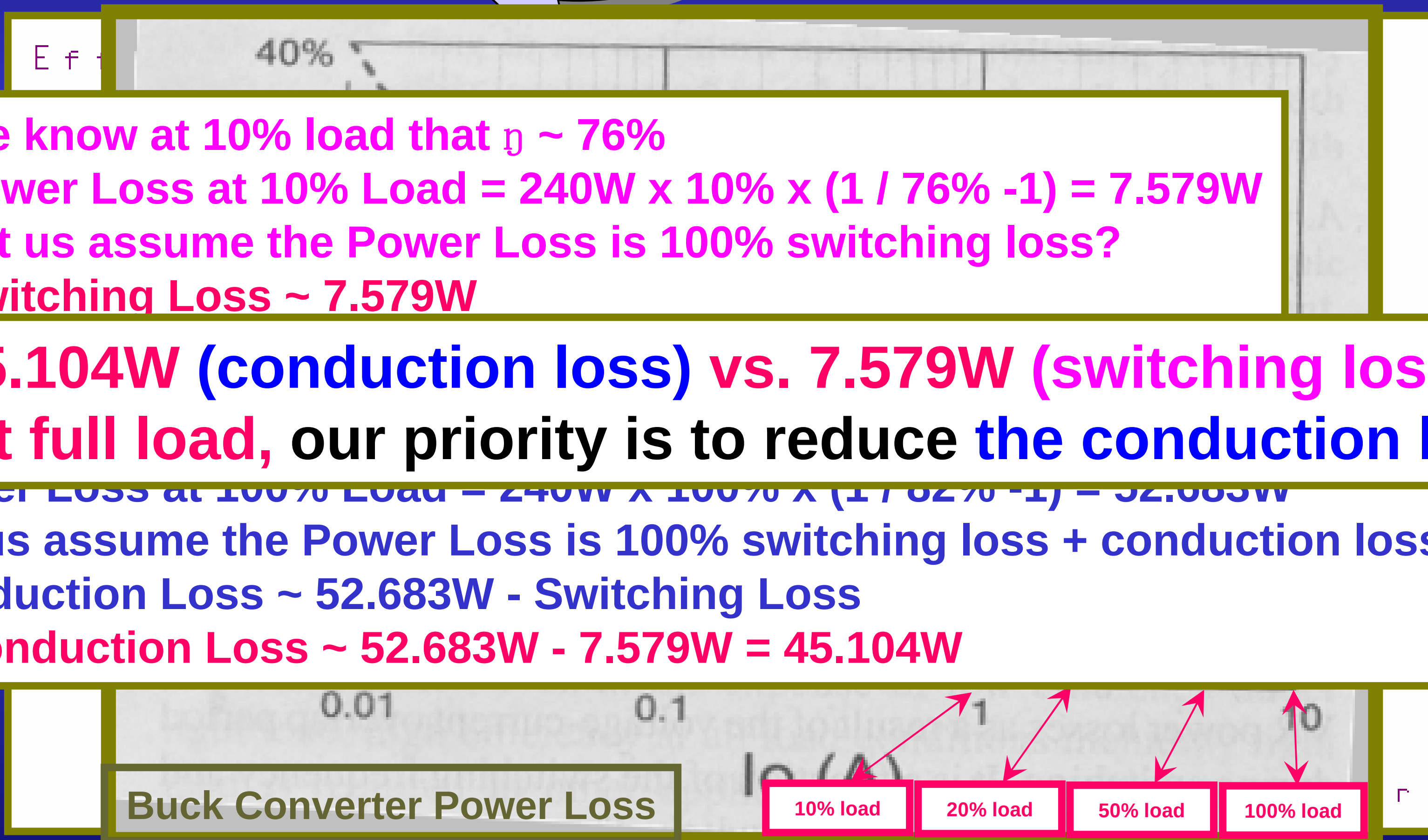
82 85 82 to 85 85 85

80++ CM6802A/B
80+ CM6800/A
Low Cost CM6805A/B

We know that…

Reduce Vin
To reduce Switching Loss!

