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Implementation of IEC 61000-4-17 DC Ripple Immunity Test Standard with Chroma 61509 Programmable AC Source

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Implementation of IEC 61000-4-17 DC Ripple Immunity Test Standard with Chroma 61509 Programmable AC Source

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1. Document Contents

This document includes the specification of IEC 61000-4-17 DC ripple immunity test standard and waveform related parameter calculations along with the operation process, test items and test waveform for performing 48V DC ripple immunity tests on Chroma 61509 Programmable AC Source.

2. Introduction to IEC 61000-4-17 Standard

2.1 Summary

This standard defines the method for testing DC input immunity on the input ports of electrical appliances or electronic equipment. The related fields of application are: appliances that provide DC power from the rectifier system, and batteries that are being charged.

2.2 Purpose

The purpose of the standard is to build a common and repeatable test basis to be applied in the laboratory or to the electrical and electronic equipment, simulating the environment when subjected to ripple voltage.

2.3 Test Conditions

2.3.1 Test Level

The percentage of each test level indicates the peak-to-peak value of the ripple voltage.

Table 1 Test Level

Level	Percentage of the nominal d.c. voltage
1	2
2	5
3	10
4	15
x	x
NOTE "x" is an open level. This level can be given in the product specification.	

2.3.2 Test Frequency

The frequency of the ripple voltage is based on the multiple of 2, 3 or 6 times of 50Hz / 60Hz.

2.3.3 Test Waveform

It defines the ripple test waveform based on the charge/discharge characteristics of rectified system with filter capacitor for single and three phase power system.

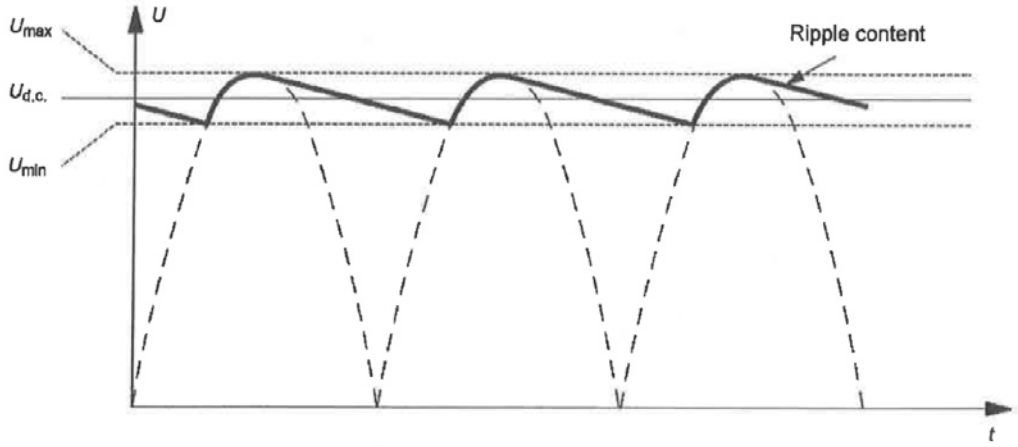

Figure 1 1-Phase Rectified Test Waveform

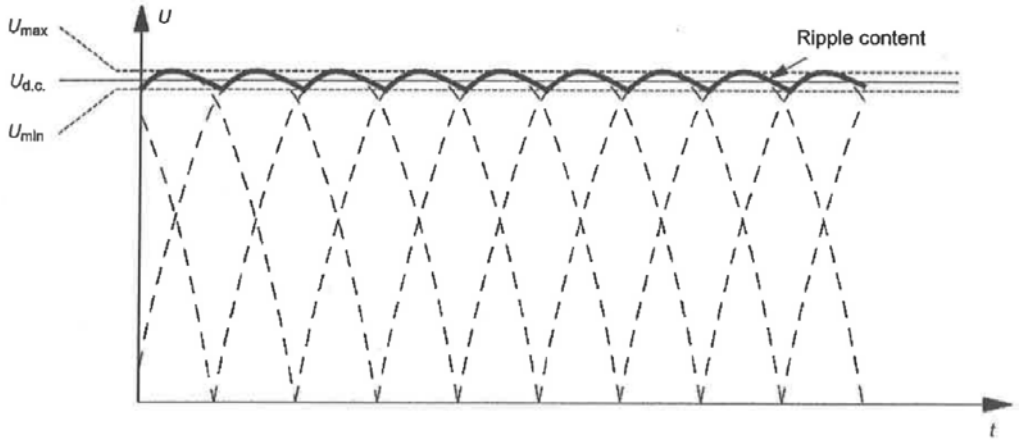

Figure 2 3-Phase Rectified Test Waveform

3. 48V DC Ripple Tests

3.1 Purpose

The 48V DC ripple test is going to simulate the specific waveform which defined in IEC 61000-4-17 by using 61509 programmable AC source as test instrument. User can use these specific output waveforms to test the ripple immunity of the DUT.

