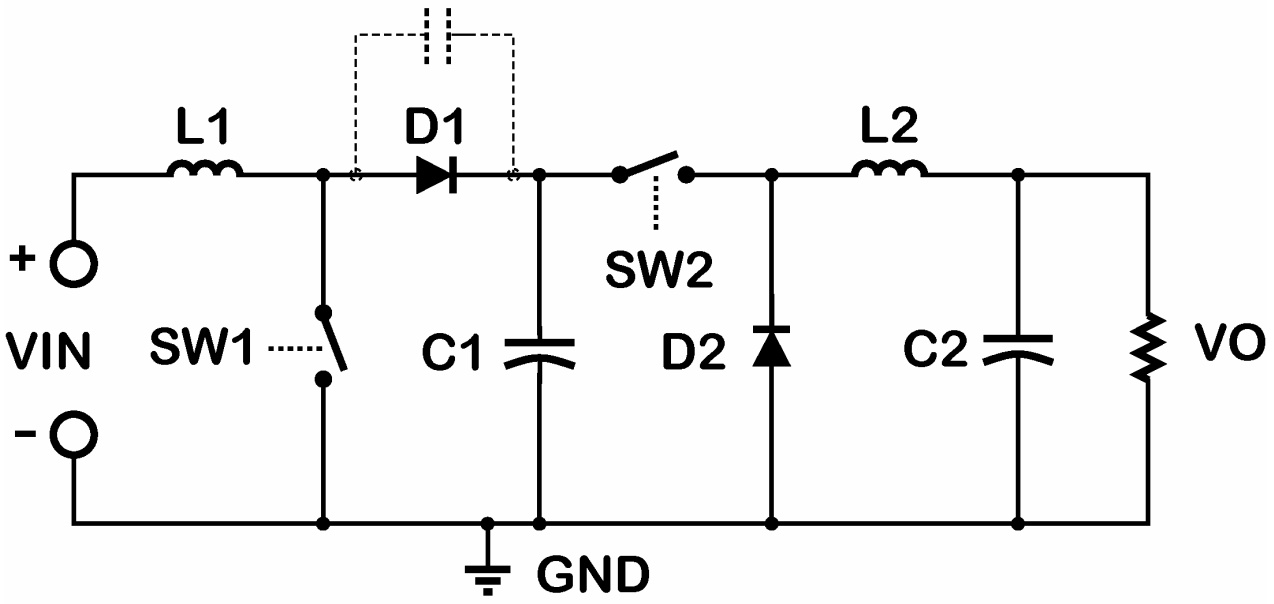
# Reduce the 400V Boost Capacitor




A Cascade Boost-Buck Power Converter
Without Synchronous Switching

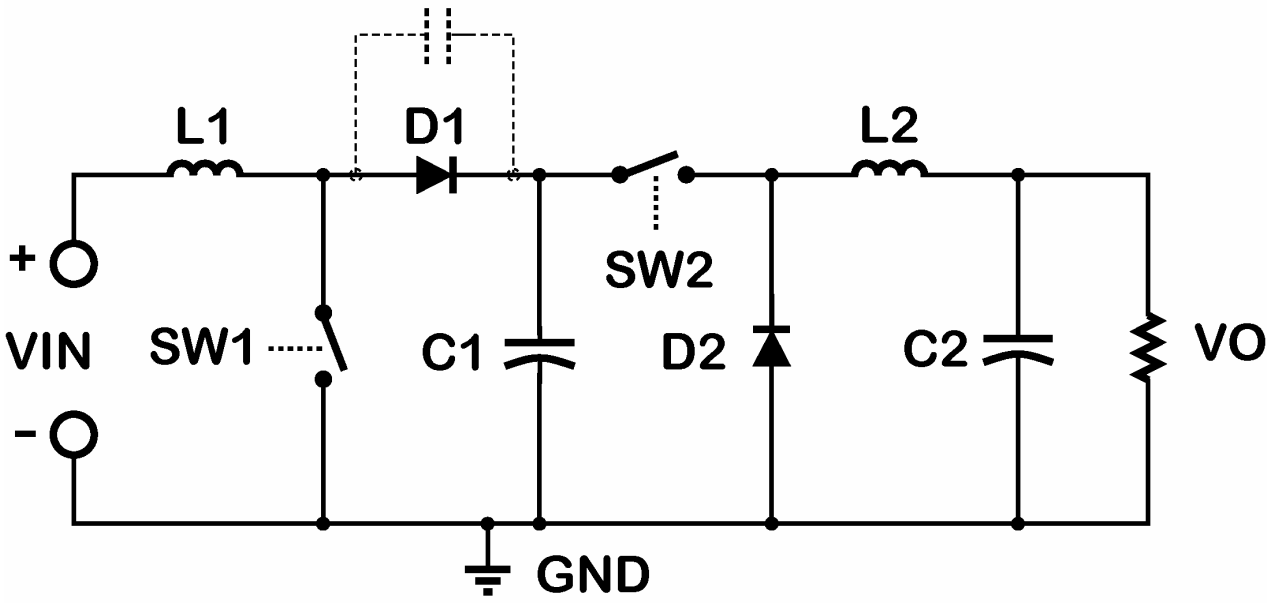
# Leading Edge Modulation PFC

+

# Trailing Edge Modulation PWM

- to reduce the 400V Boost Capacitor value by 20%
- Bandwidth increases
- Higher Efficiency
- Better reliability

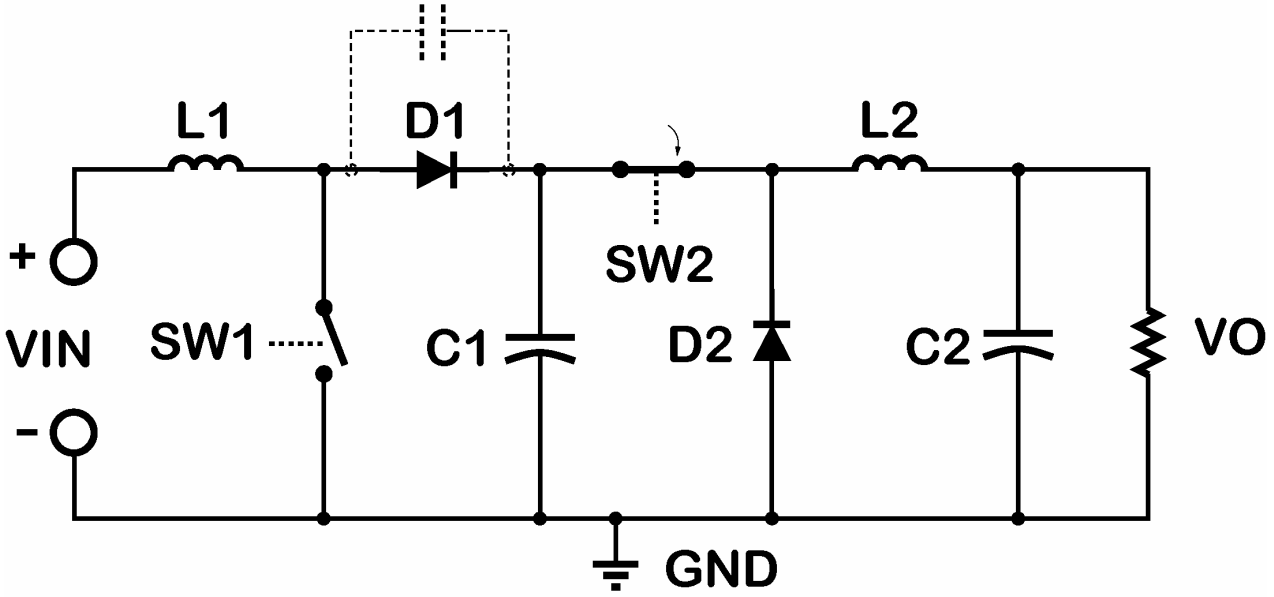
## Reduce the 400V Boost Capacitor




A Cascade Boost-Buck Power Converter
Without Synchronous Switching

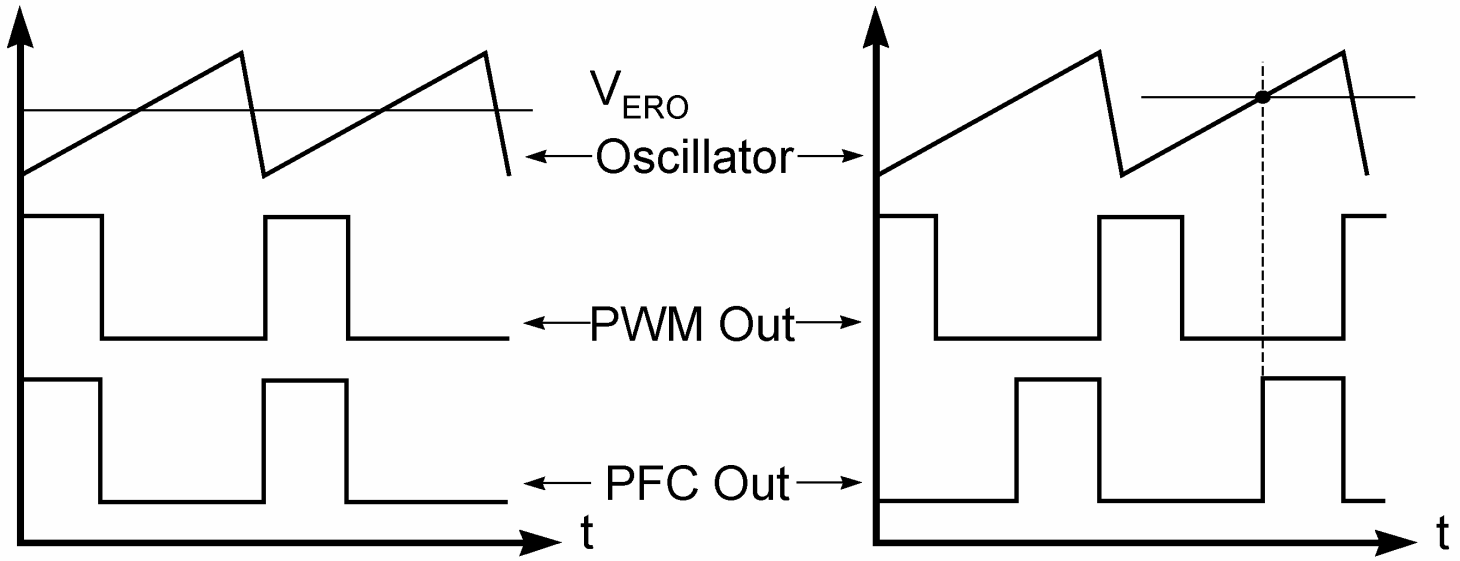
# Reduce the 400V Boost Capacitor

**Leading Edge Modulation PFC and Trailing Edge Modulation PWM for PFC Output Ripple Reduction**




**Synchronous Switching Cascade Power Converter**

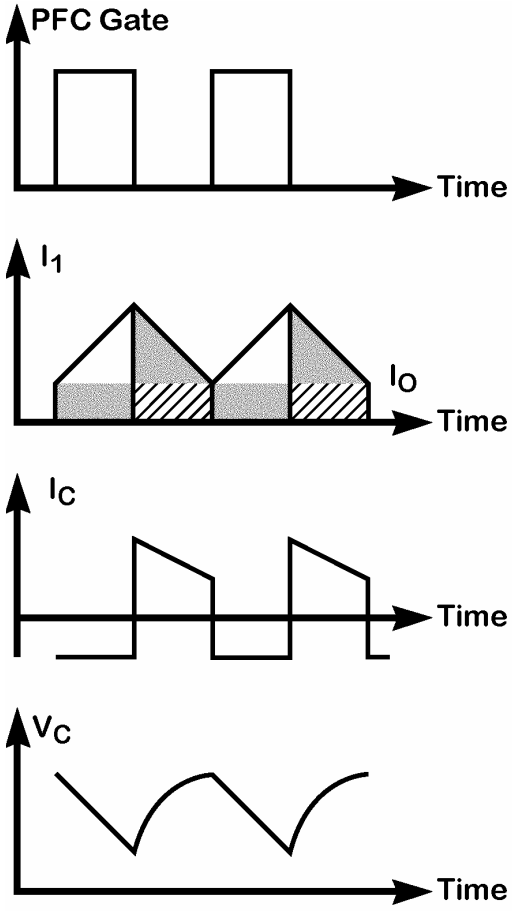
# The ML4824 vs "Other" Combo Controllers



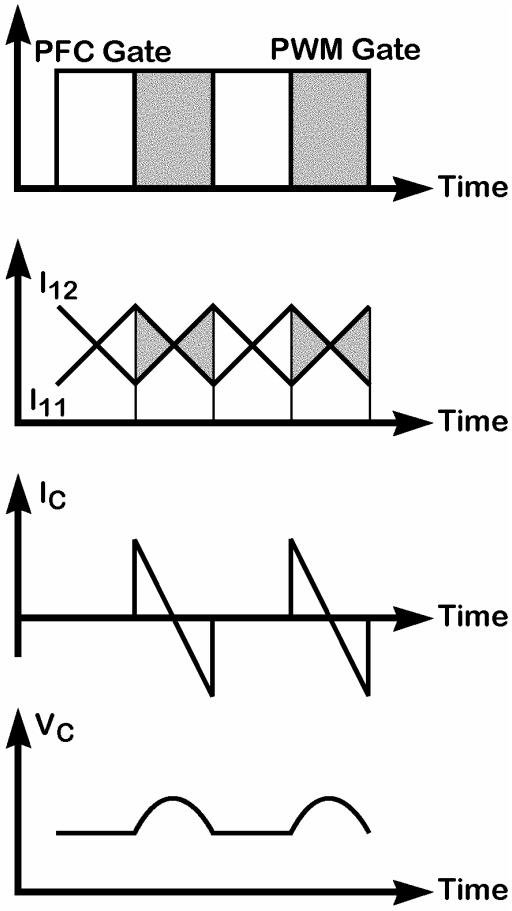

Conventional Combos use Trailing/ Trailing Edge Modulation Scheme.

