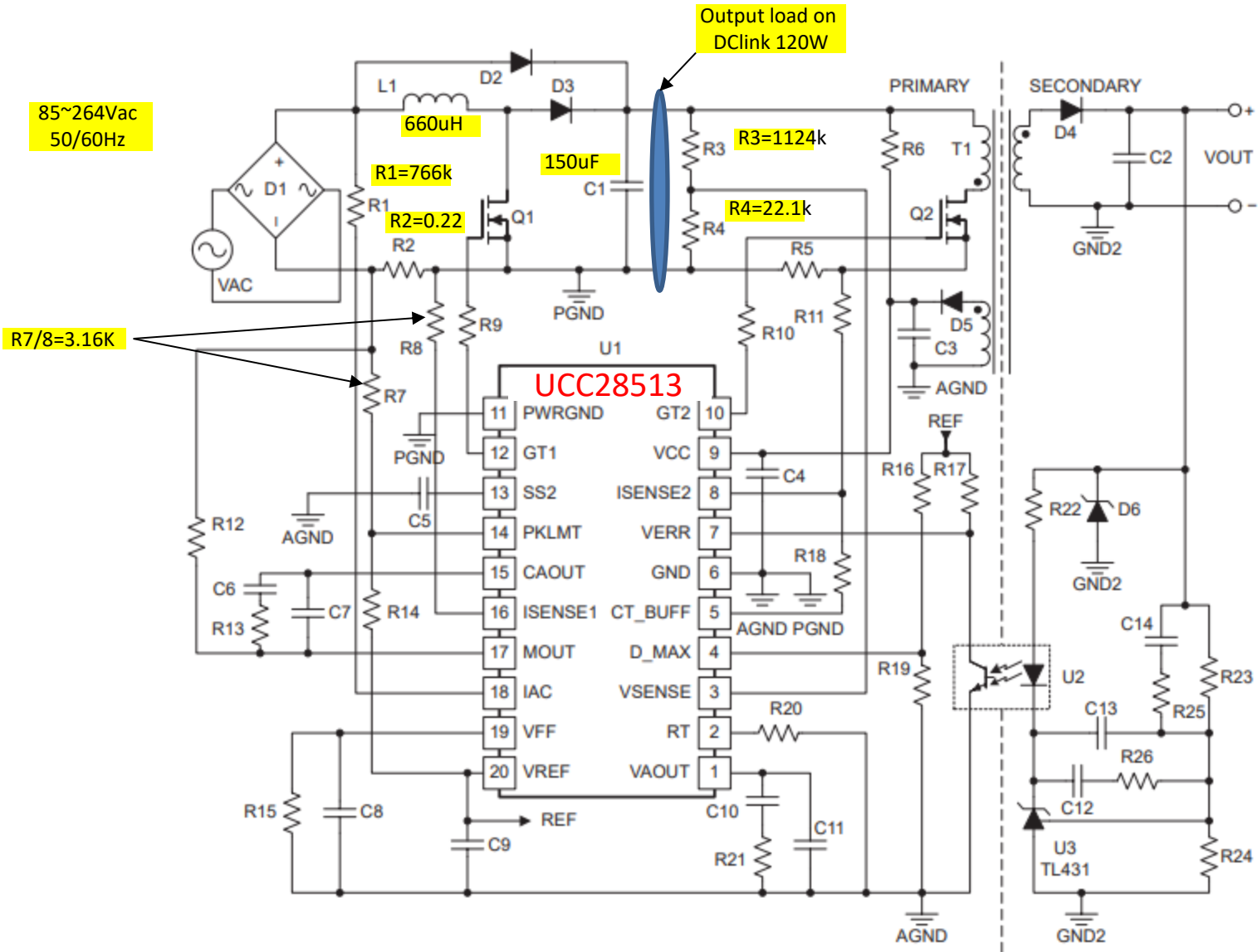


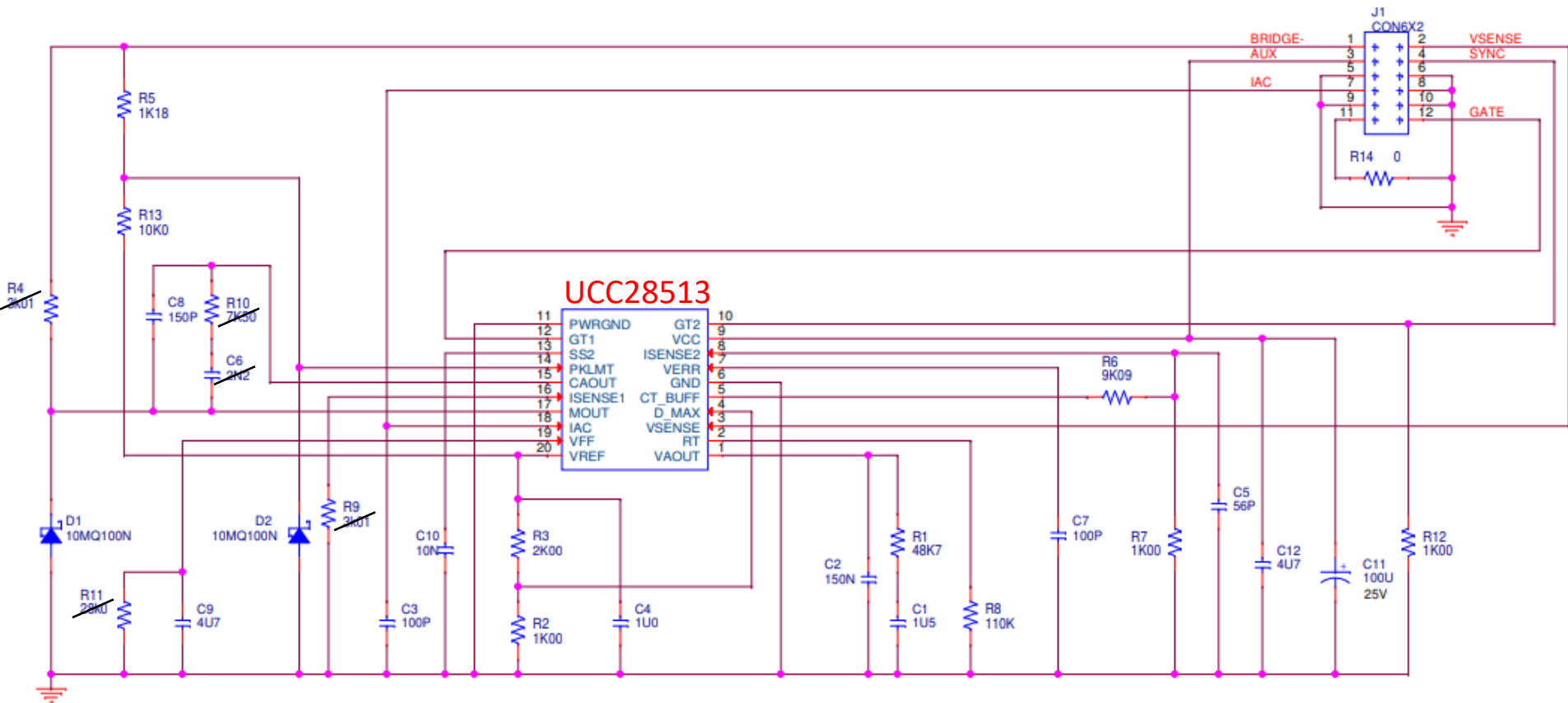
- The boost stage design is based on UCC28513. The PFC stage works well up to 200-220Vac input. Above this voltage range there are significant distortions at the points where sinusoidal input voltage reaches to its positive and negative peaks
- Output voltage is 385Vac
- Input voltage range is 85-264Vac; 50/60Hz
- The load on DC link output is 120W max
- Boost stage switching frequency is 277kHz
- Verified that the Vcc aux supply and Vref are stable
- Observed that the AC ripple on DC link goes up at around 200Vac but not sure if this is the reason or the result
- Observed that the duty cycle is about 70% at the peak sine wave at 85Vac but drops down to ~15% at the peaks of 220Vac at which point I start get distortions on the input current.
- The provided test results are at ~30W output power. It was observed that changing the load did not affect the behavior at around 220Vac.