3.2 Introduction of Test Instrument

Table 2 Chroma 61509 Programmable AC Source Specifications

Model	Chroma 61509 Programmable AC Source
Exterior	
Output Phase	1 or 3 Selectable
Power Rating	6kVA / 6kW
AC Voltage Range	0~175VLN / 0~350VLN
AC Max Current (1-Phase)	60A / 30A
DC Voltage Range	0~247.5V / 0~495V
DC Max Current (1-Phase)	60A / 30A
Peak Current Capability	240A / 120A
Voltage Setting Accuracy	0.1% of RD+0.2% of FS
Frequency	15Hz ~ 2000Hz (15Hz ~ 5000Hz @ Option)
Frequency Accuracy	0.01%
Load Regulation	0.2%

3.3 Test Items

The test items are set by adding 50Hz or 300Hz to 48VDC on the 1-phase or 3-phase rectified waveforms with 15% amplitude (level 4) ripples.

Table 3 IEC 61000-4-17 Standard Test Items

Test Item	Rectification Type	Ripple Frequency	Nominal Voltage	Ripple Amplitude
1	1-Phase	50Hz	48Vdc	15%
2	1-Phase	300Hz	48Vdc	15%
3	3-Phase	50Hz	48Vdc	15%
4	3-Phase	300Hz	48Vdc	15%

The test will use the Sequence 0 and Sequence 1 of LIST mode advanced programming function of 61509 programmable AC source to simulate the ripple waveform occurred with the charging and discharging of the filter capacitor. And repeat these sequences continuously to simulate the ripple test waveform defined by the standard.