Effici… …rtional to cost



We know at 10% load that ŋ ~ 76%
Power Loss at 10% Load = 240W x 10% x (1 / 76% -1) = 7.579W
Let us assume the Power Loss is 100% switching loss?
Switching Loss ~ 7.579W

45.104W (conduction loss) vs. 7.579W (switching loss)
∴ at full load, our priority is to reduce the conduction loss

Let us assume the Power Loss is 100% switching loss + conduction loss
Conduction Loss ~ 52.683W - Switching Loss
∴Conduction Loss ~ 52.683W - 7.579W = 45.104W

Buck Converter Power Loss

Example with a 240W Power Supply

82 85 82 to 85 85 85 With CM6802

Priority: Drop Conduction Loss

Pconduction ~ 45.104W = I x I x R

We can drop I

or

We can drop R

Example with a 240W Power Supply

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80++ CM6802A/B
80+ CM6800/A
Low Cost CM6805A/B

Our Ultimate Target is to reduced 6W by reducing R.

For Conduction Loss, We can drop R

At Full Load, 82% to 85% for a 240W Power Supply

We need to reduce 11W from the Conduction Loss
(3.666 W ~ 1%)

- Increase the Heat Sink Area to reduce MOSFET temperature
- Add Schottky Diodes to parallel with the bottom MOSFET (only the bottom one) at SR to reduce Qrr

For Pout = 240W:

- *SR at 12V, I12 x Vf = 12A x 0.6V = 7.2W --- 12A x 12A x 0.02 = 2.88W … Δ = 4.32W … 1.1782%*
- *SR at 5V, I5 x Vf = 11A x 0.33V = 3.64W --- 11A x 11A x 0.02 = 2.42W … Δ = 1.22W … 0.332%*
- Total diode loss = 10.84W ……. SR loss = 5.3W … Δ = 5.30W … 1.44545%
- **Total Δ = 5.30W + 4.187W = 9.487W**
- 2 Layer PCB with 4 ounces thickness … 1% 2 to 4 ounces
- Change PFC Boost Inductor Core from Sundest to Ferrite Pot Core…Δ = 4.187W…1.142%
- Switching Frequency Drops to 58Khz from 67.5Khz
- Reduce Rise Time and Fall Time for the 2 gate drives below 100nS…. Δ = 3.6W (However, PFC gate drive rise time needs to be slow) …1.03%