### **Questions:**

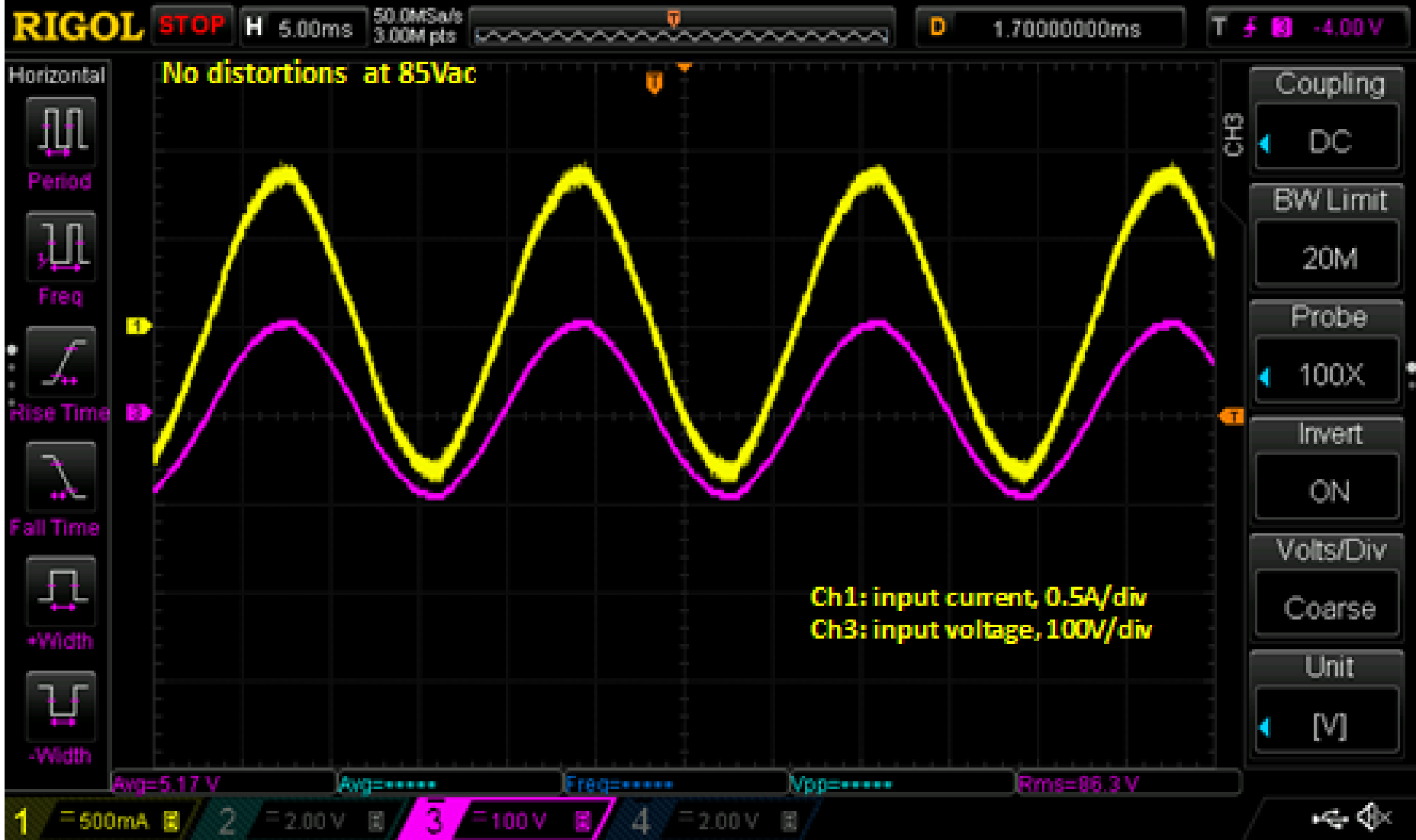
1. Based on the design values, what could potentially cause the distortions at the peak of sine waves at and above ~ 200Vac?
2. Fig. 36 on data sheet talks about max capacitance vs min duty cycle. What capacitor is referred in Fig 36?



RefDes on data sheet	RefDes in design	values
R1	R47+R50	766K
R2	R43	0.22
R8/R12	R4/R9	3.16K
R3	R44+R49	1124K
R4	R60	22.1k
C1	C32	150uF
L1	L2	660uH
R13	R10	15.8K
C6	C6	680pF
C7	C8	150pF
R15	R11	30.1K
C8	C9	4.7uF
C10	C1	1.5uF
C11	C2	150nF
R21	R1	48.7K
R14	R13	10K
R7	R5	1.18K
C9	C4	1uF



RefDes on data sheet	RefDes in design	values
R8/R12	R4/R9	3.16K
R13	R10	15.8K
C6	C6	680pF
R15	R11	30.1K