The ML4824 uses Trailing Edge PWM and Leading Edge PFC for Optimum PFC to PWM Inductor Charge Transfer.

# Reduce the 400V Boost Capacitor




Boost Stage with a Constant Current Loss

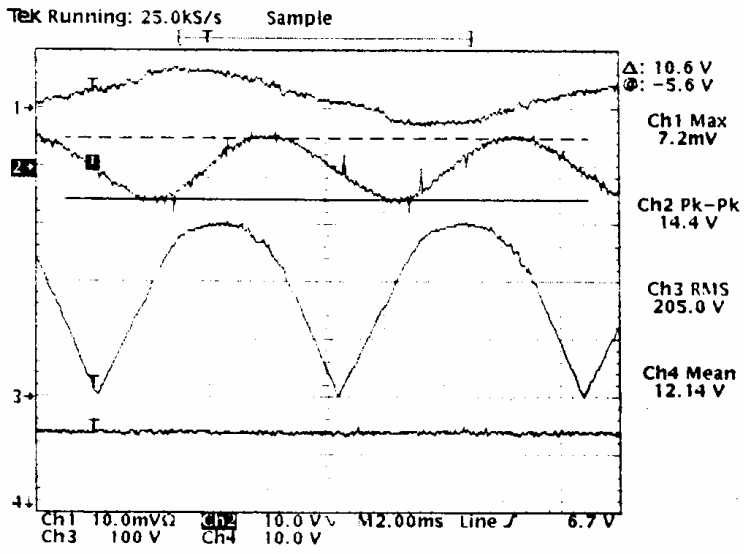



Cascade Power Stage with Synchronous Switching

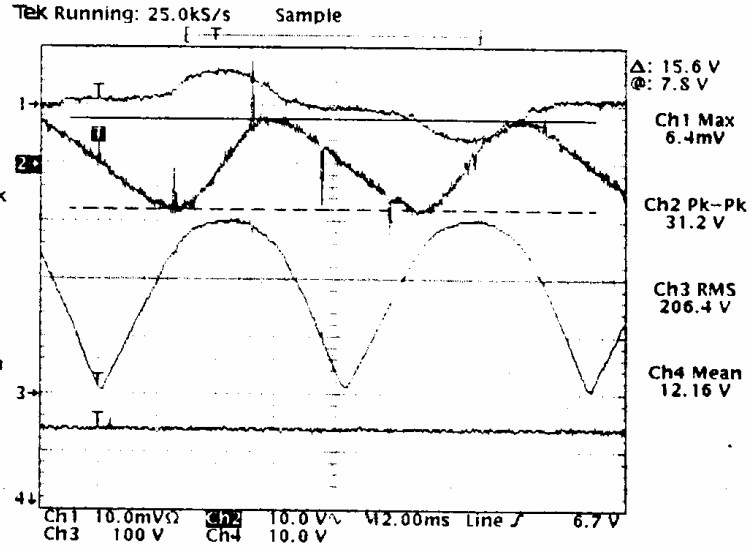
# ML4824 vs. ML4819 EXPERIMENTAL RESULTS

Test Conditions: $V_{IN}$ = 220VAC, $P_{IN}$ = 75W,
$f_{PFC}$ = 80kHz, $C_{PFC}$ = 50µF, $L_{PFC}$ = 1.5mH