Example with a 240W Power Supply

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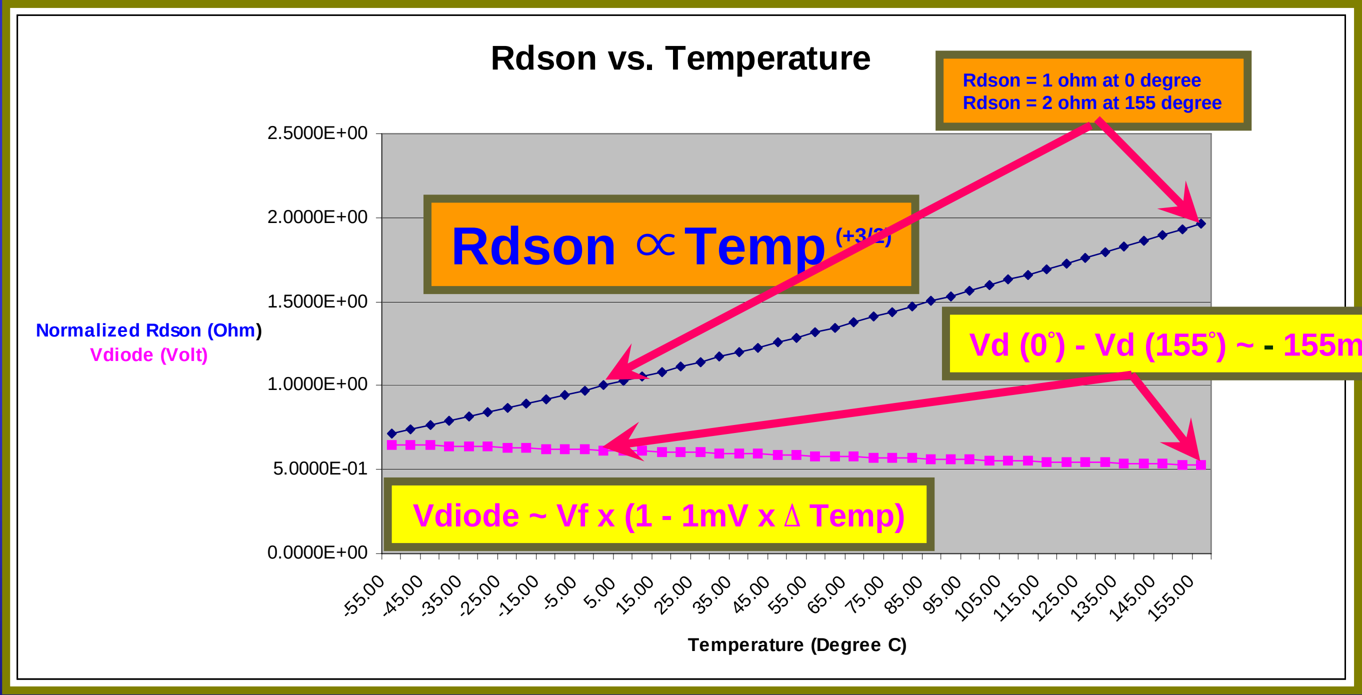
80++ CM6802A/B
80+ CM6800/A
Low Cost CM6805A/B

Our Ultimate Target is to reduced 6W by reducing R.

For Conduction Loss, We can drop R

Mosfet Rdson and Vd vs. Temp



In Order for SR with MOSfet works properly!
The temperature of MOSfet has to be cooled down.
It means more Heat Sinks!

Example with a 24

82 85 82 to 85 85 85
With CM6802

80++ CM6802A/B
80+ CM6800/A
Low Cost CM6805A/B

To Boost Efficiency at Light Load, 80% to 85% for a 20% x 300W = 60W Power Supply

We need to reduce 4.41W from the switching loss

- Change PFC Boost Inductor Core from Sundest to Ferrite Pot Core…Δ = 0.5 W...0.7%
- Drop from 380V to 304V… Δ = 1.4W ··· 2%
- Drop from 67.5Khz to 58Khz…. Δ = 1.5W ···2.2%
- Reduce Rise Time and Fall Time for the 2 gate drives …. Δ = 0.3W … 0.425%
- Due to SR, Dual Switch Forward is at CCM, we can remove the dummy load…… Δ = 0.3W ··· 0.425%