RIGOL

TD

H 5.00ms

50.0MSa/s  
3.00M pts

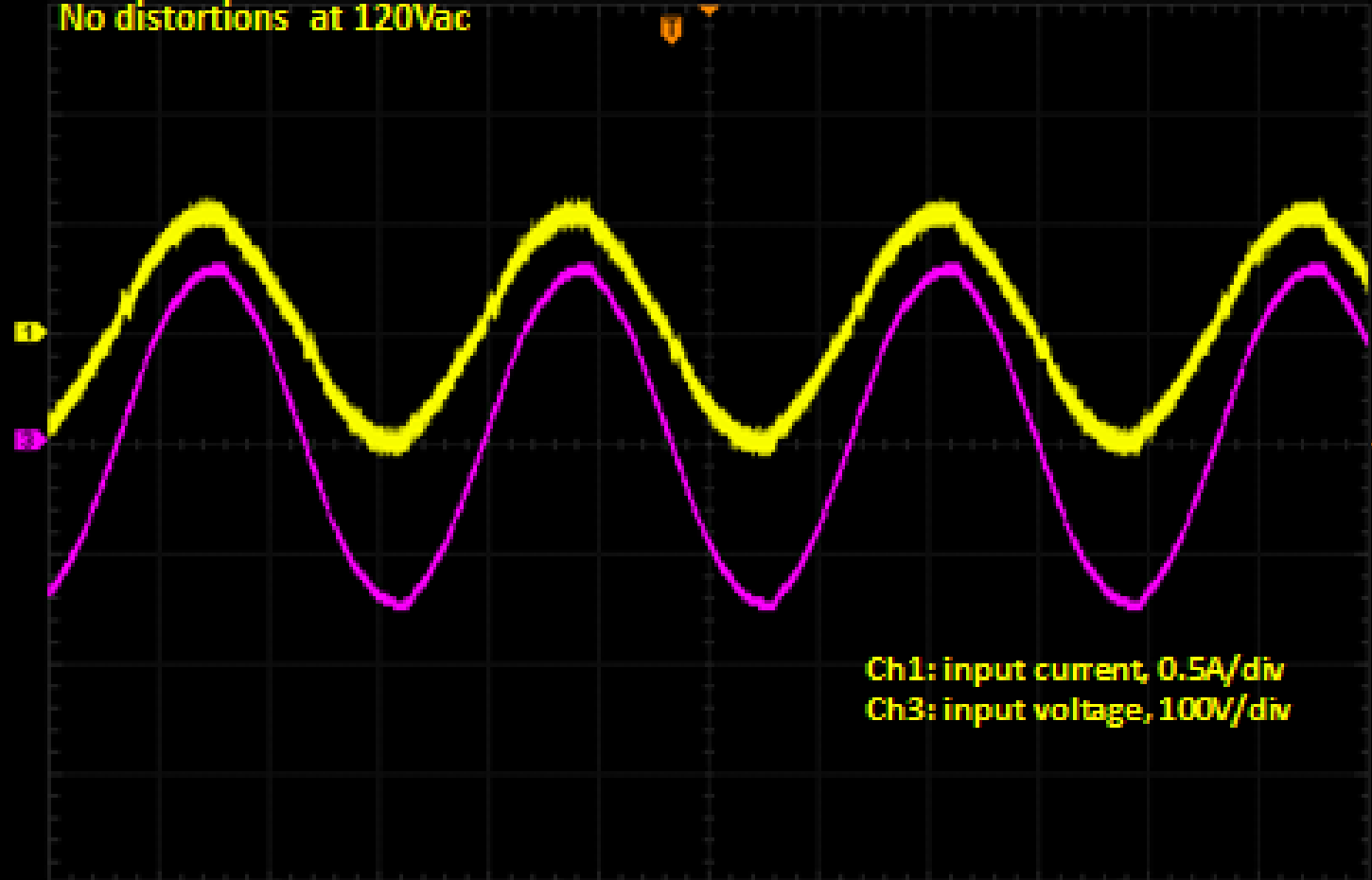
D 1.70000000ms

T f [ ] -4.00 V

Horizontal

No distortions at 120Vac

-  Period
-  Freq
-  Rise Time
-  Fall Time
-  +Width
-  -Width



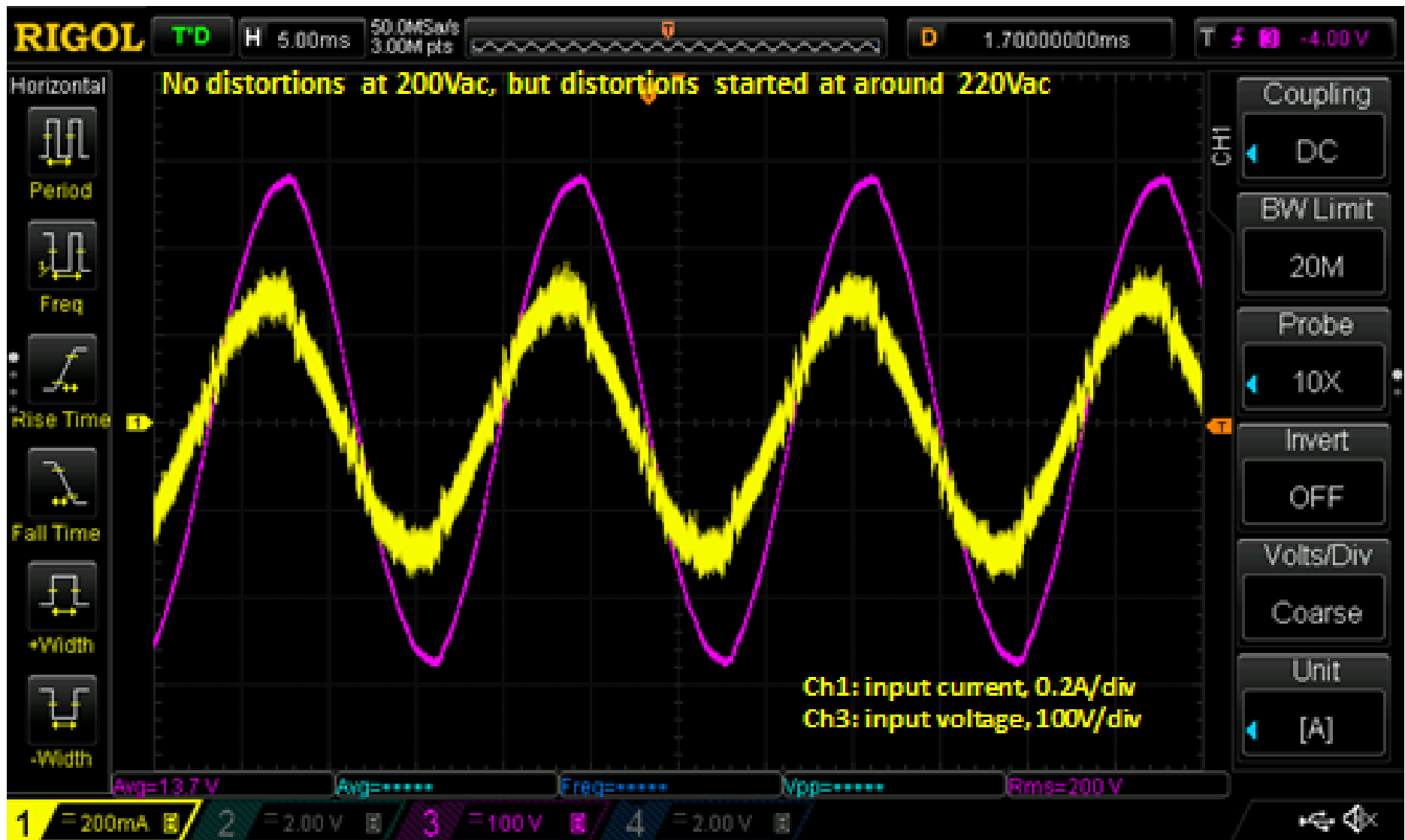
- Coupling  
DC
- BW Limit  
20M
- Probe  
100X
- Invert  
ON
- Volts/Div  
Coarse
- Unit  
[V]

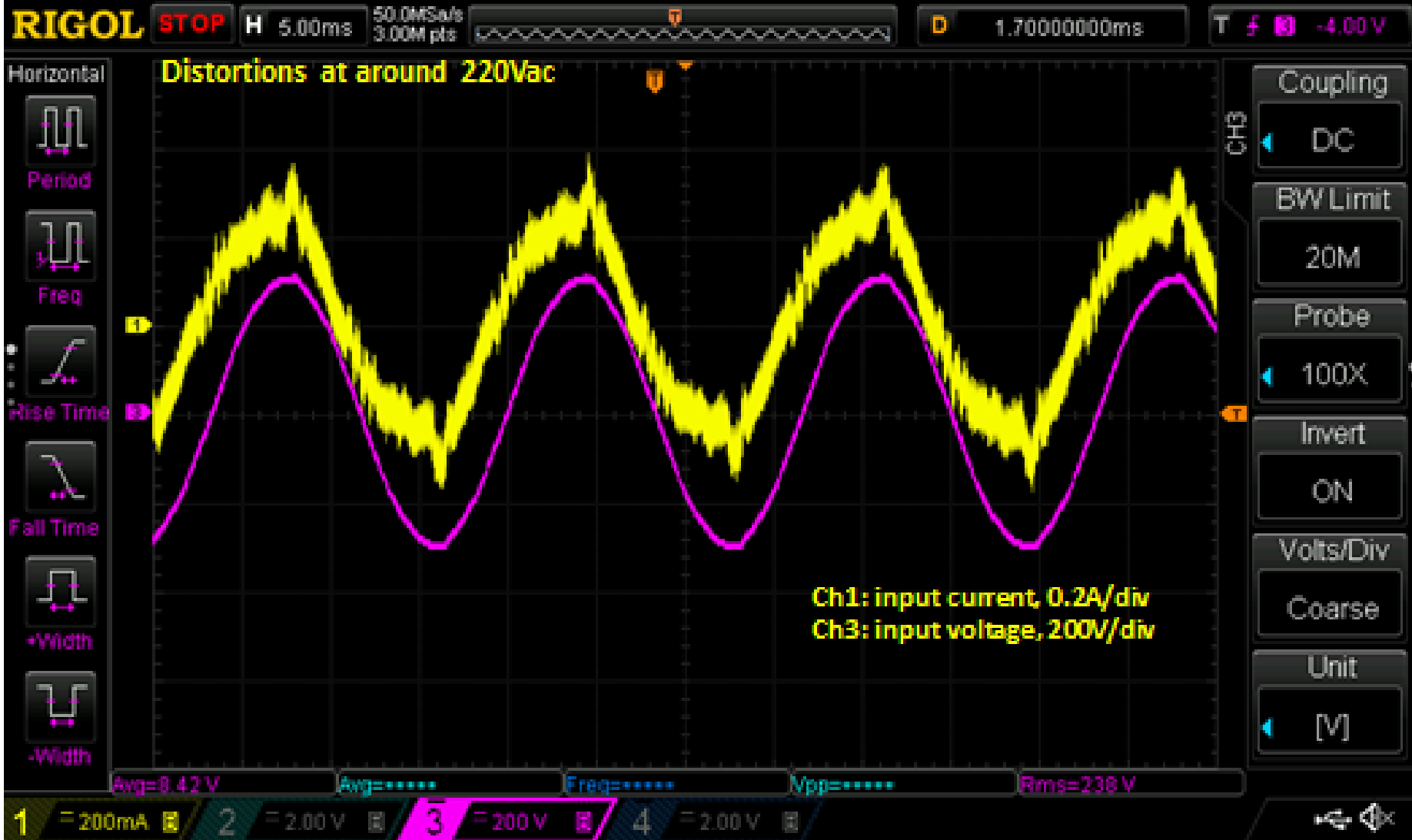
Ch1: input current, 0.5A/div  
Ch3: input voltage, 100V/div

Avg=7.88 V    Avg=.....    Freq=.....    Vpp=.....    Rms=119 V

- 1 = 500mA
- 2 = 2.00 V
- 3 = 100 V
- 4 = 2.00 V

No distortions at 200Vac input, displacement between current and voltage is probably caused by the input capacitors on EMI filter