3.3.1 Test 1: 1-Phase Rectified Waveform (50Hz)

1. Parameter calculation schematic

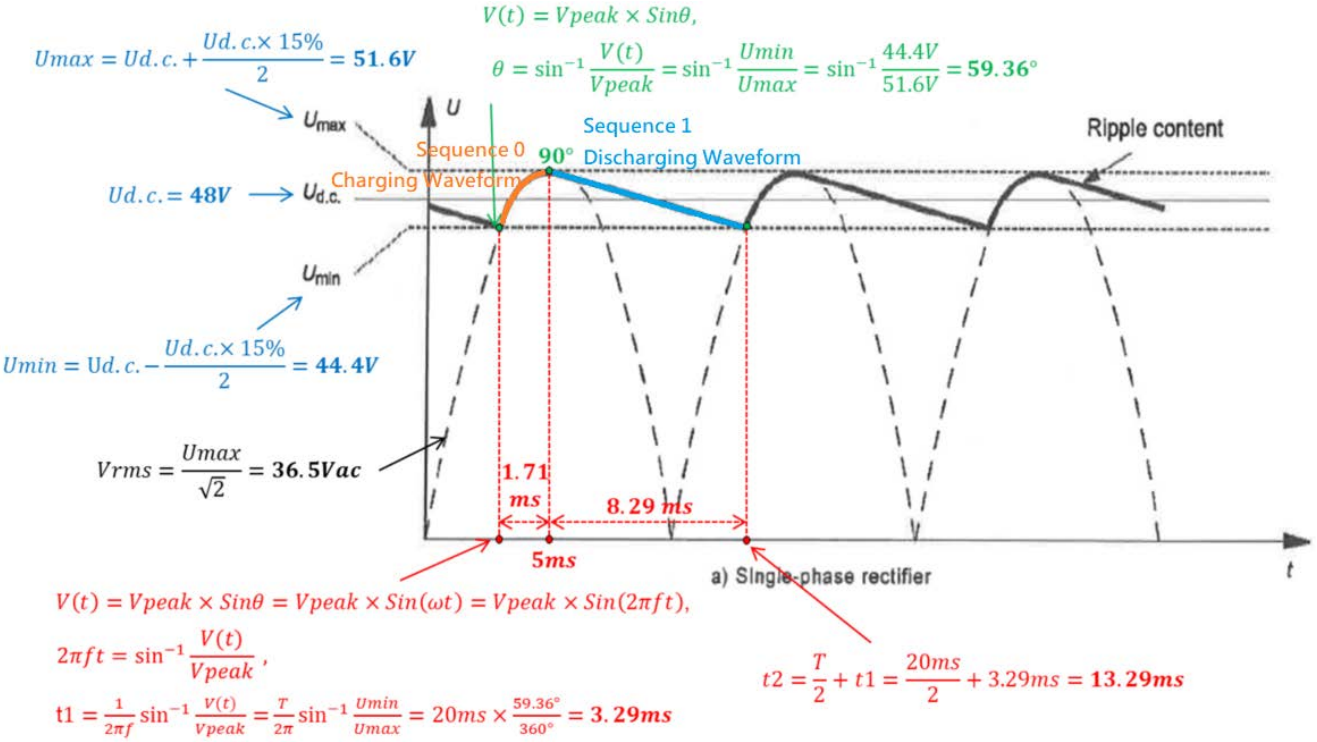

Figure 3 1-Phase Rectified Waveform (50Hz) –Parameter Calculation Schematic (voltage, phase angle, time)

2. Sequence 0 charging parameter calculation

   A. Ripple voltage RMS value

   The peak value of ripple is the base voltage 48V plus 15% amplitude = 51.6V. And let 51.6V divided by$\sqrt{2}$ to get the ripple voltage RMS value = 36.5Vac.

   B. Ripple frequency

   Test 1 frequency is 50Hz.

C. Starting phase angle of ripple

The start value of ripple is the base voltage 48V minus 15% amplitude = 44.4V. Use sine wave formula to calculate the starting phase angle θ.

$V(t) = Vpeak \times Sin\theta;$

$44.4 = 51.6 \times Sin\theta;$

$\theta = 59.36°$

D. The charging duration time

Sequence 0 is to simulate the ripple caused by capacitor in charging. Use sine wave formula to calculate the starting time t1.

$V(t) = Vpeak \times Sin\theta = Vpeak \times Sin(2\pi ft);$

$Sin(2\pi ft) = \frac{V(t)}{Vpeak};$

$t1 = \frac{1}{2\pi f}\sin^{-1}\frac{V(t)}{Vpeak} = \frac{T}{2\pi}\sin^{-1}\frac{44.4}{51.6} = 20 \times \frac{59.36°}{360°} = 3.29\ ms$

The charging is end at the one quarter of period $= \frac{1}{4} \times 20 = 5ms$. So we can get the Sequence 0 duration time = 5 – 3.29 = 1.71ms.

E. Chroma 61509 List Mode operation menu

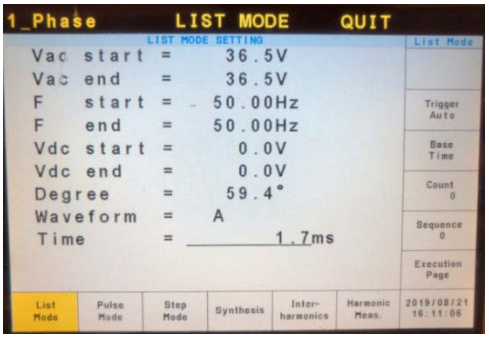

Figure 4 1-Phase Rectified Waveform (50Hz) - Sequence0 Edit Menu

3. Sequence 1 discharging parameter calculation

A. Discharging voltage

The charging starting voltage is the peak value of ripple = 51.6V. The ending voltage is equal to the start value of charging = 44.4V.

B. The discharging duration time

The discharging is end at $t2 = \frac{T}{2} + t1 = \frac{20}{2} + 3.29 = 13.29ms$. So we get the Sequence 1 duration time $= t2 - \frac{T}{4} = 13.29 - 5 = 8.29ms$.

C. Chroma 61509 List Mode operation menu

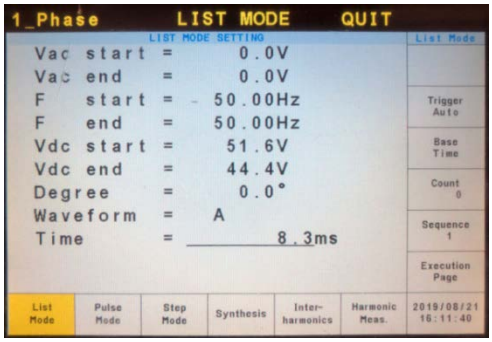

Figure 5 1-Phase Rectified Waveform (50Hz) – Sequence1 Edit Menu

4. Actual waveform

A. Charging waveform

Charging from 44.4V to 51.6V, and the charging time is approximately 1.71ms. Meet the definition of ripple waveform in the standard.