- **Total Δ = 4W**

Example with a 240W Power Supply

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80++ CM6802A/B

80+ CM6800/A

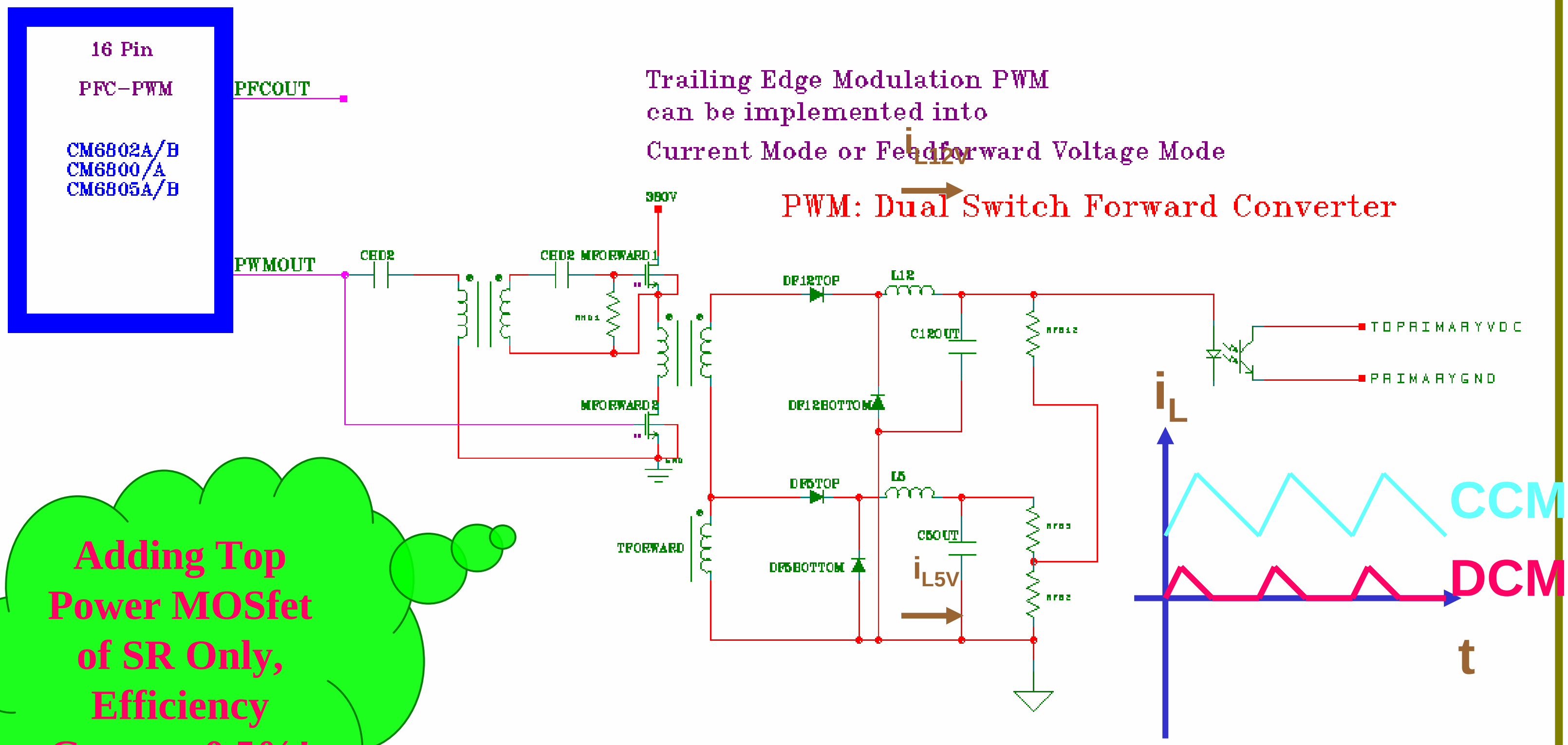
Low Cost CM6805A/B

Our Ultimate Target is to reduced 6W by reducing R.

For Conduction Loss, We can drop R

Champion 80++ Solution with Lowest Cost

Champion 80+ Solution with Lowest Cost



Adding Top Power MOSfet of SR Only, Efficiency Goes up 0.5%!

Adding Top SR, η improved from 82% to 82.5%

Example with a 240W Power Supply

Our Ultimate Target is to reduced 6W by reducing R.