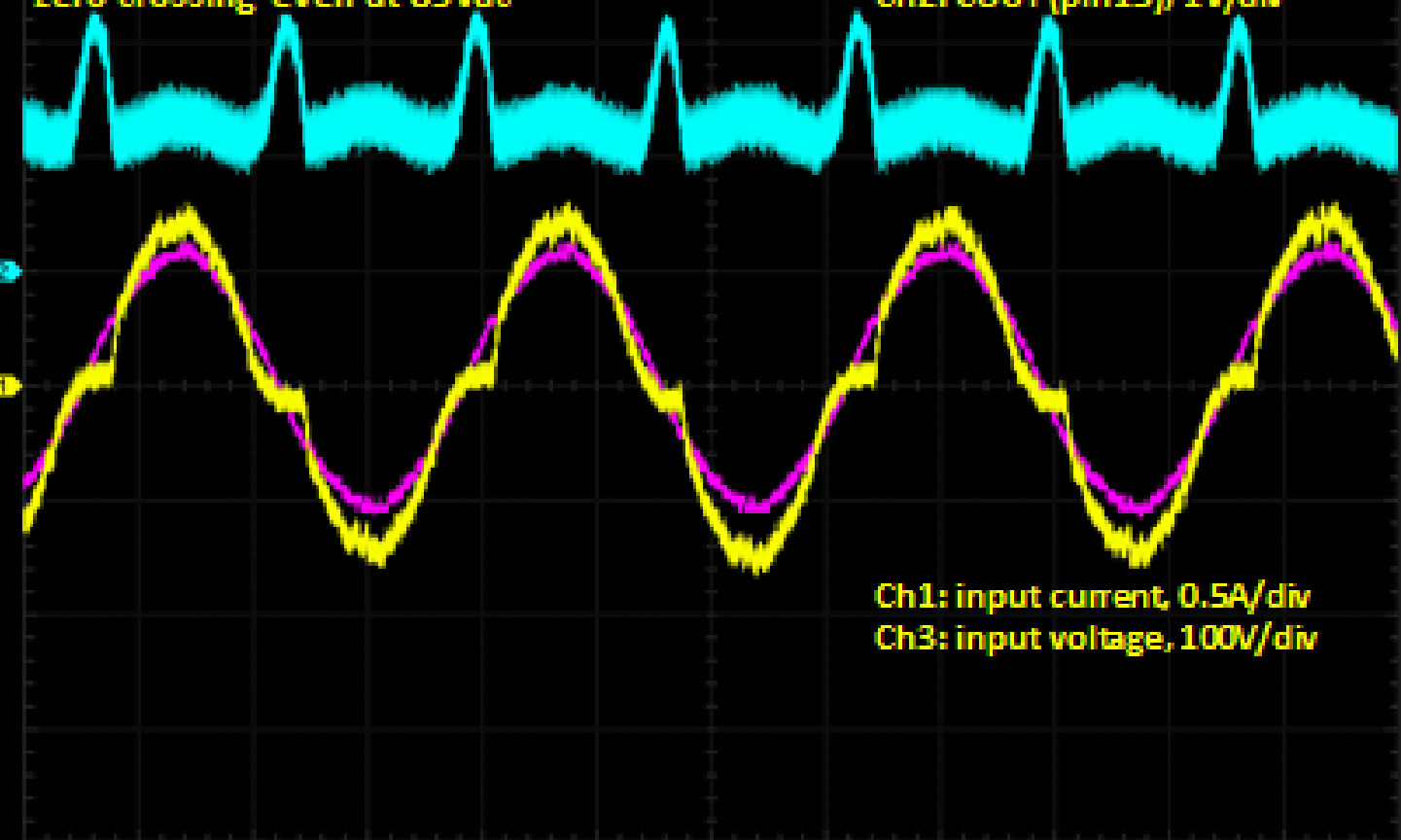




**RIGOL** STOP H 5.00ms 50.0MS/s 3.00M pts 2.20000000ms T f -4.00V

- Horizontal
- Period
- Freq
- Rise Time
- Fall Time
- +Width
- Width

Connecting diff probe to COUT (pin15) resulted in more distortions around zero crossing even at 85Vac  
Ch2: COUT (pin15), 1V/div



CH2

Coupling  
DC

BW Limit  
20M

Probe  
10X

Invert  
OFF

Volts/Div  
Coarse

Unit  
[V]