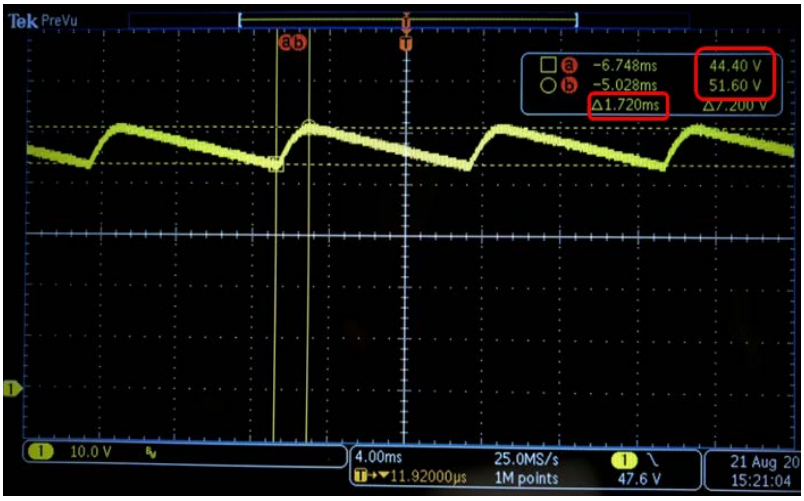

Figure 6 1-Phase Rectified Waveform (50Hz) – Actual Charging Waveform

B. Discharging waveform

Discharging from 51.6V to 44.4V, and the discharging time is approximately 8.29ms. Meet the definition of ripple waveform in the standard.