82 85 82 to 85 85 85 With CM6802

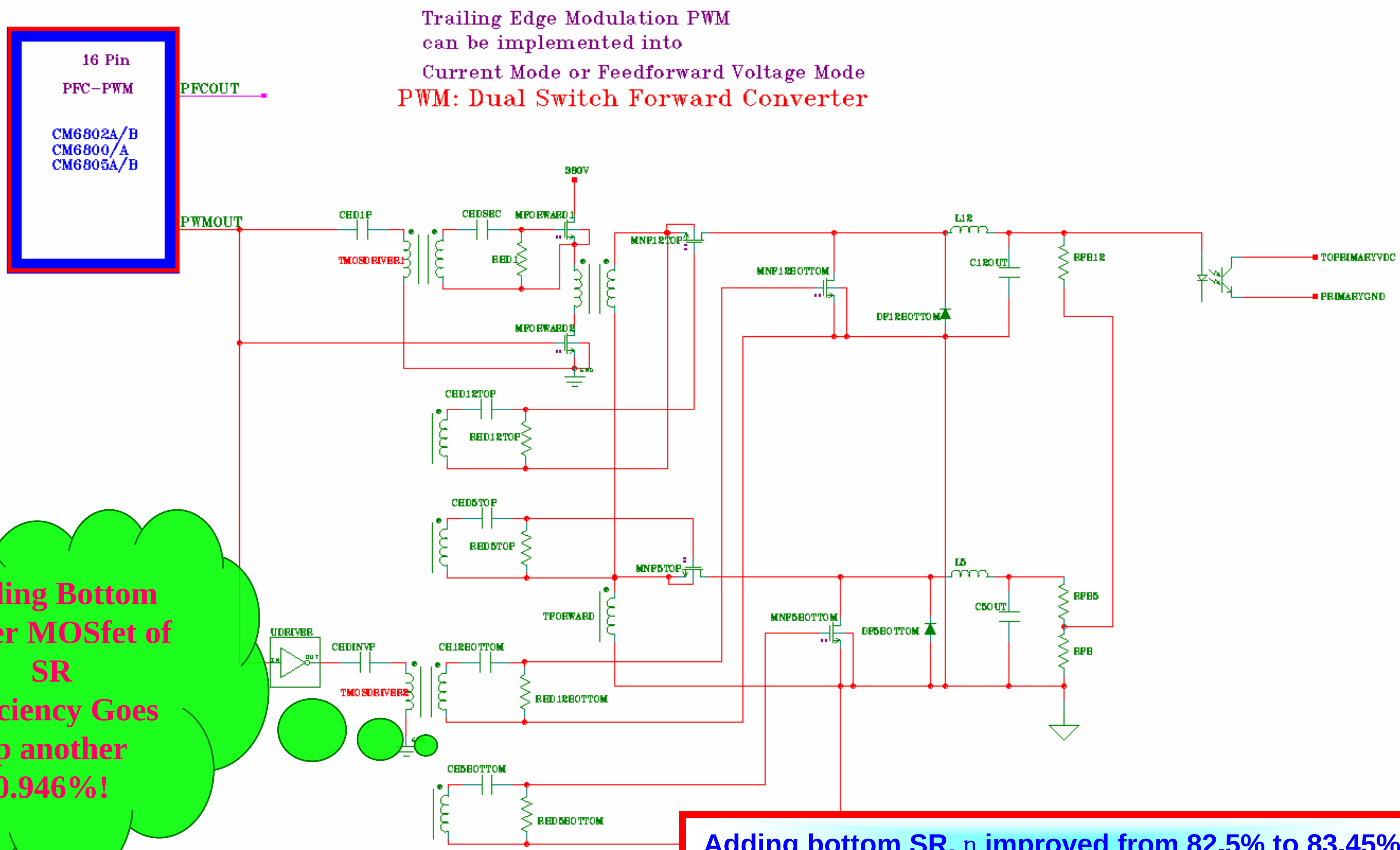
For Conduction Loss, We can drop R

80++ CM6802A/B

80+ CM6800/A

Low Cost CM6805A/B

Champion 85+ Solution with Lowest Cost



Adding Bottom Power MOSfet of SR Efficiency Goes up another 0.946%!