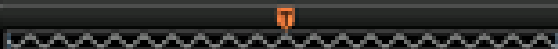
1 = 500mA 2 = 2.00V 3 = 100V 4 = 2.00V

RIGOL

STOP

H 5.00ms

50.0MSa/s  
3.00M pts



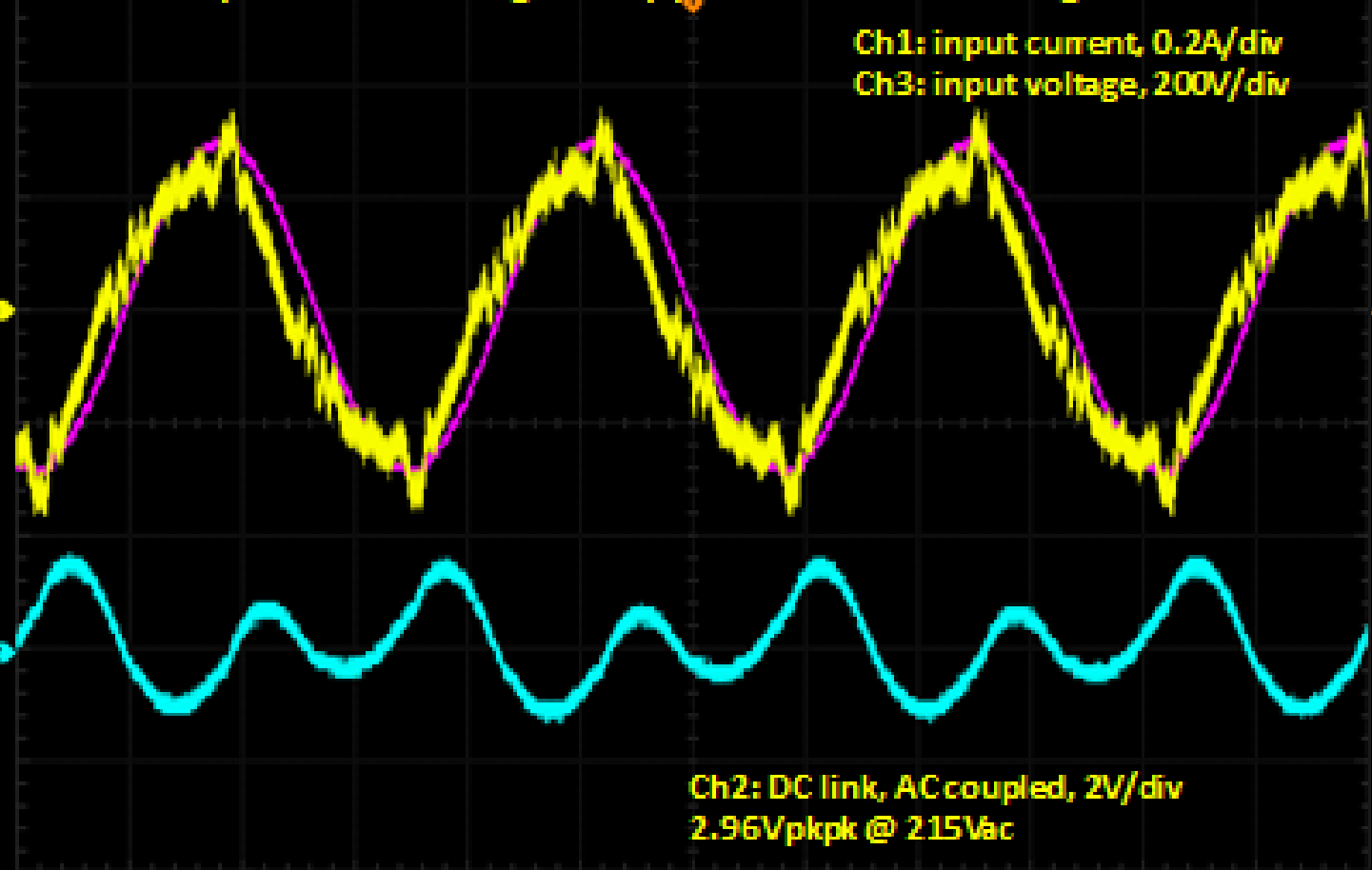
D 0.00000000ps

T  $f$   $\square$  -4.00 V

### 215Vac input, measuring the ripple on DC link voltage

- Horizontal
- Period
- Freq
- Rise Time
- Fall Time
- +Width
- Width

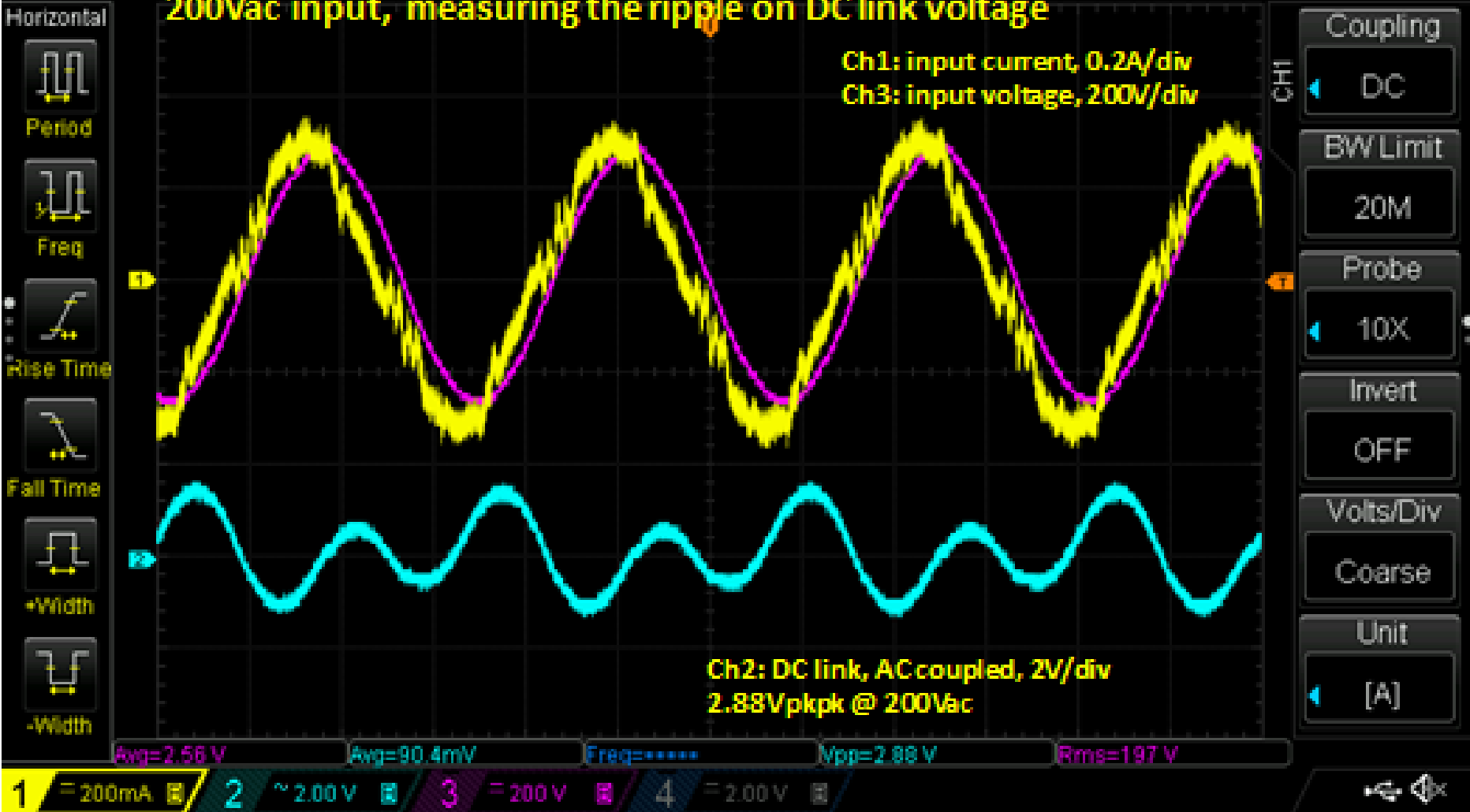
- Coupling: DC
- BW Limit: 20M
- Probe: 10X
- Invert: OFF
- Volts/Div: Coarse
- Unit: [A]



Avg=2.10 V    Avg=78.5mV    Freq=.....    Vpp=2.96 V    Rms=212 V

- 1 = 200mA
- 2 ~ 2.00 V
- 3 = 200 V
- 4 = 2.00 V

### 200Vac input, measuring the ripple on DC link voltage

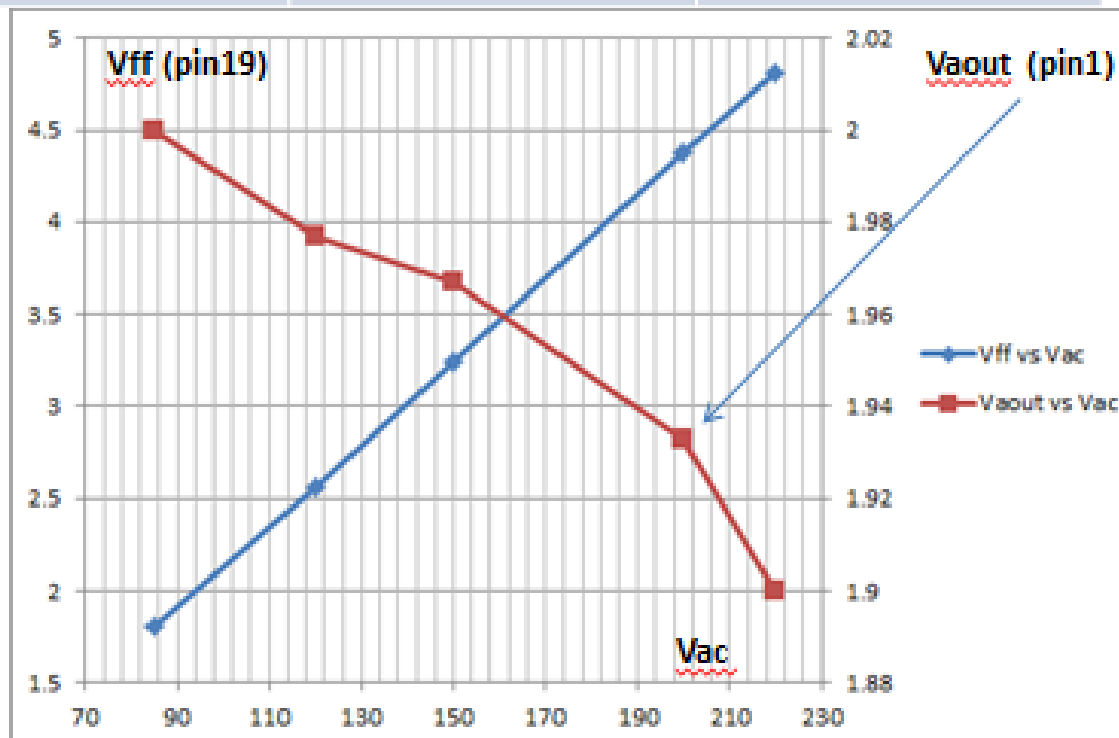


Input voltage ( $V_{rms}$ )	$V_{ff}$ on pin19 w/ DiffProbe ( $V_{dc}$ )	$V_{aout}$ on pin1 w/ DVM ( $V_{dc}$ )
85	1.80	2.000
120	2.56	1.977
150	3.24	1.967
200	4.38	1.933
220	4.81	1.900

$$0 \leq i_{IAC}(t) \leq 500 \mu A,$$

$$0 \leq V_{VAOUT}(t) \leq 5 V,$$

$$1.4 V \leq V_{VFF} \leq V_{VREF} - 1.4 V$$



- $V_{ff}$  increases proportionally and  $V_{aout}$  drops inversely as  $V_{ac}$  increases.
- $V_{aout}$  seems to start low at 2V and not varying within its full range of 0-5V