## ML4824 TEST RESULTS

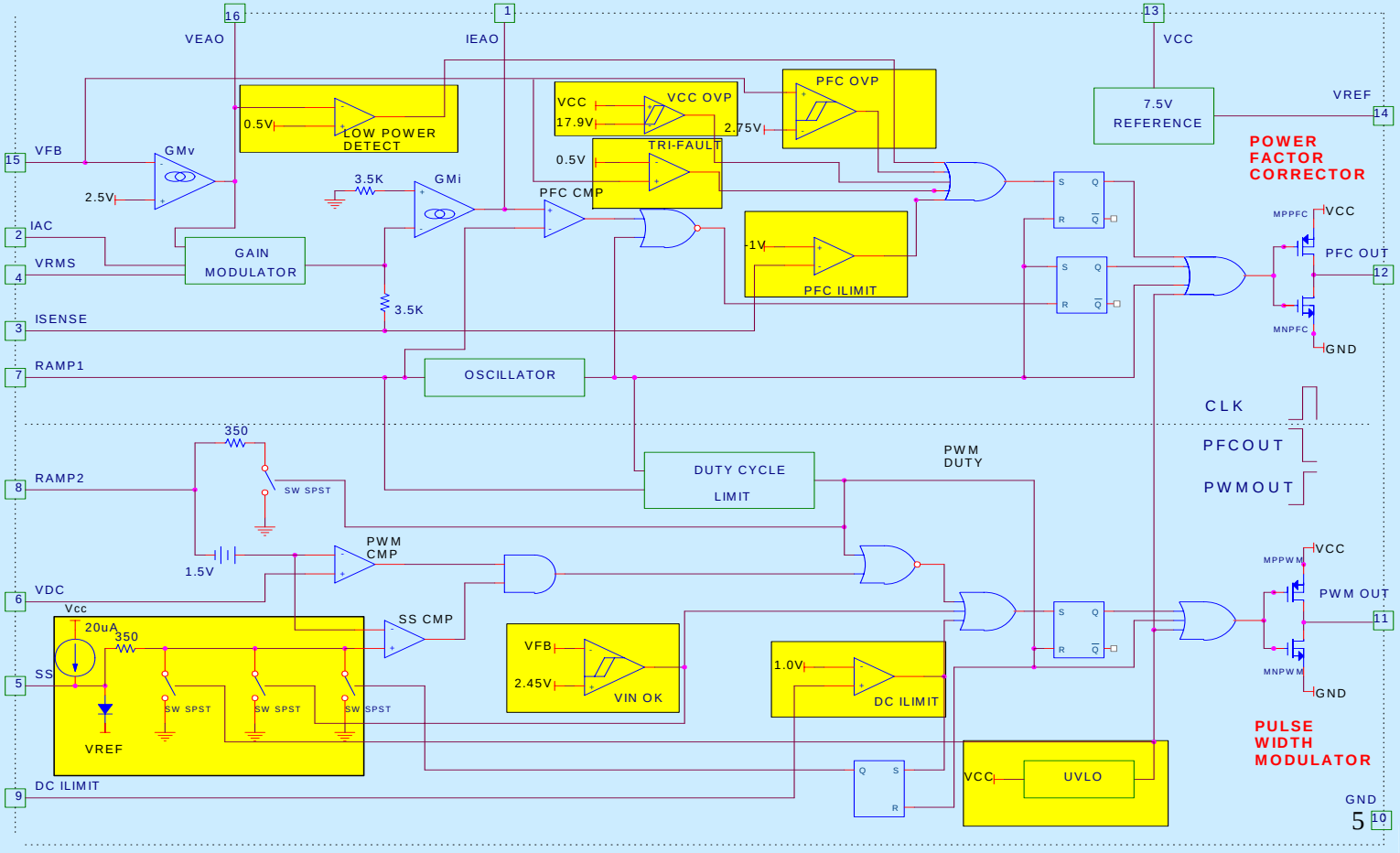



## ML4819 TEST RESULTS

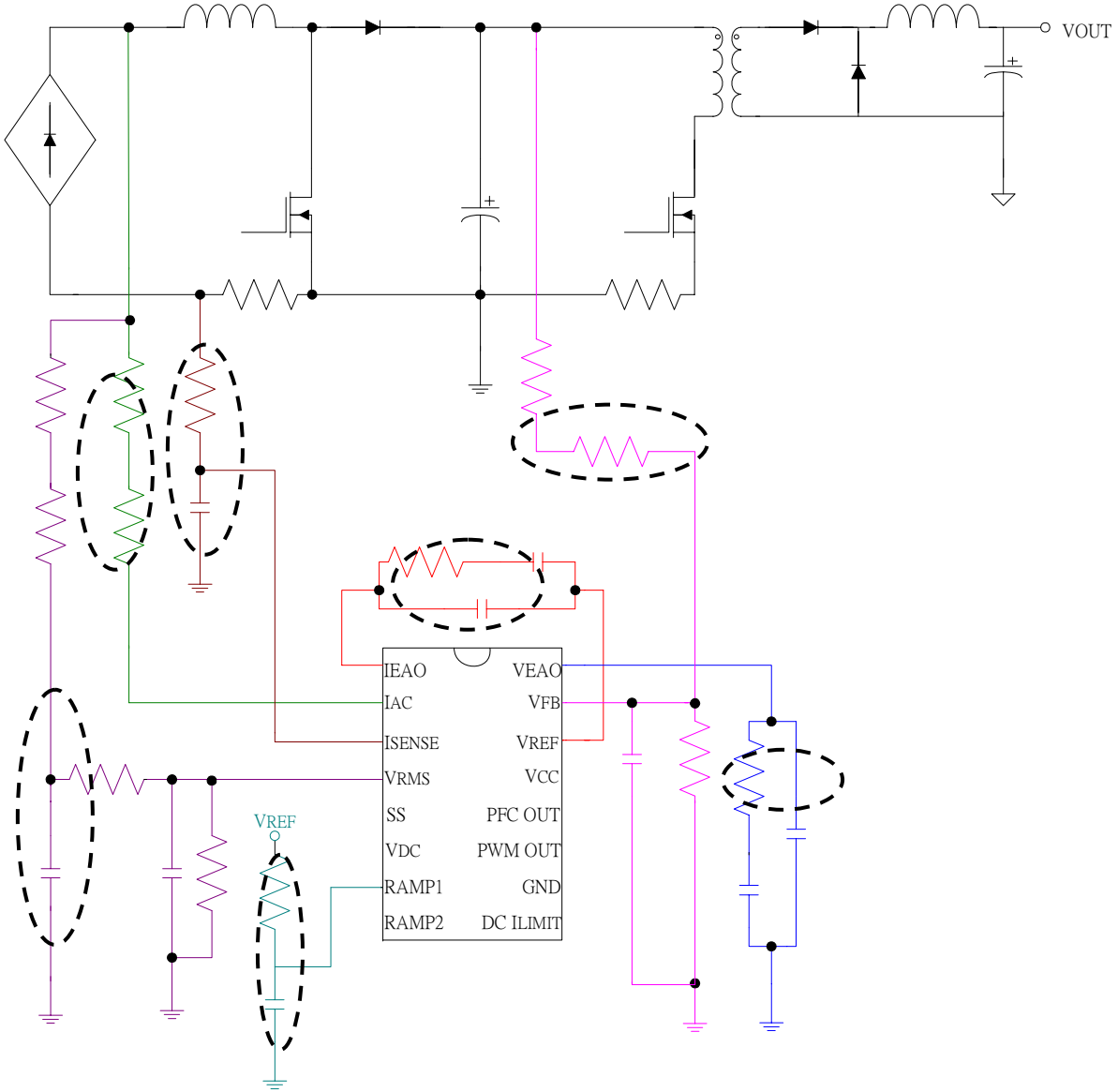


# 6800 Basic

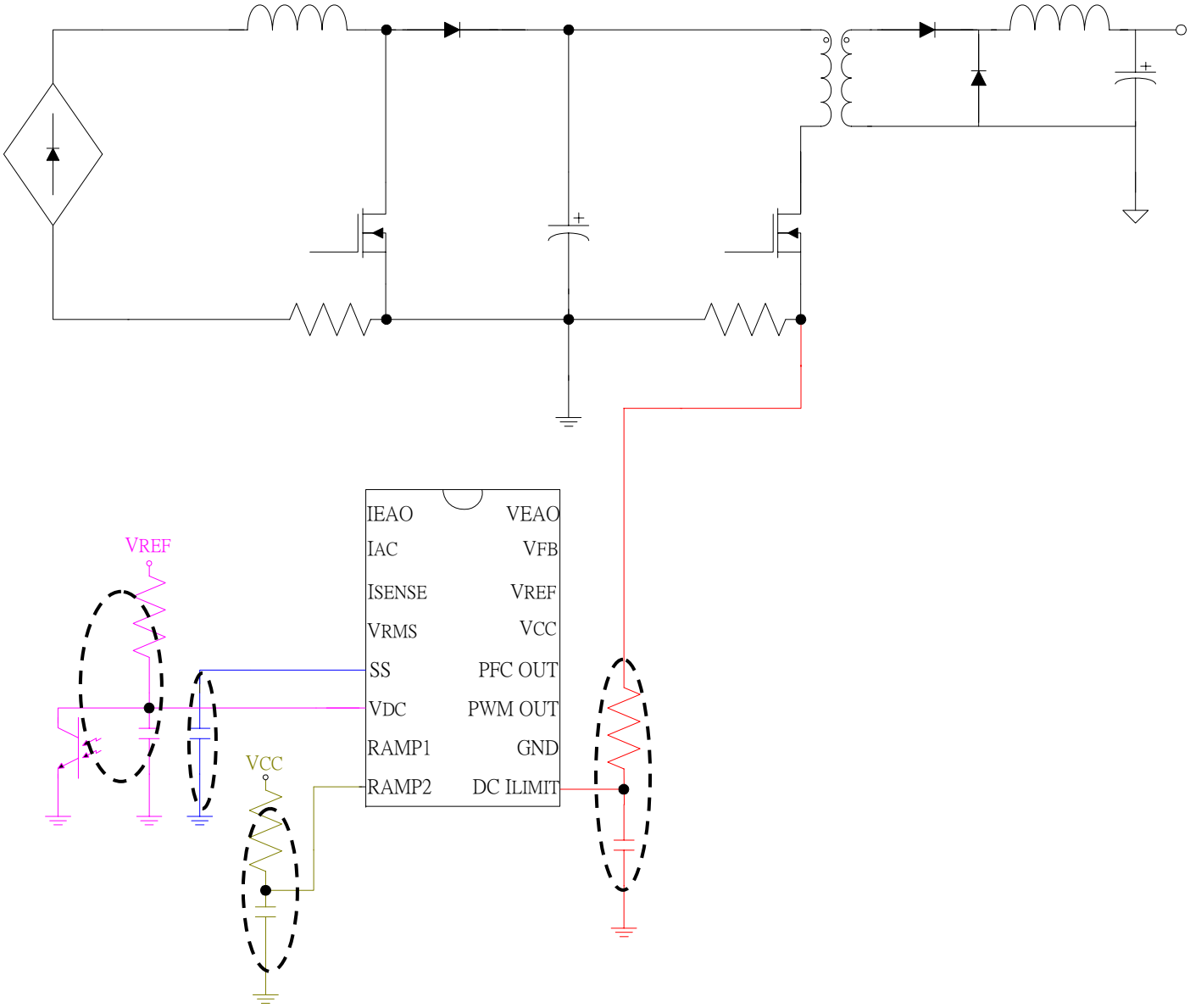
## CM6800 Block



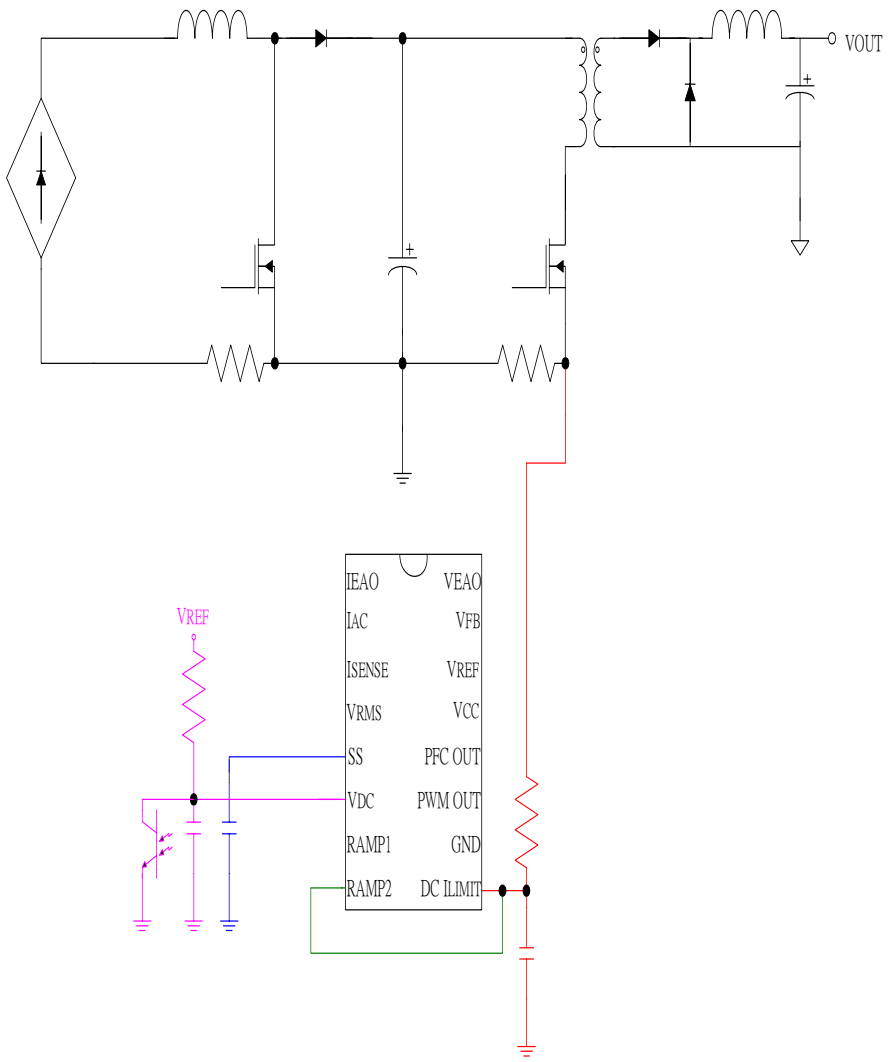
# PFC Block

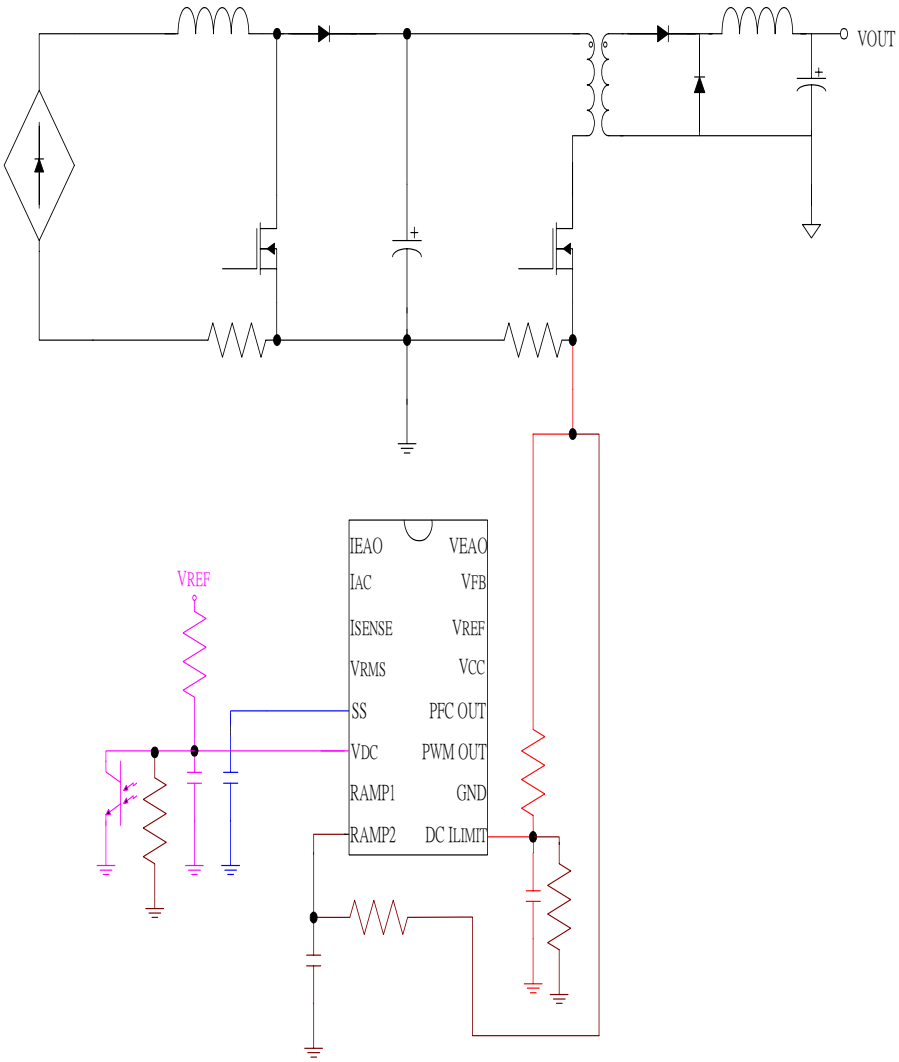

VOUT
IEAO
IAC
ISENSE
VRMS
SS
VDC