Adding bottom SR, η improved from 82.5% to 83.45%

Example with a 240W Power Supply

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82 85 82 to 85 85 85 With CM6802

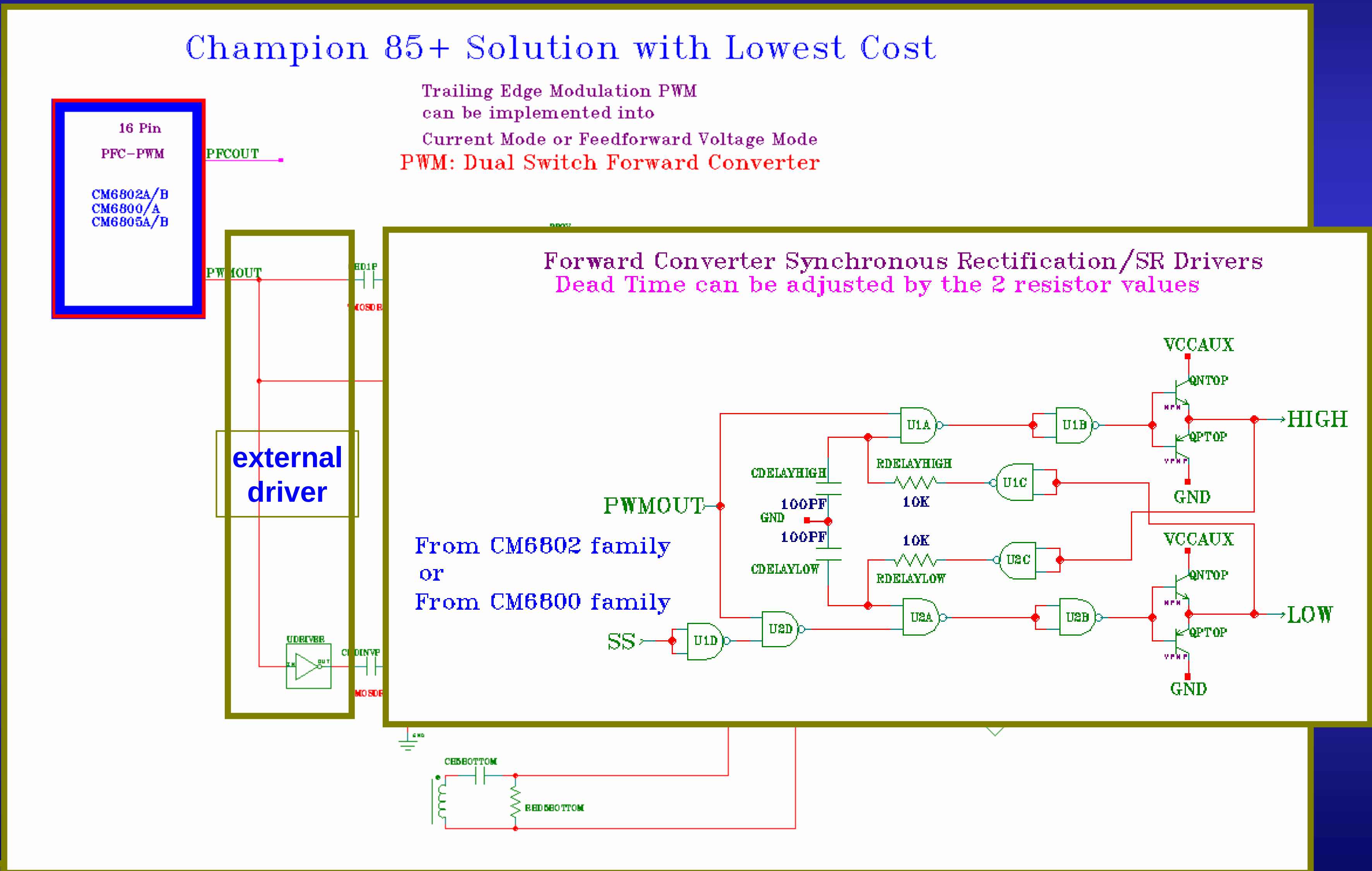
80++ CM6802A/B

80+ CM6800/A

Low Cost CM6805A/B

Our Ultimate Target is to reduced 6W by reducing R.