RIGOL

STOP

H 5.00ms

50.0MSa/s  
3.00M pts



D

0.00000000ps

T f -4.00V

Horizontal



Period



Freq



Rise Time



Fall Time

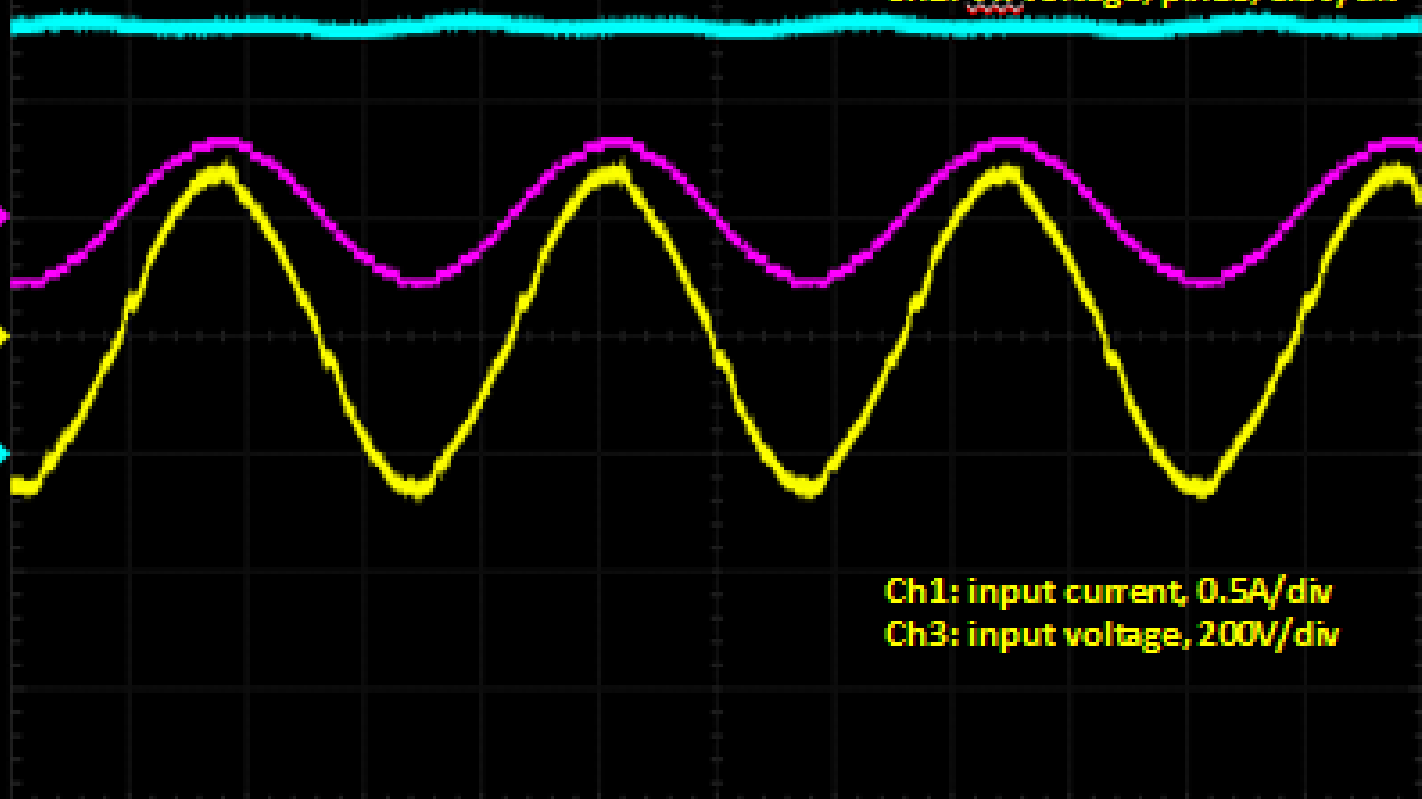


+Width



-Width

85Vac input,  $V_{ff}=1.80V$



Ch2:  $V_{ff}$  voltage, pin19, 0.5V/div

Ch1: input current, 0.5A/div

Ch3: input voltage, 200V/div

CH2

Coupling

DC

BW Limit

20M

Probe

10X

Invert

OFF

Volts/Div

Coarse

Unit

[V]

Rms=85.3 V    Rms=466mA    Avg=5.60 V    Avg=1.80 V    Freq=.....

1 = 500mA    2 = 500mV    3 = 200 V    4 = 2.00 V



RIGOL

STOP

H 5.00ms

50.0MS/s  
3.00M pts

D

0.00000000ps

T f -4.00V

Horizontal



Period



Freq



Rise Time



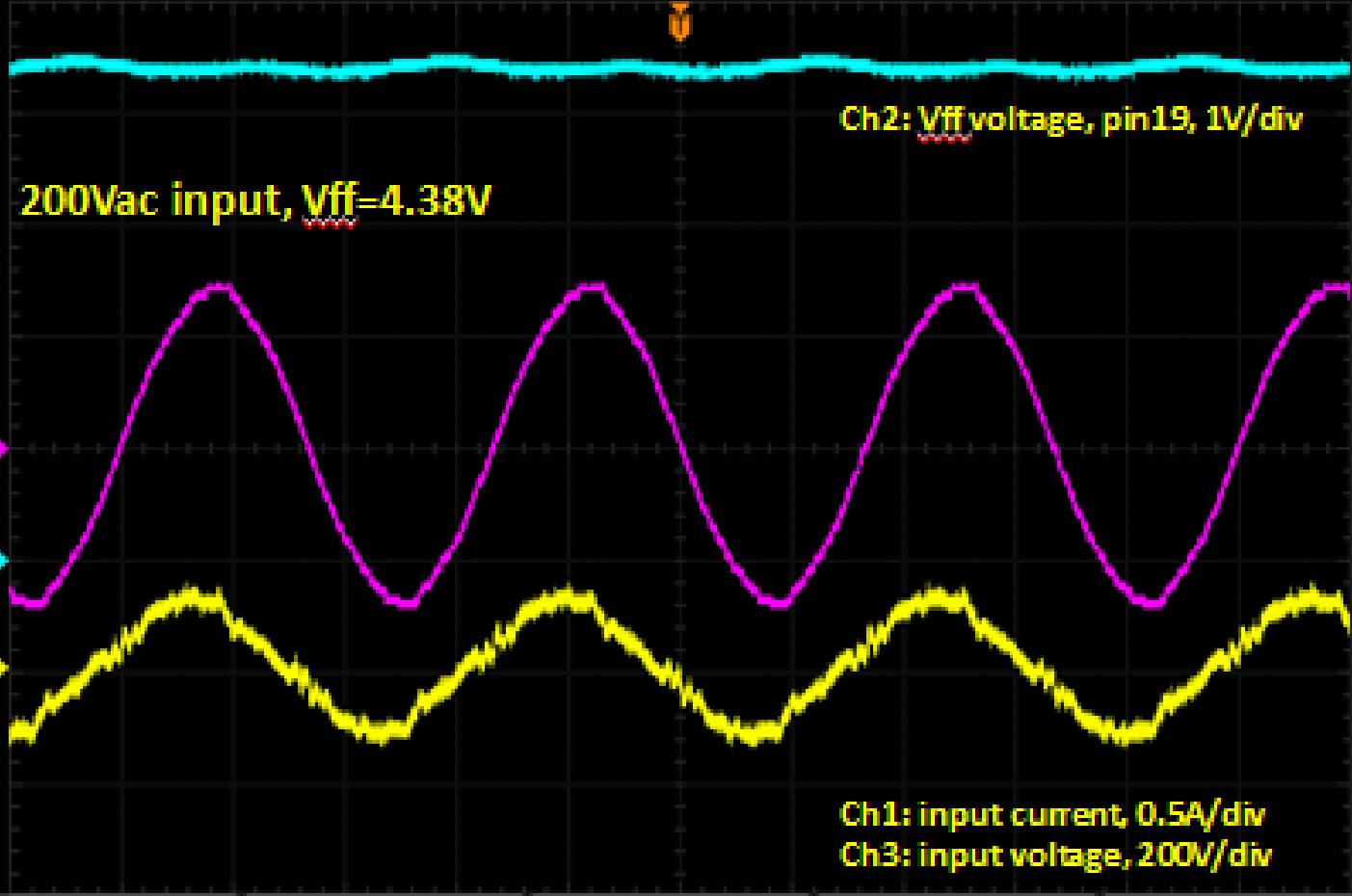
Fall Time



+Width



-Width



CH2

Coupling  
DC

BW Limit  
20M

Probe  
10X

Invert  
OFF

Volts/Div  
Coarse

Unit  
[V]

Rms=200 V      Rms=207mA      Avg=-729mV      Avg=4.38 V      Freq=.....