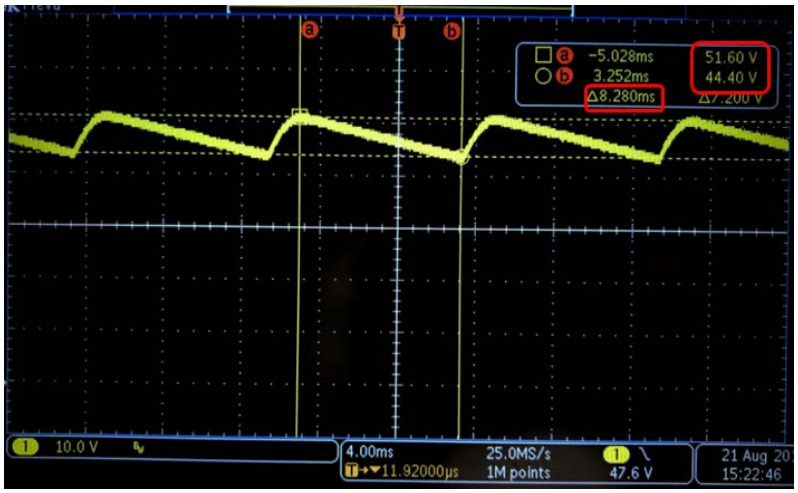

Figure 7 1-Phase Rectified Waveform (50Hz) – Actual Discharging Waveform

3.3.2 Test 2: 1-Phase Rectified Waveform (300Hz)

1. Parameter calculation schematic

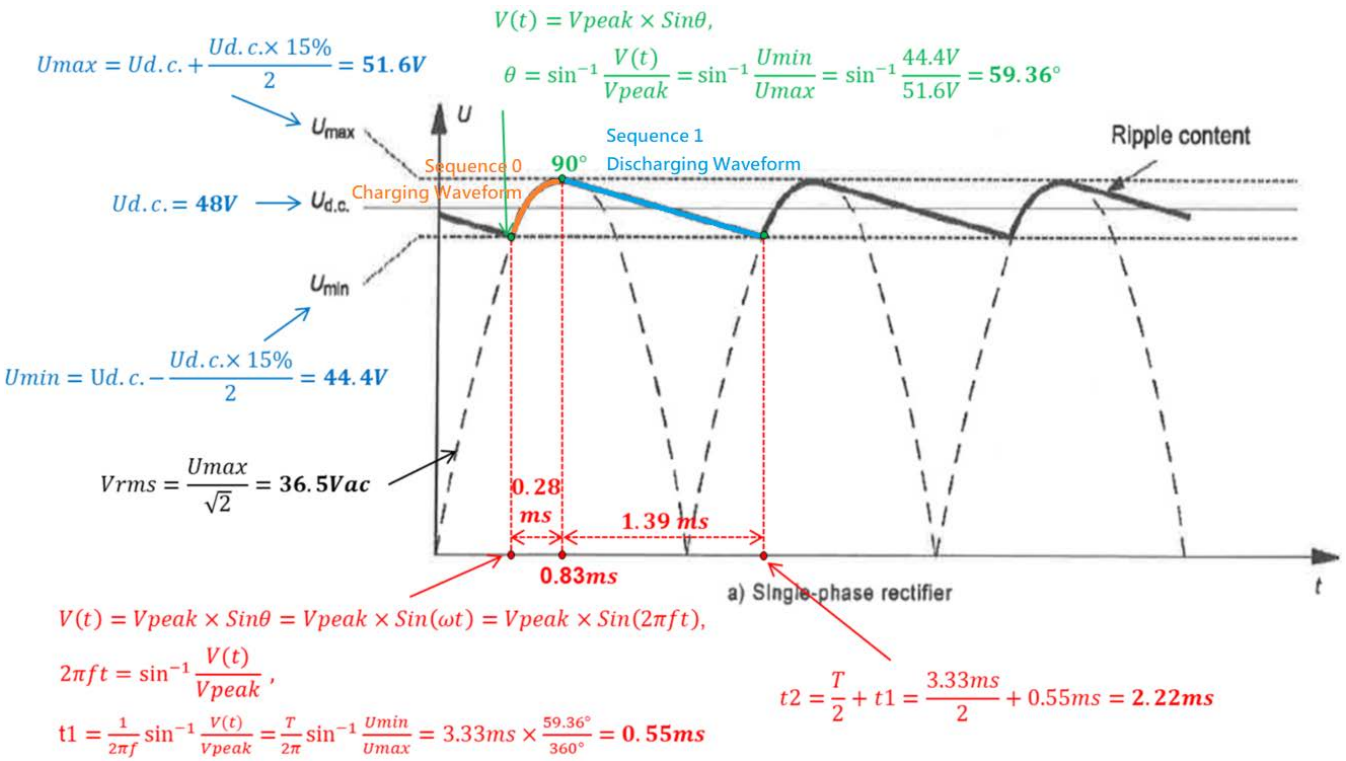

Figure 8 1-Phase Rectified Waveform (300Hz) –Parameter Calculation Schematic (voltage, phase angle, time)

2. Sequence 0 charging parameter calculation

   A. Ripple voltage RMS value

   The peak value of ripple is the base voltage 48V plus 15% amplitude = 51.6V. And let 51.6V divided by$\sqrt{2}$ to get the ripple voltage RMS value = 36.5Vac.

   B. Ripple frequency

   Test 2 frequency is 300Hz.

   C. Starting phase angle of ripple

   The start value of ripple is the base voltage 48V minus 15% amplitude = 44.4V. Use sine wave formula to calculate the starting phase angle θ.

   $V(t) = Vpeak \times Sin\theta;$
   $44.4 = 51.6 \times Sin\theta;$
   $\theta = 59.36°$

   D. The charging duration time

   Sequence 0 is to simulate the ripple caused by capacitor in charging. Use sine wave formula to calculate the starting time t1.

   $V(t) = Vpeak \times Sin\theta = Vpeak \times Sin(2\pi ft);$
   $Sin(2\pi ft) = \frac{V(t)}{Vpeak};$

$$t1 = \frac{1}{2\pi f}\sin^{-1}\frac{V(t)}{Vpeak} = \frac{T}{2\pi}\sin^{-1}\frac{44.4}{51.6} = 3.33 \times \frac{59.36°}{360°} = 0.55\ \text{ms}$$

The charging is end at the one quarter of period $= \frac{1}{4} \times 3.33 = 0.83ms$. So we can get the Sequence 0 duration time = 0.83 – 0.55 = 0.28ms.

E. Chroma 61509 List Mode operation menu

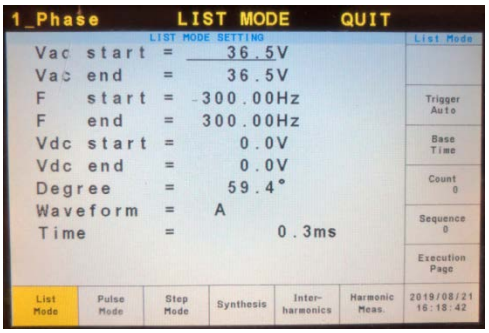

Figure 9 1-Phase Rectified Waveform (300Hz) - Sequence0 Edit Menu

3. Sequence 1 discharging parameter calculation

A. Discharging voltage

The charging starting voltage is the peak value of ripple = 51.6V. The ending voltage is equal to the start value of charging = 44.4V.