For Conduction Loss, We can drop R



Example with a 240W Power Supply

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Our Ultimate Target is to reduced 6W by reducing R.

82 85 82 to 85 85 85 With CM6802

80++ CM6802A/B

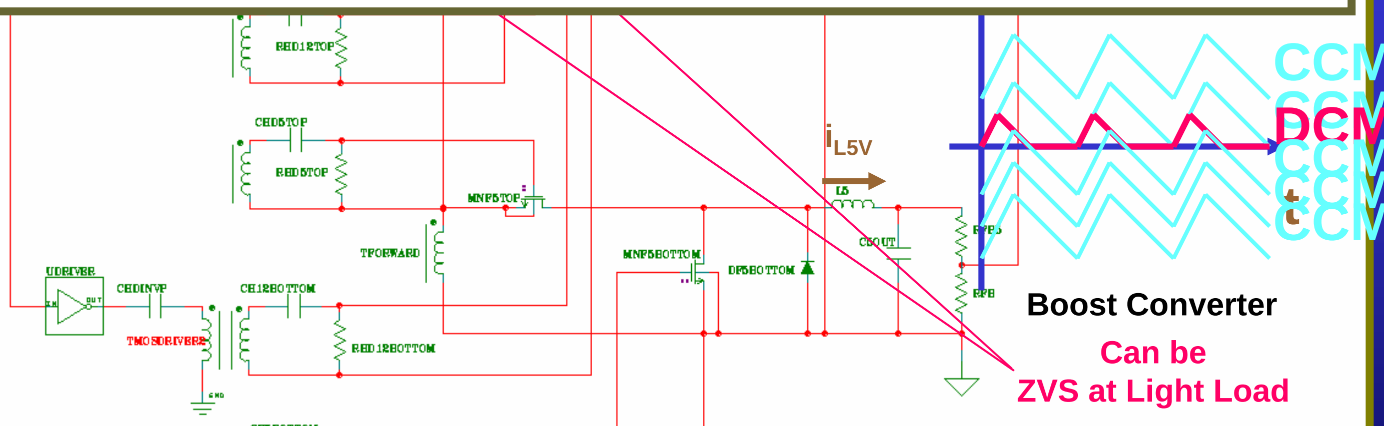
80+ CM6800/A

Low Cost CM6805A/B

For Conduction Loss, We can drop R

Champion 85+ Solution with Lowest Cost

Top and Bottom Switch SR
Causes
Forward Converter always in the CCM,
It means Vout = Vin x n x D.
Since Vin & n are ~ constant, D is ~ constant.
Cross regulation is easy and 3.3V can be using the same transformer.
Output Filter Cross Couple Inductor can be smaller.
Efficiency goes up because DCR goes down.



Now, η improved from 82% to 83.45%

In Order for SR with MOSfet works properly!
the temperature of MOSfet has be cooled down
It means more Heat Sinks!