RAMP1
RAMP2
VEAO
VFB
VREF
VCC
PFC OUT
PWM OUT
GND
DC ILIMIT
VREF

# PWM Voltage Mode



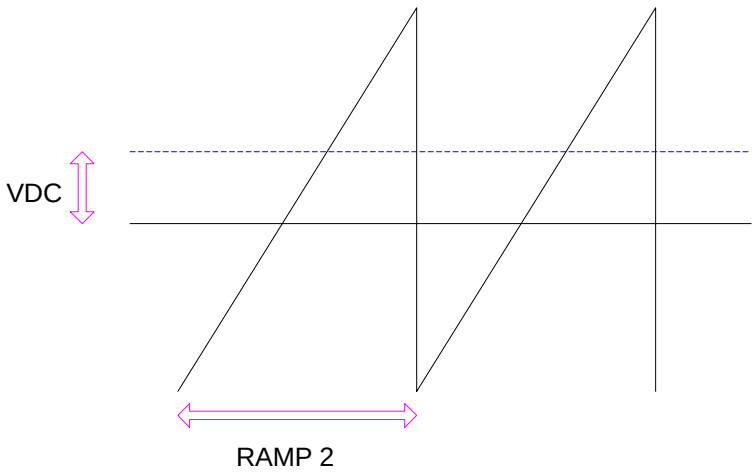
# PWM Current Mode



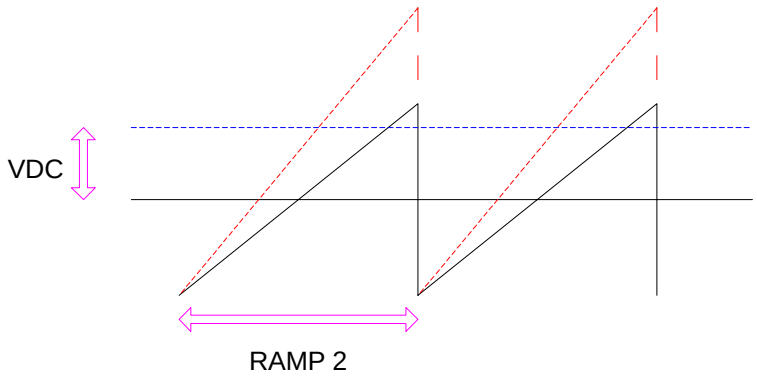



# Voltage與Current Mode比較

| | Layout | Dynamic Transient |
|---|---|---|
| Voltage Mode | Good | Ordinary |
| Current Mode | Ordinary | Good |