1 = 500mA    2 = 1.00 V    3 = 200 V    4 = 2.00 V



RIGOL

STOP

H 5.00ms

50.0MSa/s  
3.00M pts

D 0.00000000ps

T f -4.00V

Horizontal



Period



Freq



Rise Time



Fall Time



+Width

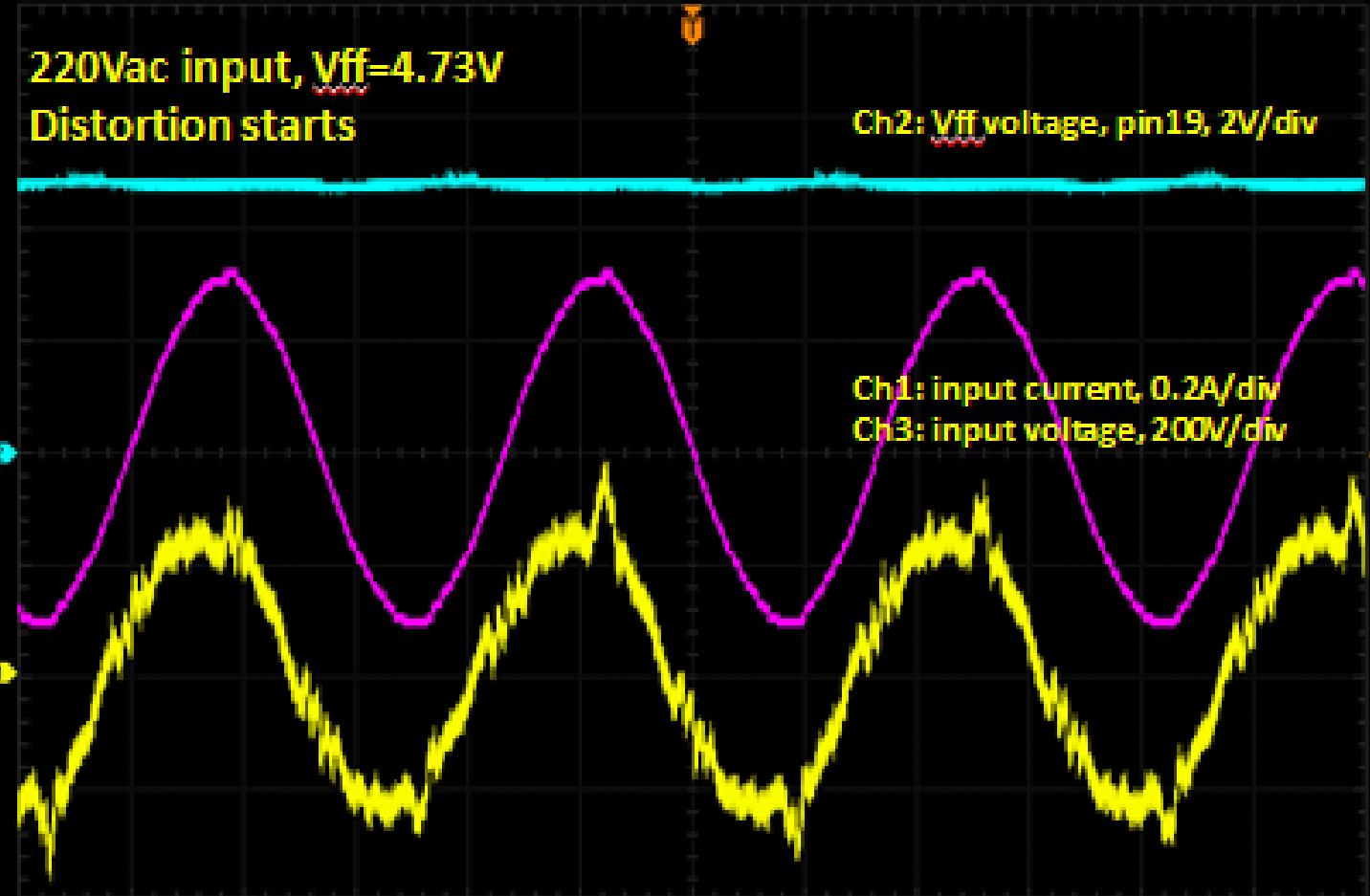


-Width

220Vac input,  $V_{ff}=4.73V$   
Distortion starts

Ch2:  $V_{ff}$  voltage, pin19, 2V/div

Ch1: input current, 0.2A/div  
Ch3: input voltage, 200V/div



Rms=219 V      Rms=186mA      Avg=-475mV      Avg=4.73 V      Freq=\*\*\*\*\*

1 = 200mA    2 = 2.00 V    3 = 200 V    4 = 2.00 V

Coupling

DC

BW Limit

20M

Probe

10X

Invert

OFF

Volts/Div

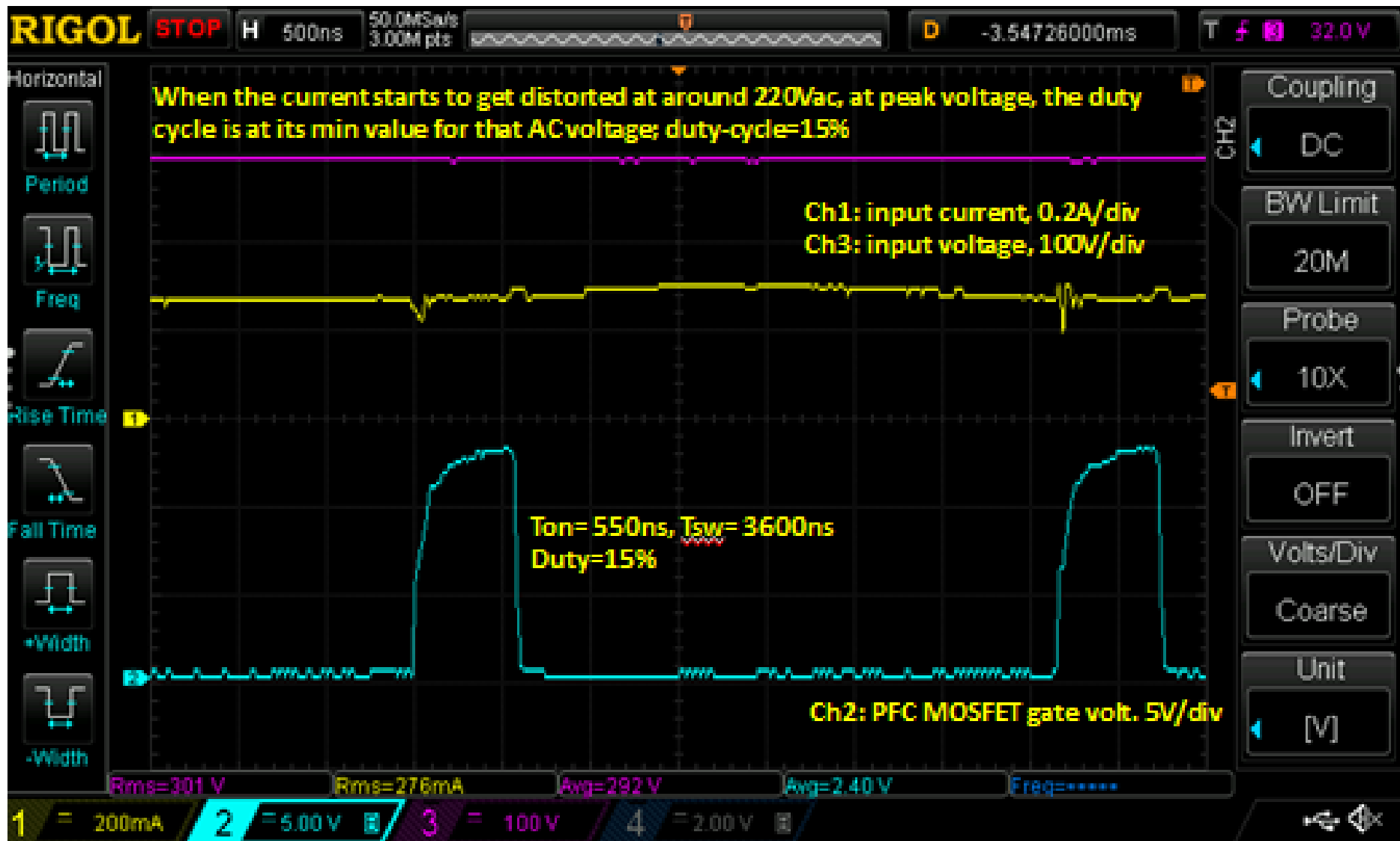
Coarse

Unit

[A]