80++ CM6802A/B

80+ CM6800/A

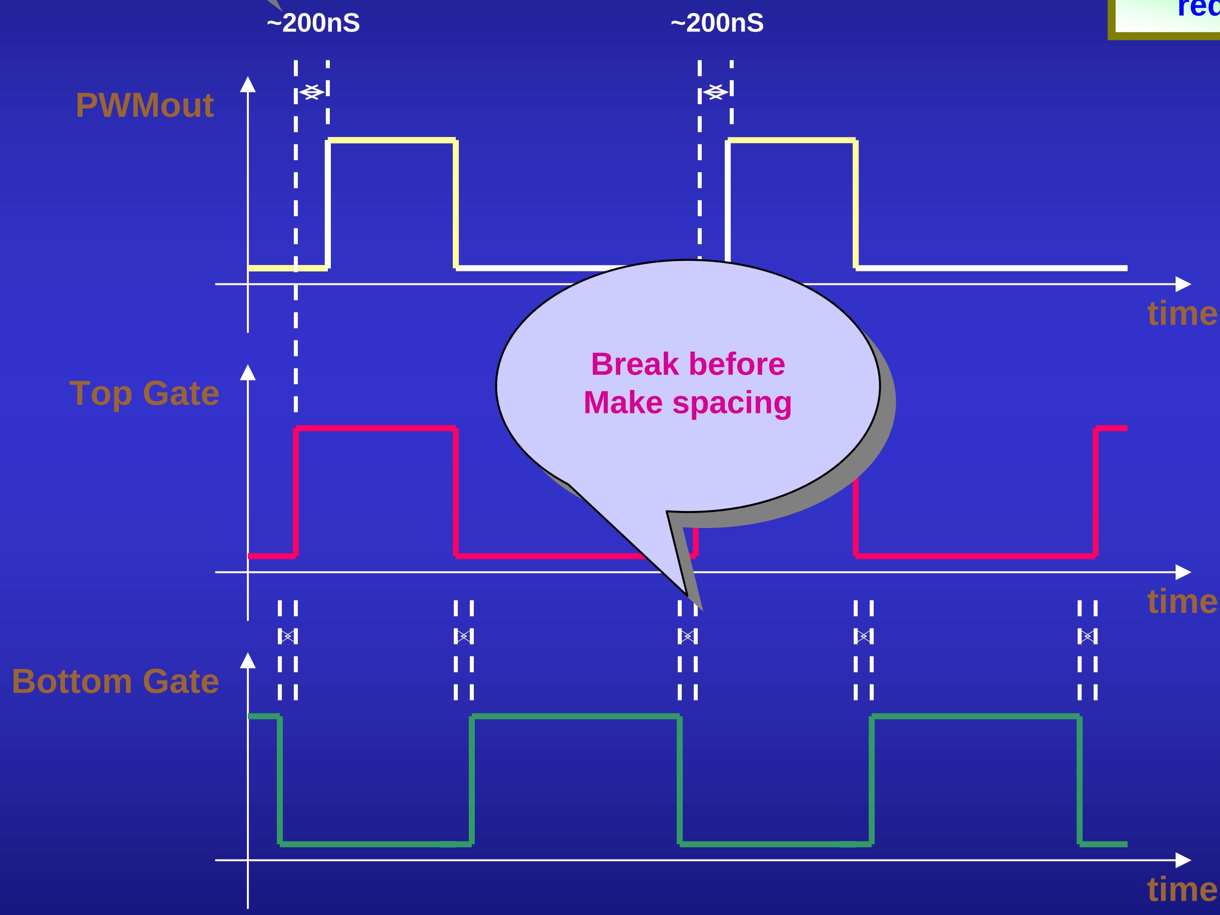
Low Cost CM6805A/B

For ZVS

82 85 82 to 85 85 85
With CM6802

For Conduction Loss, We can drop R

Our Ultimate Target is to reduced 6W by reducing R.



Gate Drive Timing Diagram

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80++ CM6802A/B
80+ CM6800/A
Low Cost CM6805A/B

82 85 82 to 85 85 85
With CM6802

Summary

1. Using ZVS-Like PFC-PWM combo, CM6802 to boost light load η
2. 80+ to 82 85 82 = CM6802 + 3.3V DC to DC (Same Cost as 80+ and Ready) :
   - Industry standard
   - High Volume Manufacture Ready
   - Similar Inventory
3. 80+ to 85 85 85 = CM6802 Solution Identified = Hard Switching PFC + Dual Forward + SR for 12V and 5V
4. Cost Effective 85 85 85 = CM6808 = Hard Switching PFC + Dual Forward + SR for 12V and 5V + Smart Transformer*: Best Solution in the long Run (*Patent Pending)
5. Other improvements: such Ferrite Core for PFC, Increase Turn Ratio, Improve Totem Pole to reduce rise time, Reduce Frequency from 67.5Khz to ~ 57Khz …