Voltage Mode




Current Mode

# Functions

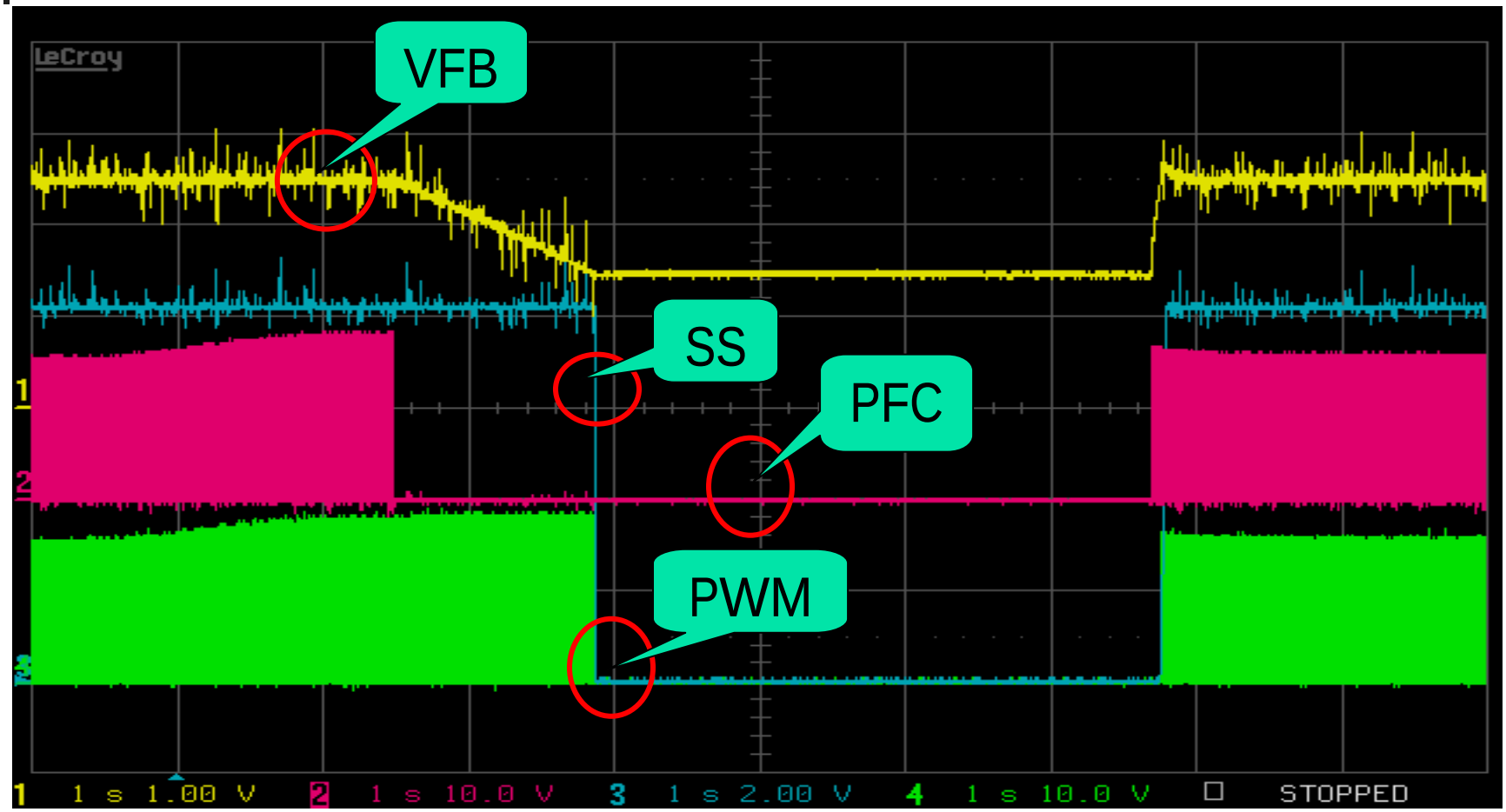
PFC :

- PFC turn-on
- PFC turn-off
- VCC O.V.P
- VCC U.V.L.O

PWM :

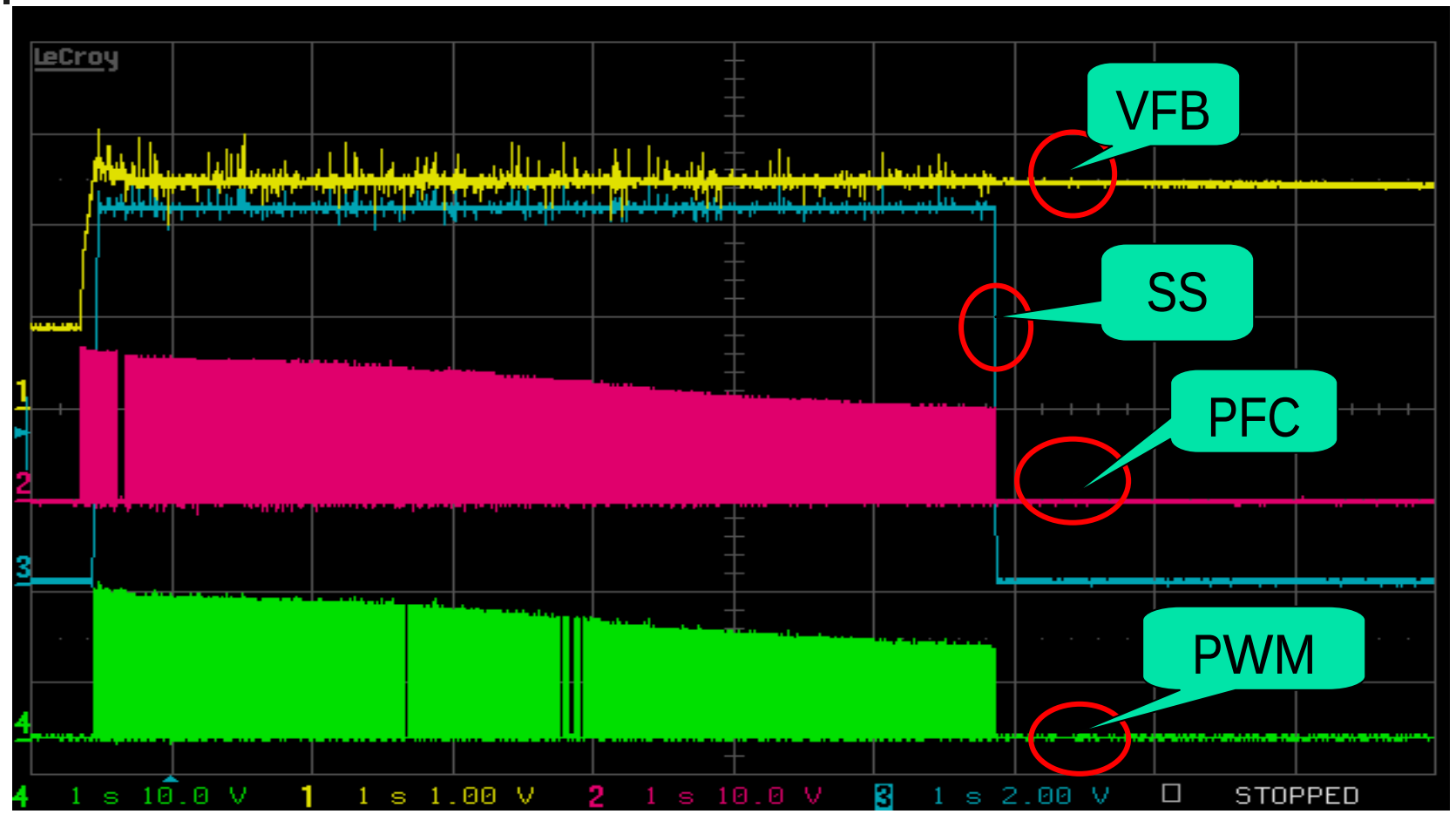
- PWM stage
- Soft Start
- PWM current limit

# VCC O.V.P



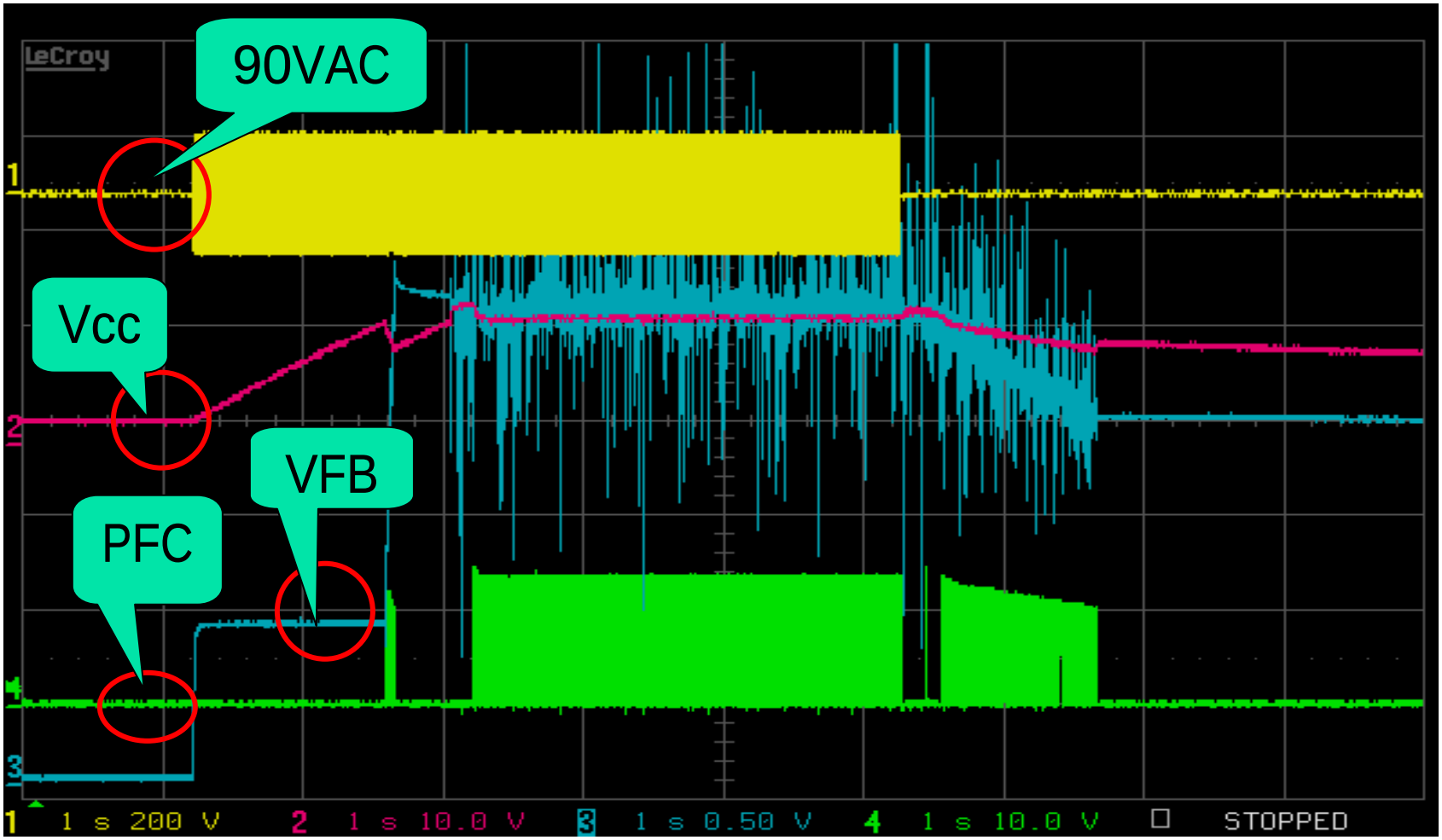

VCC=19V → PFC turn-off →Vin OK(X) →PWM turn-off
(VCC OVP)