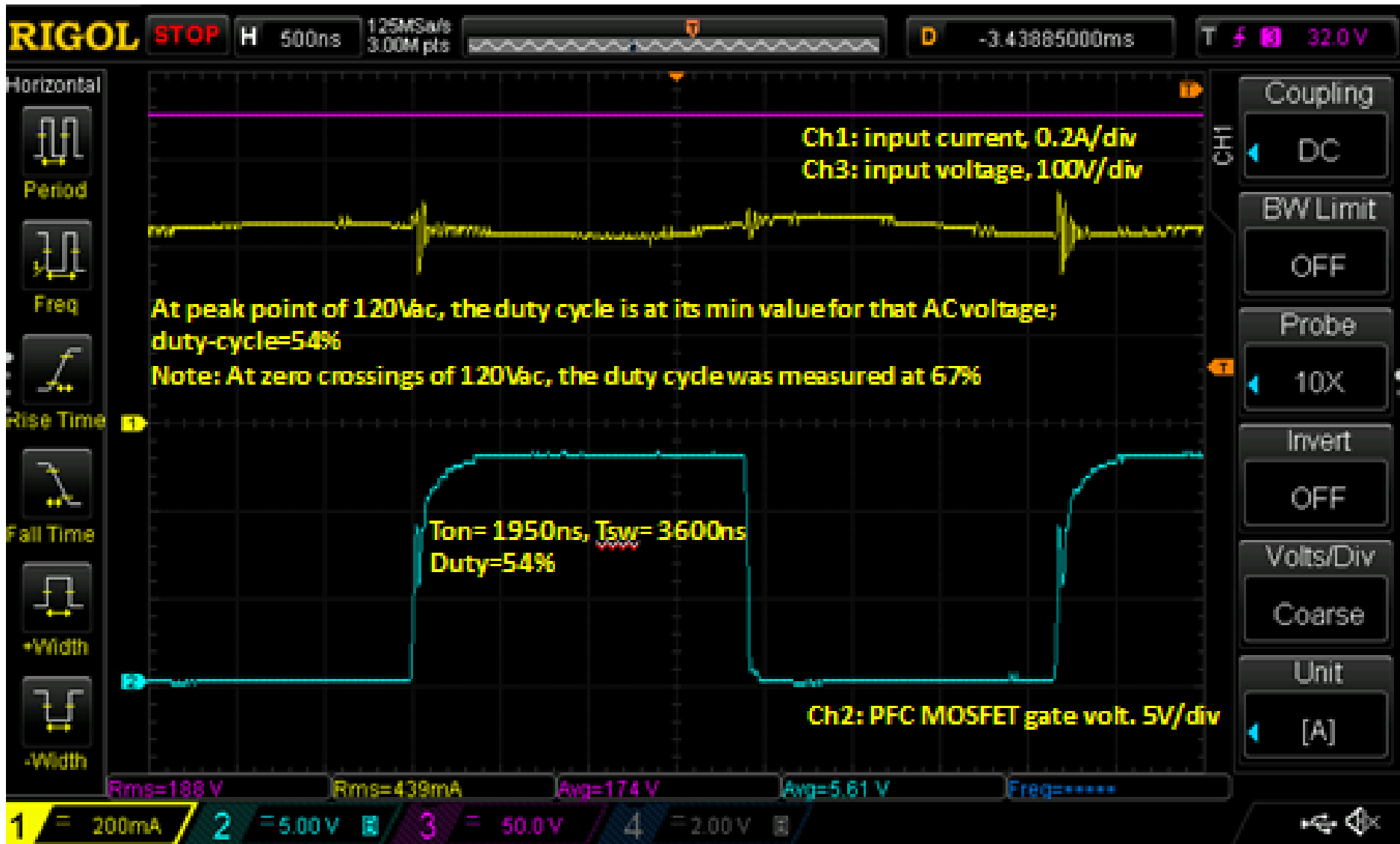


At the peak of sinewaves when distortion starts, the duty cycle of boost MOSFET is about 15%

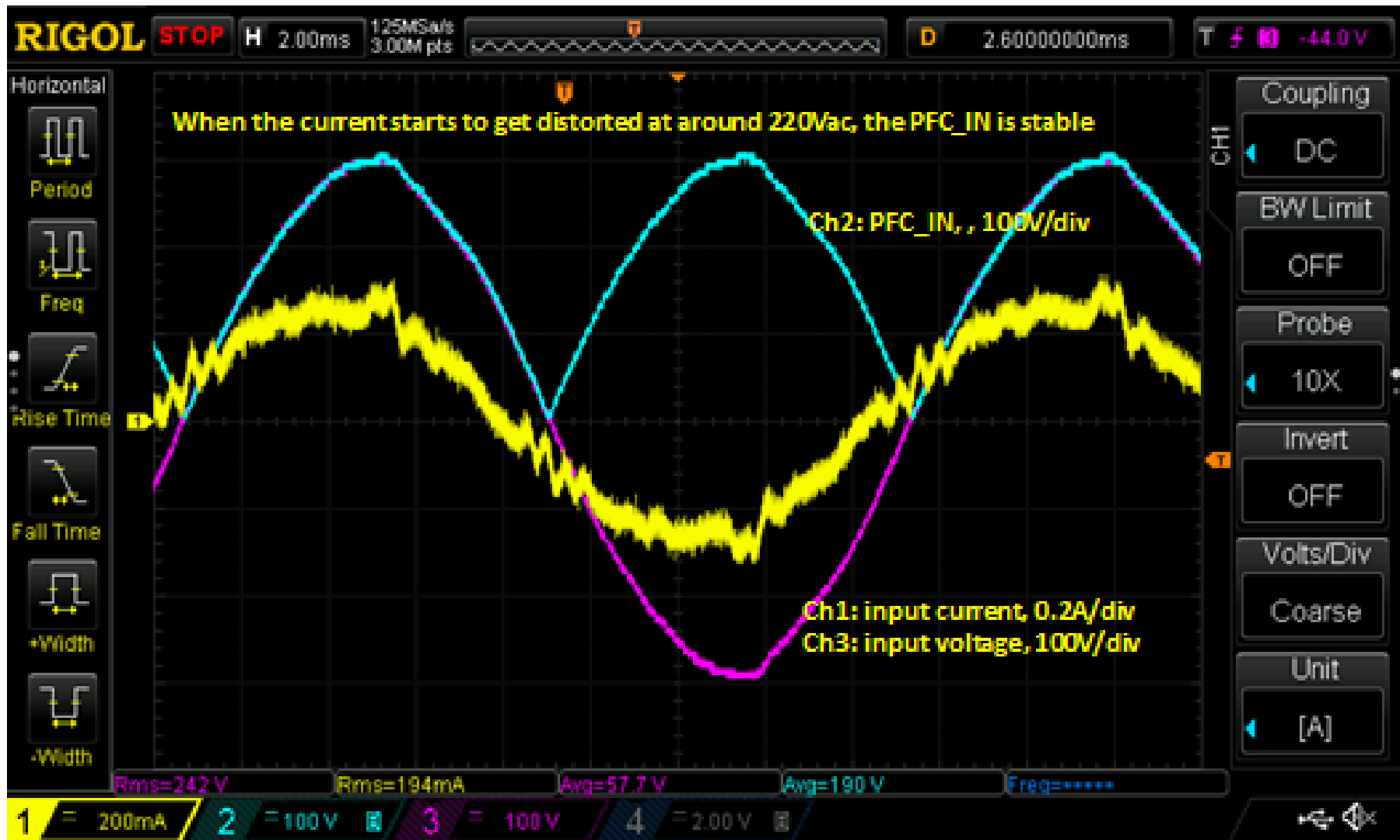




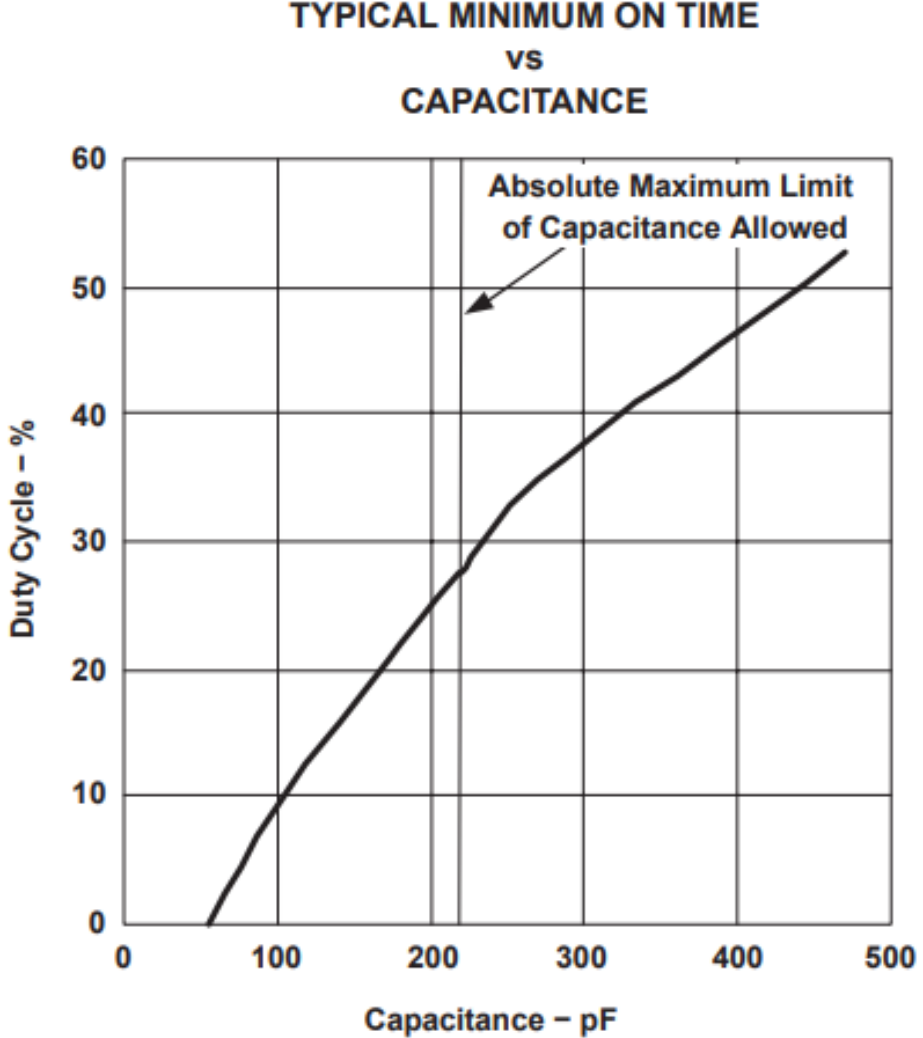
At the peak of sinewaves at 120Vac, the duty cycle of boost MOSFET is about 54%



At 220Vac when distortions starts, the rectified input voltage (used for Vff) is shown below



Referring to Fig 36 in the data sheet of UCC28513DW, what specific capacitor controls the min duty cycle?



**Figure 36**