# VCC U.V.L.O



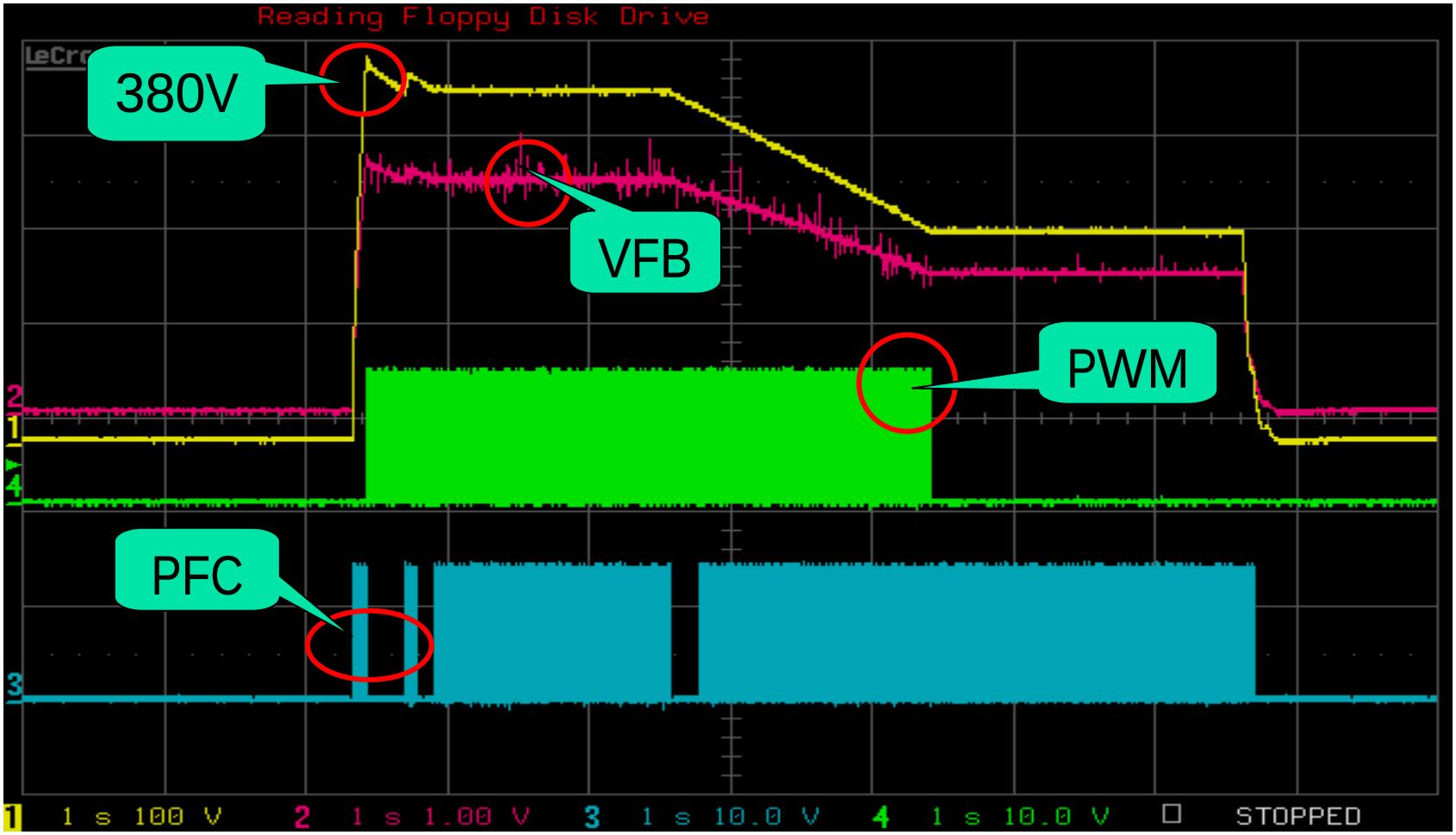

VCC=9V(U.V.L.O) → PFC turn-off
PWM turn-off

# PFC turn-on



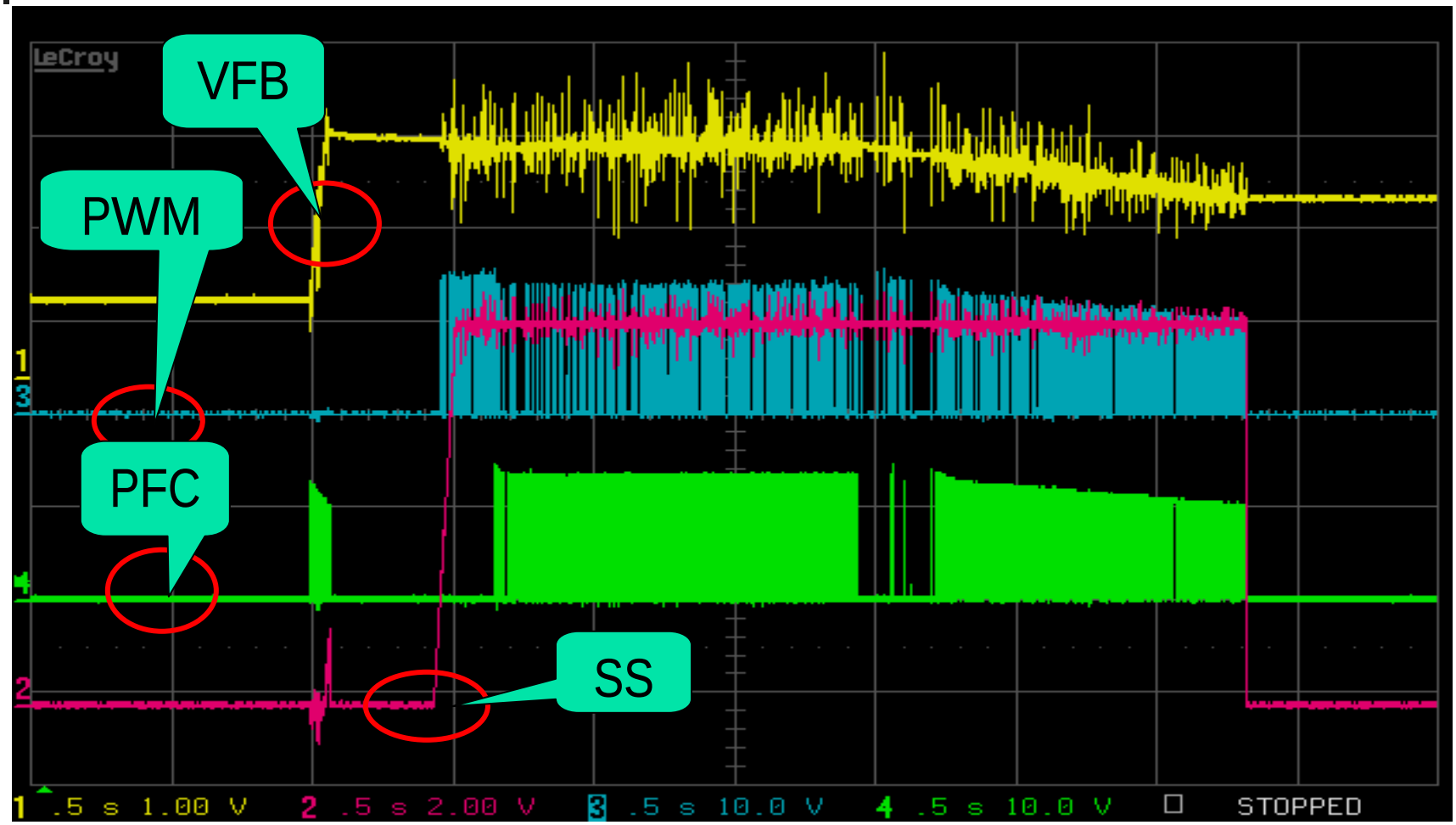

Vin OK → Vcc OK → VFB>0.5V → PFC turn-on
VFB=2.5V → PFC stage OK

# PFC turn-off




VFB<0.5V → PFC turn-off

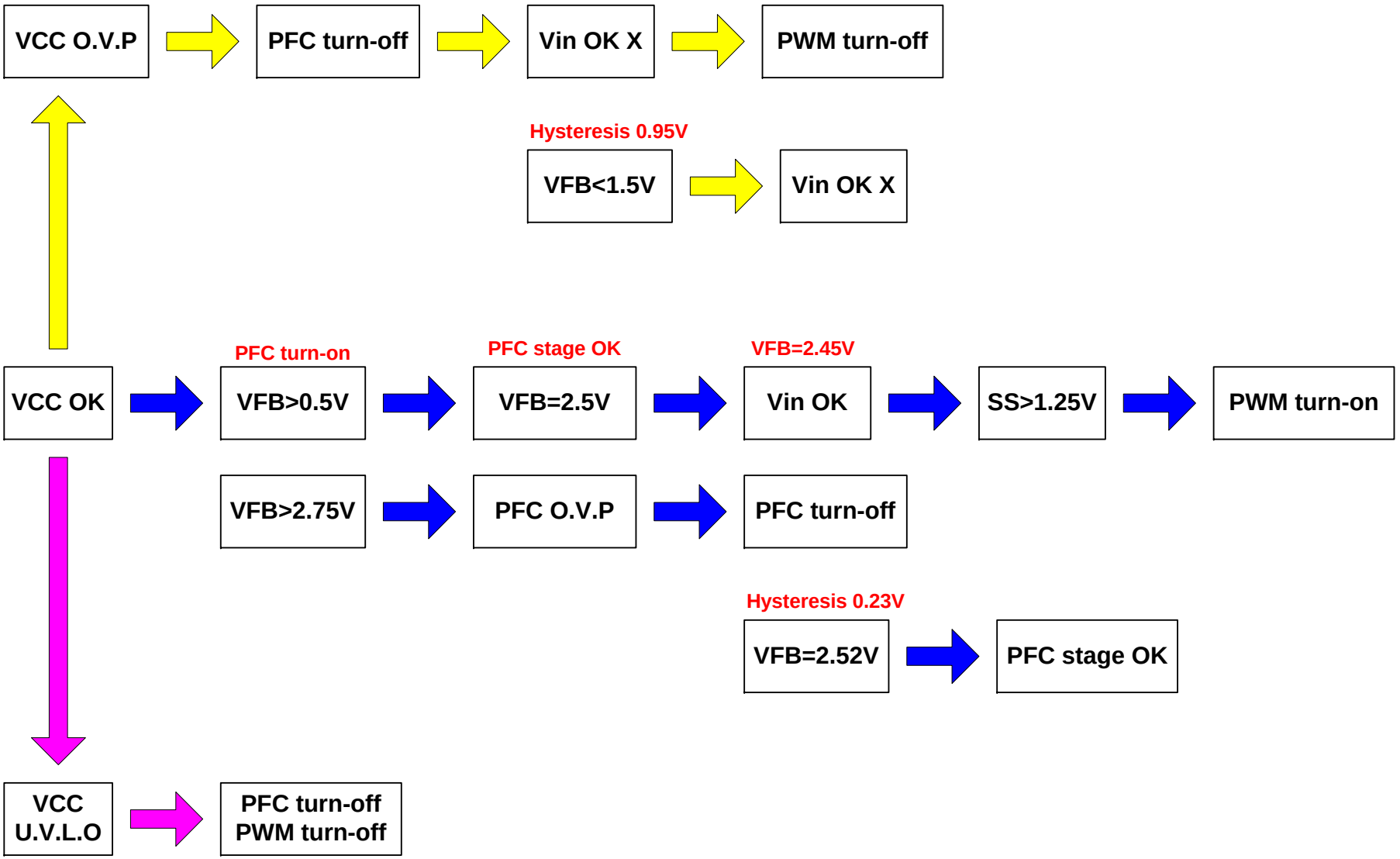
# PWM stage



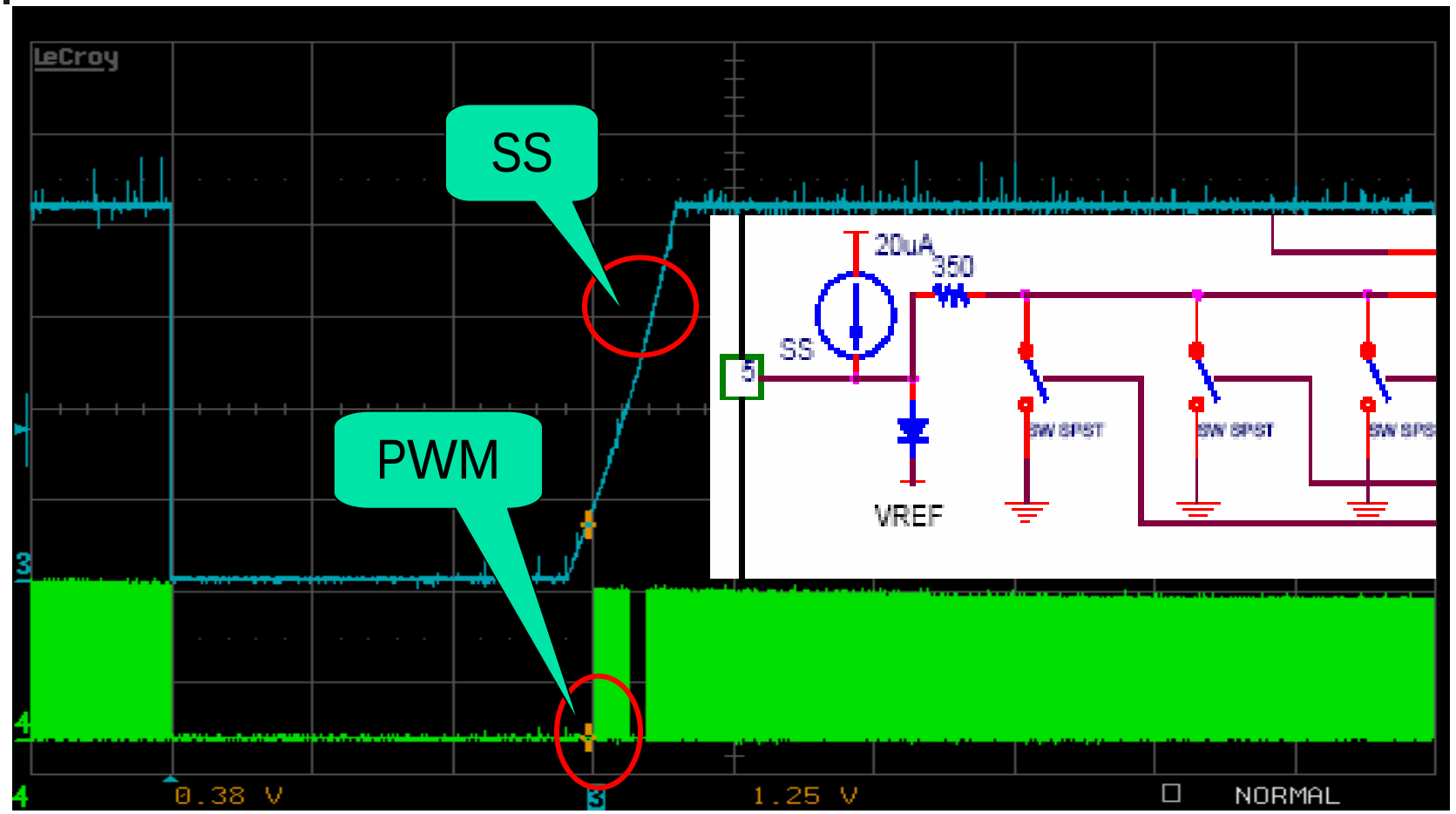

VFB>2.45V→ Vss>1.25V → PWM turn-on

VFB<1.5V → PWM turn-off

# Summary


VCC O.V.P
PFC turn-off
Vin OK X
PWM turn-off
Hysteresis 0.95V
VFB<1.5V
Vin OK X
VCC OK
PFC turn-on
VFB>0.5V
PFC stage OK
VFB=2.5V
VFB=2.45V
Vin OK
SS>1.25V
PWM turn-on
VFB>2.75V
PFC O.V.P
PFC turn-off
Hysteresis 0.23V
VFB=2.52V
PFC stage OK
VCC
U.V.L.O
PFC turn-off
PWM turn-off

# Soft Start

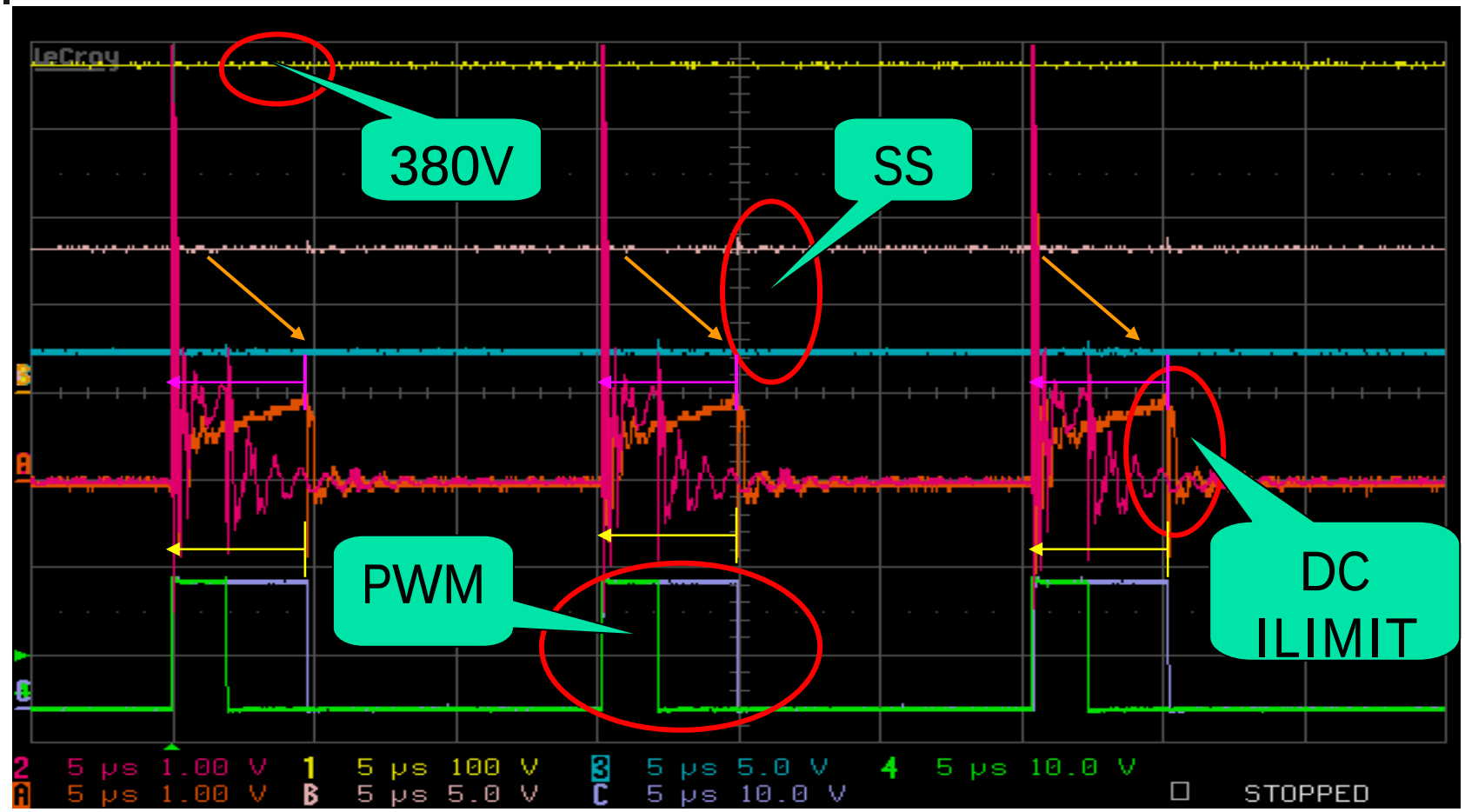



→ UVLO

SW SPST → VIN OK

→ DC ILIMIT

# DC ILIMIT




SS from 8V to 2V

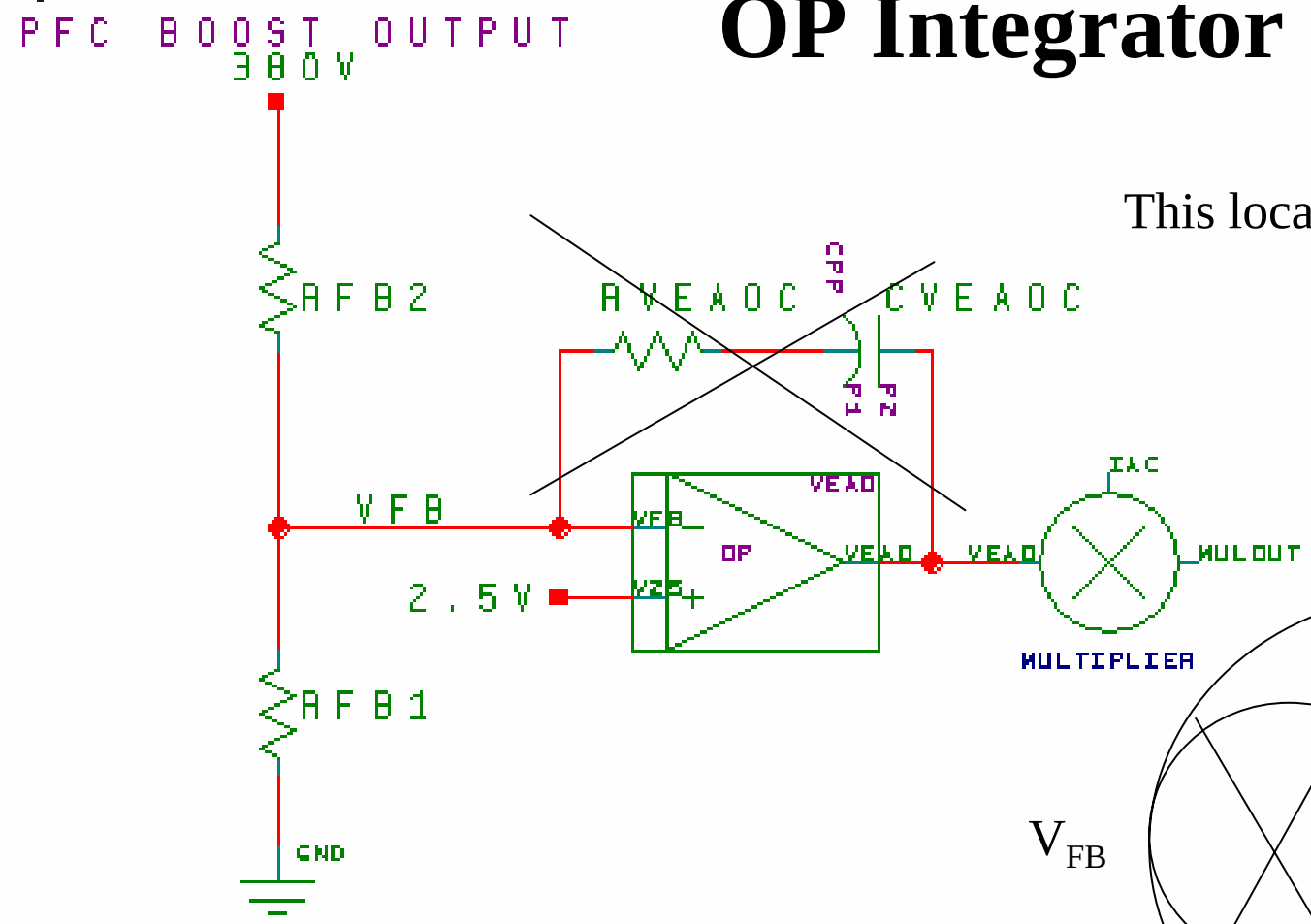
Duty Cycle from 32% to 12%

# Speed up the PFC Voltage Loop 3X

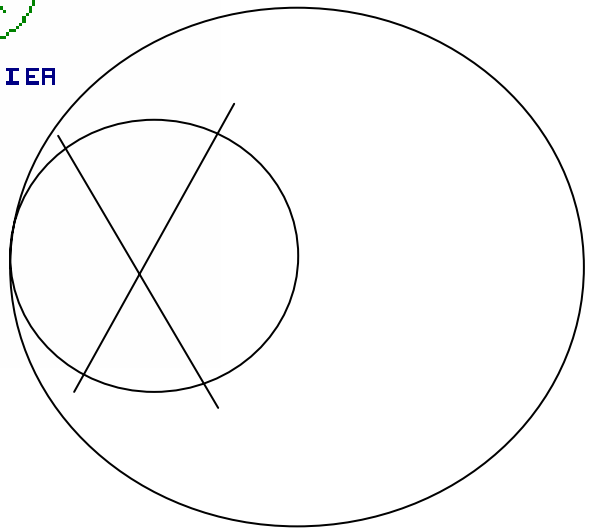
Error Amplifier

Transconductance Amp, GM
vs.
Operational Amp, OP

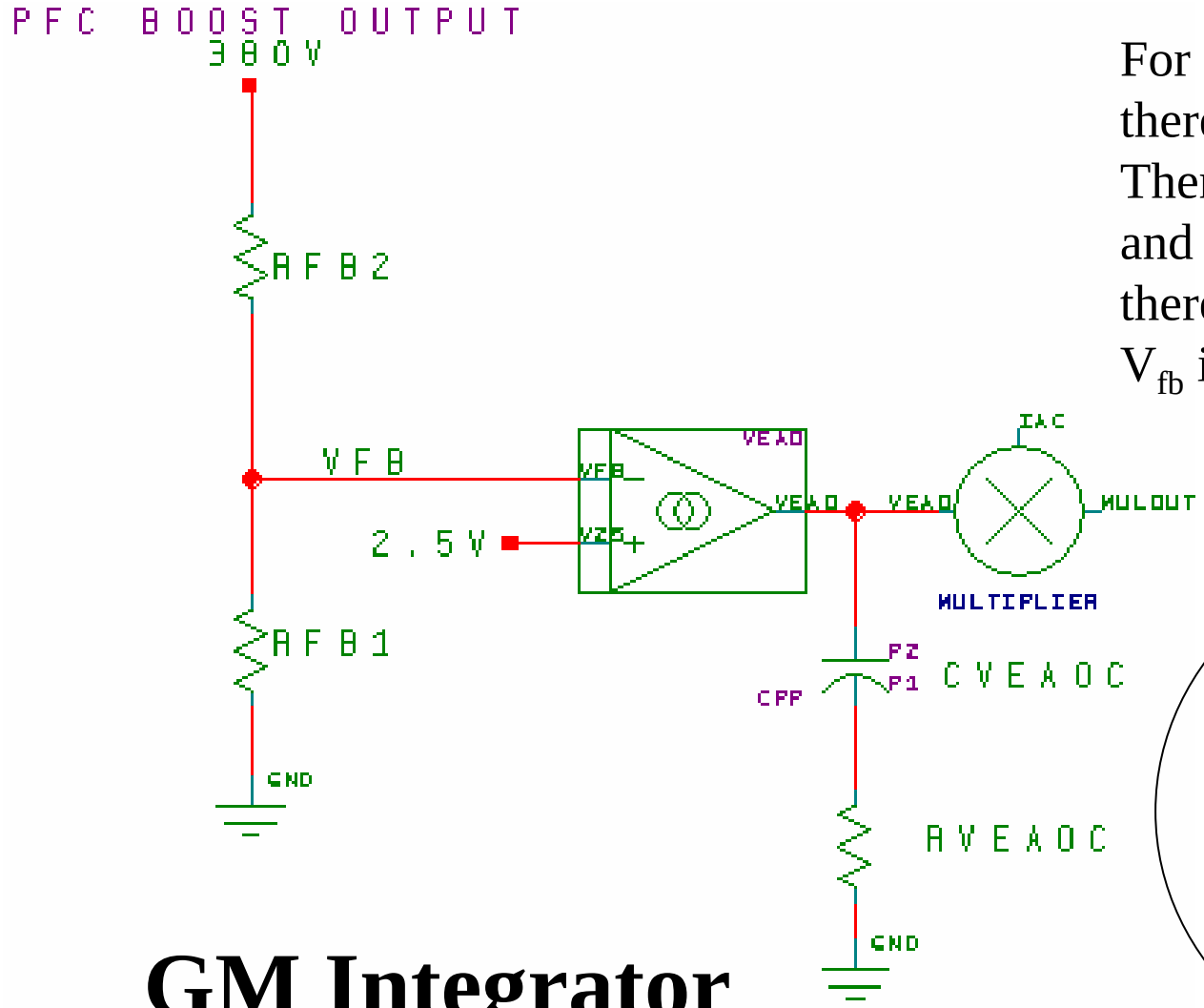
# OP Integrator




This local feedback is bad!




The Miller Effect slows down the $V_{fb}$ node.
Also, PFC Voltage Loop is very slow.
The consequence: $V_{fb}$ becomes very slow.

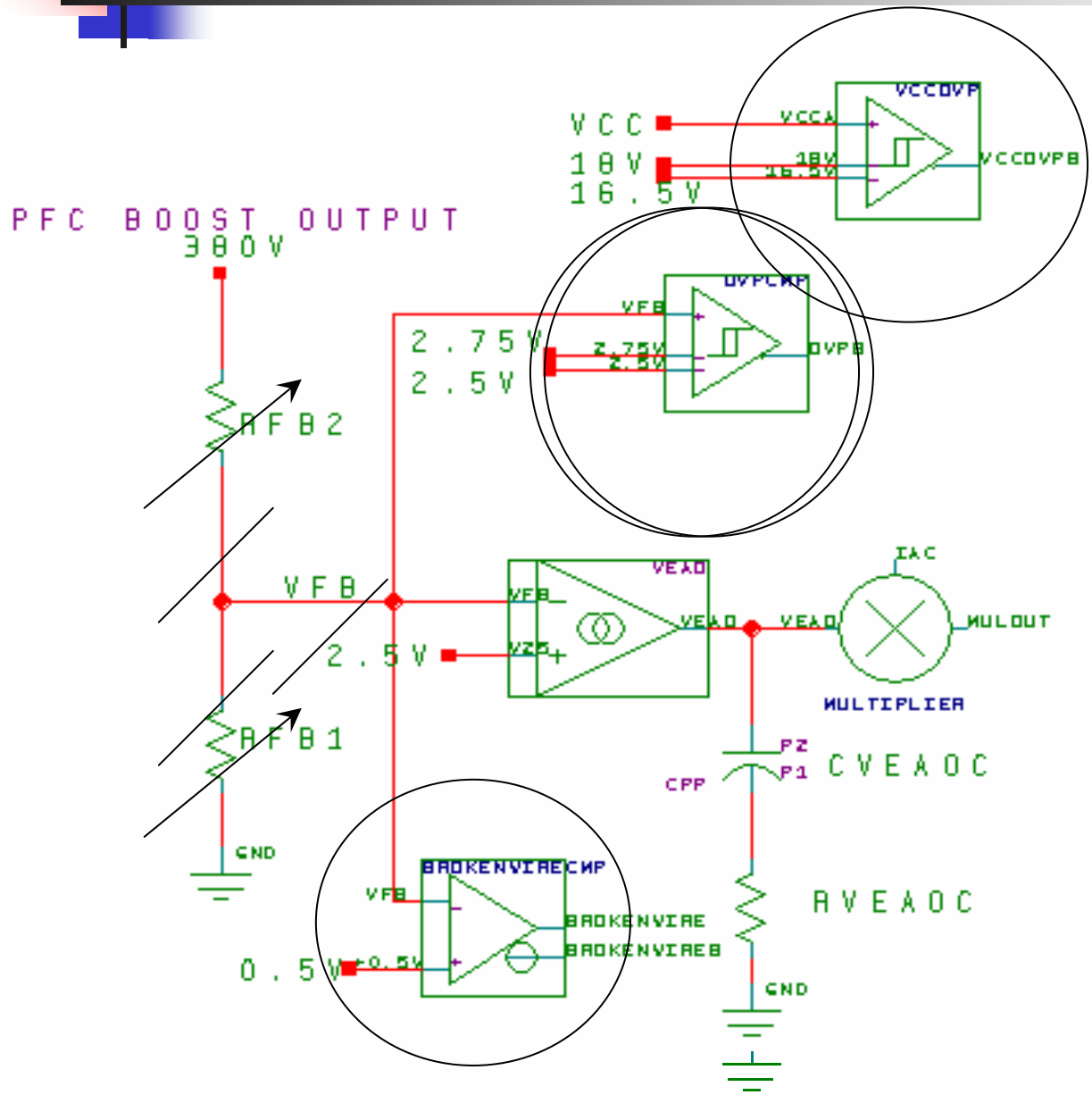



For GM,
there is no local feedback.
There is only one outer loop
and
there is no inner loop.
$V_{fb}$ is a much faster node.

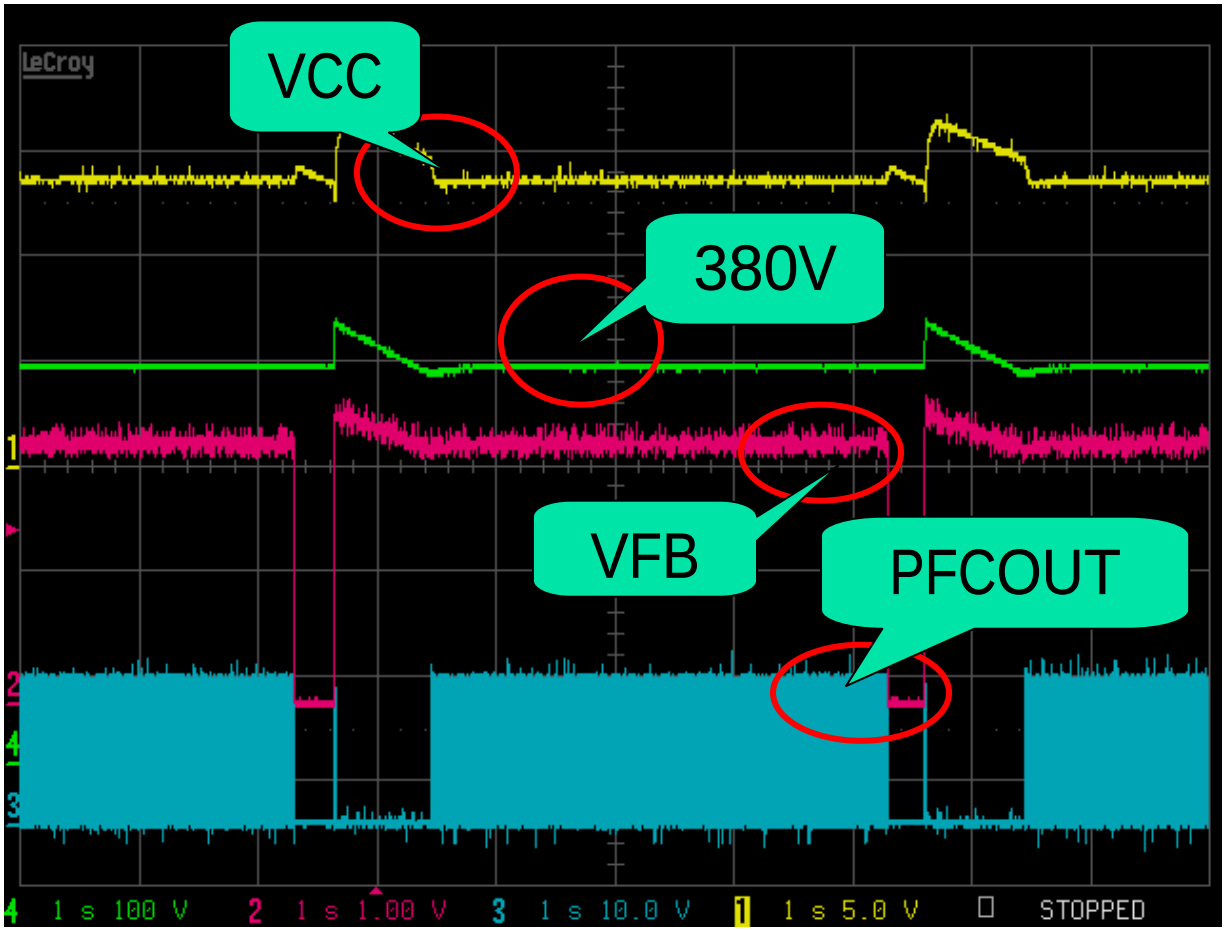
# GM Integrator

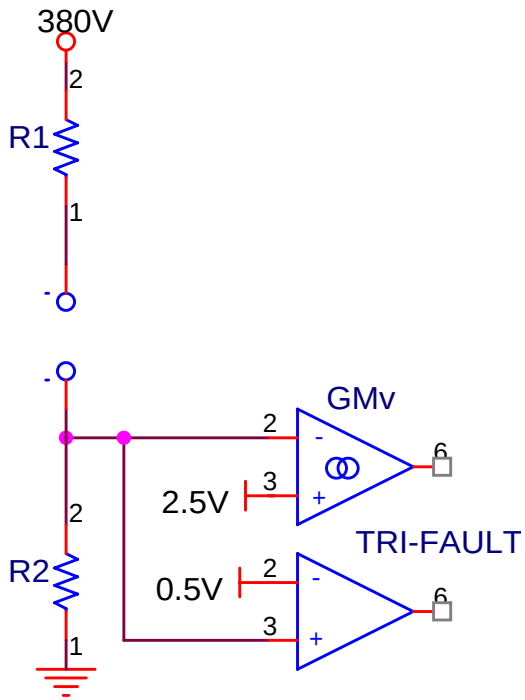
# Speed up the PFC Voltage Loop 3X

## Easy to meet UL1950

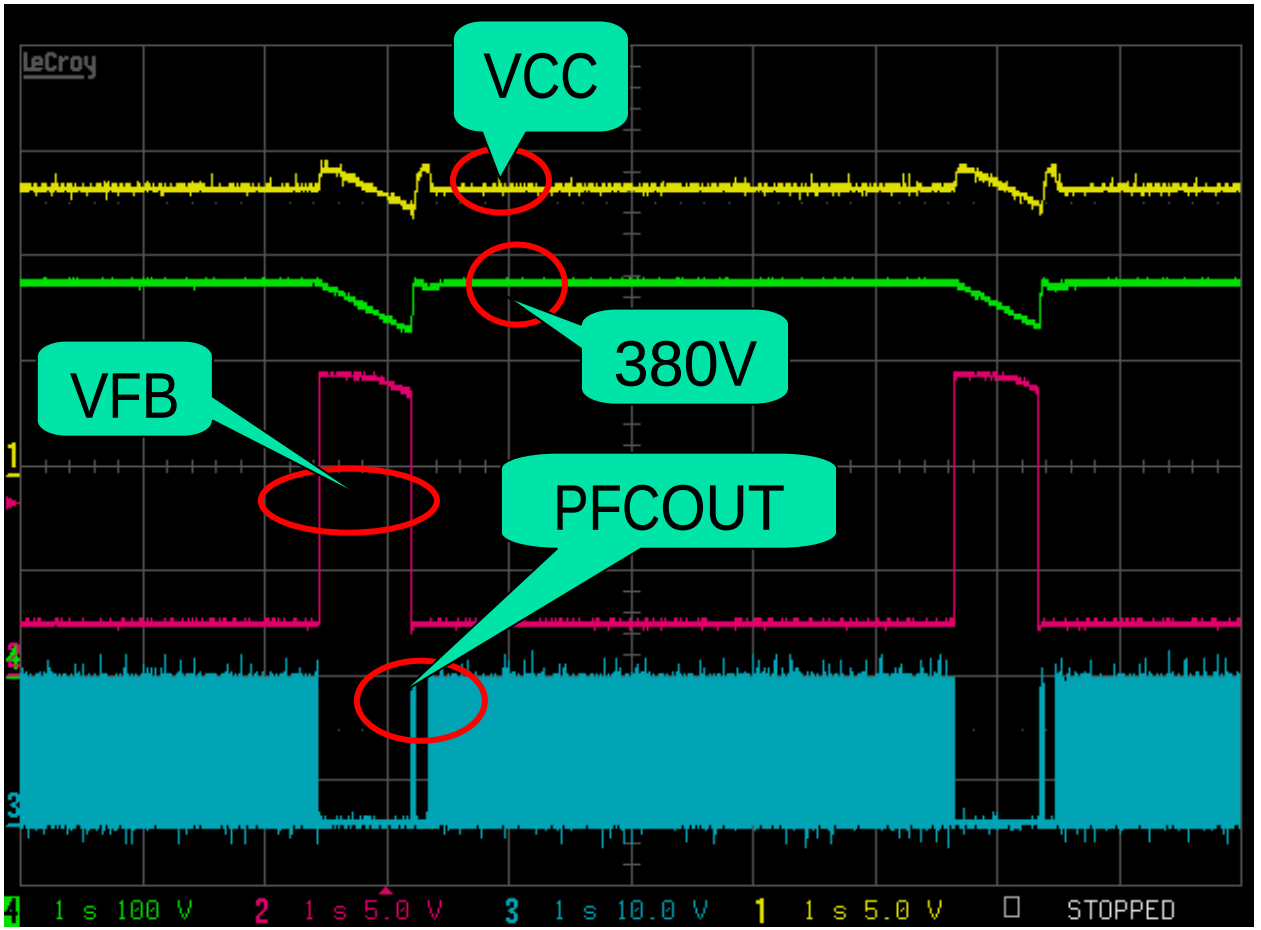


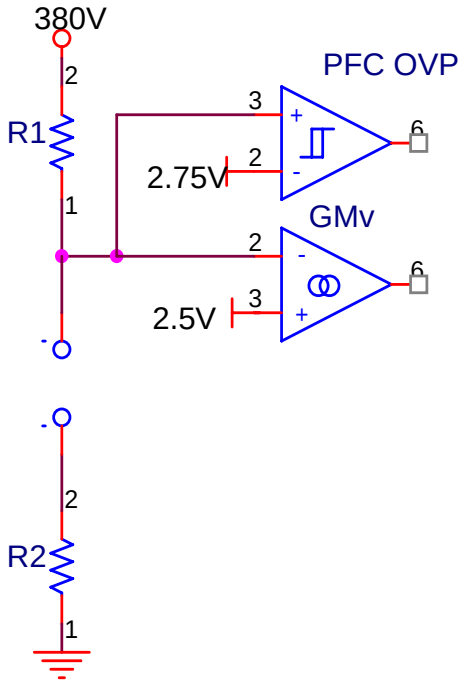
# CASE 1


LeCroy
VCC
380V
VFB
PFCOUT
1 s 100 V
1 s 1.00 V
1 s 10.0 V
1 s 5.0 V
STOPPED

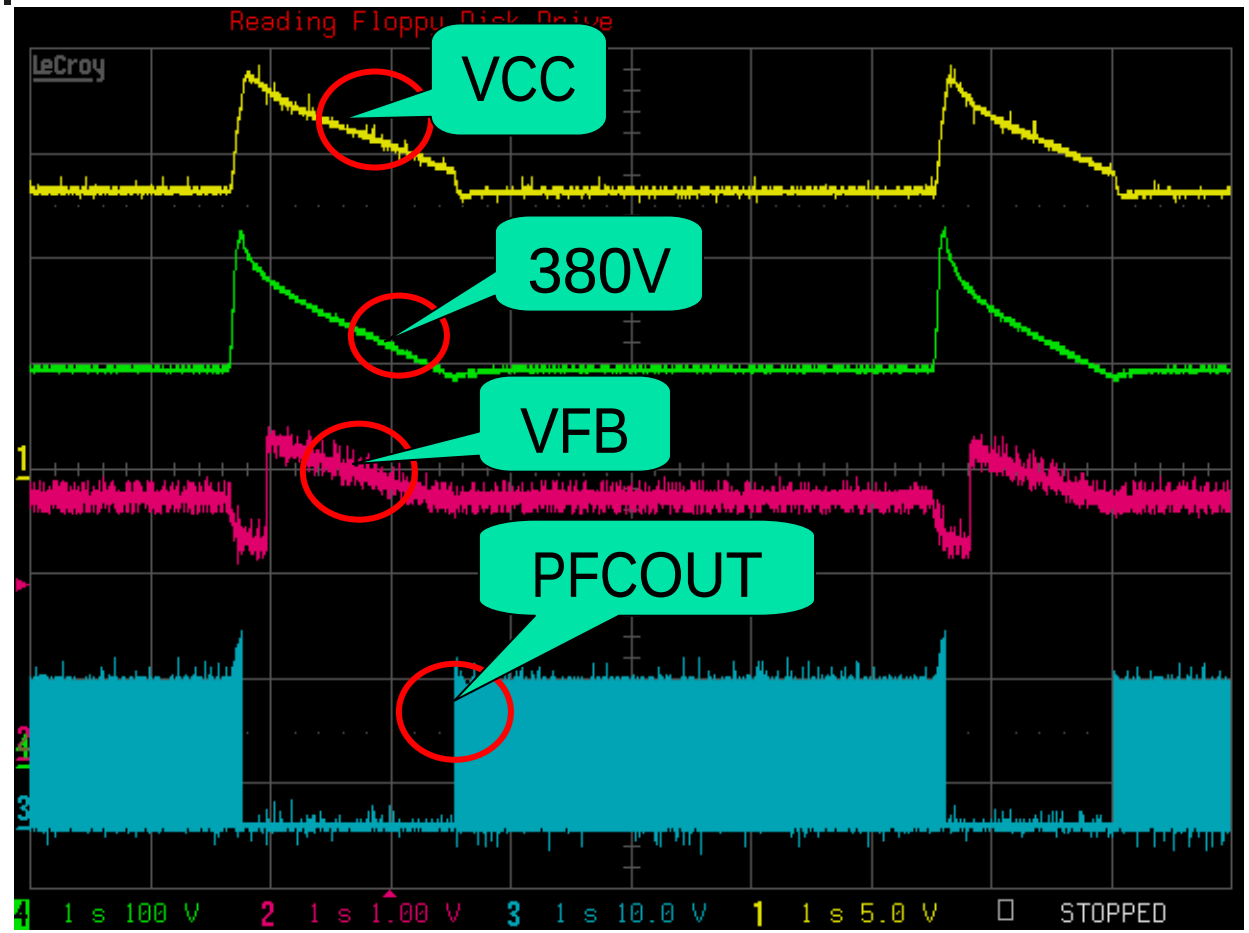

380V
2
R1
1
-
-
2
R2
1
GMv
2
3
2.5V
TRI-FAULT
2
3
0.5V
6
6

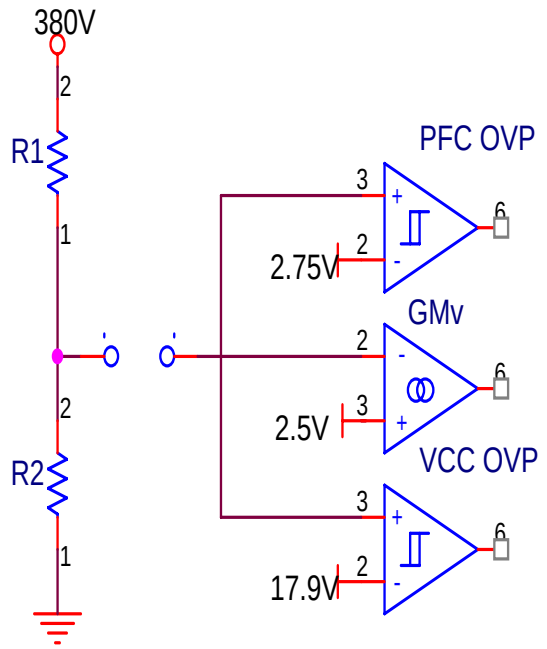
# CASE 2


LeCroy
VCC
380V
VFB
PFCOUT
1 s 100 V
2 1 s 5.0 V
3 1 s 10.0 V
1 1 s 5.0 V
STOPPED


380V
R1
2
1
PFC OVP
3
2
6
2.75V
GMv
2
6
3
2.5V
R2
2
1

# CASE 3


LeCroy
VCC
380V
VFB
PFCOUT
1 s 100 V
1 s 1.00 V
1 s 10.0 V
1 s 5.0 V
STOPPED


380V
R1
R2
PFC OVP
2.75V
GMv
2.5V
VCC OVP
17.9V

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