B. The discharging duration time

The discharging is end at $t2 = \frac{T}{2} + t1 = \frac{3.33}{2} + 0.55 = 2.22ms$. So we get the Sequence 1 duration time $= t2 - \frac{T}{4} = 2.22 - 0.83 = 1.39ms$.

C. Chroma 61509 List Mode operation menu

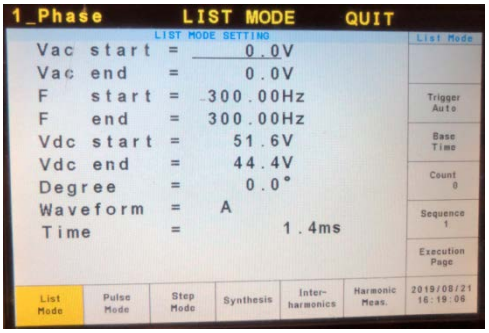

Figure 10 1-Phase Rectified Waveform (300Hz) – Sequence1 Edit Menu

4. Actual waveform

A. Charging waveform

Charging from 44.4V to 51.6V, and the charging time is approximately 0.28ms. Meet the definition of ripple waveform in the standard.

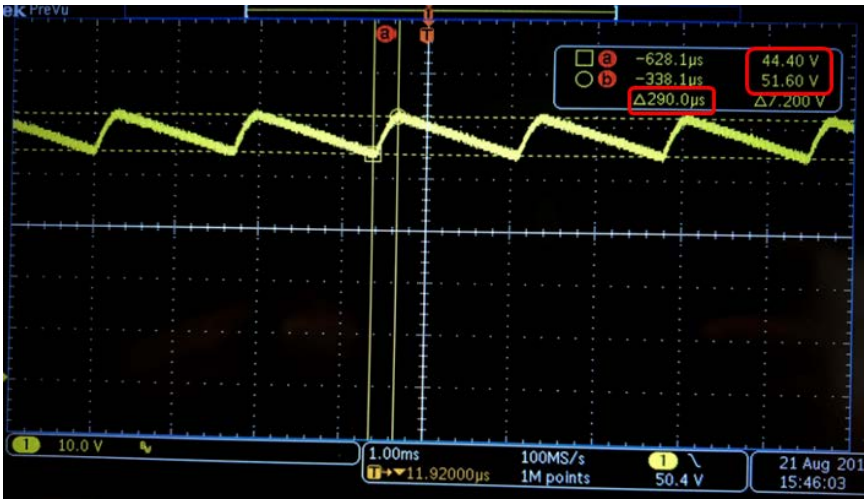

Figure 11 1-Phase Rectified Waveform (300Hz) – Actual Charging Waveform

B. Discharging waveform

Discharging from 51.6V to 44.4V, and the discharging time is approximately 1.39ms. Meet the definition of ripple waveform in the standard.

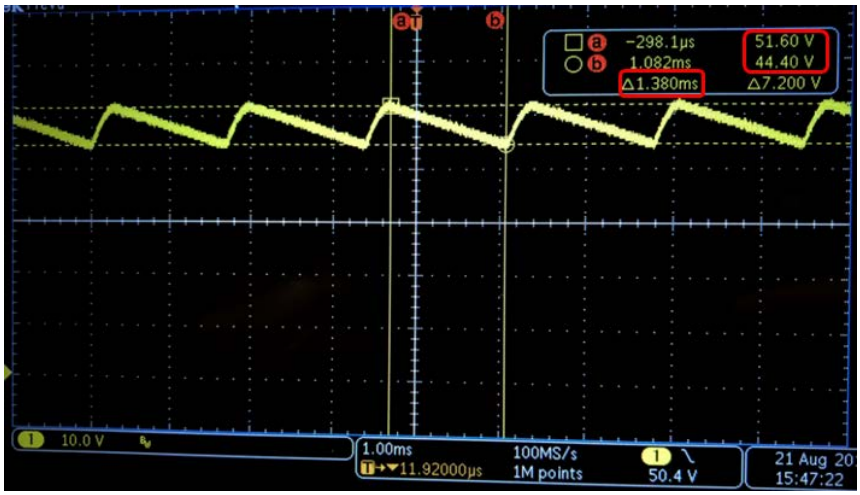

Figure 12 1-Phase Rectified Waveform (300Hz) – Actual Discharging Waveform

3.3.3 Test 3: 3-Phase Rectified Waveform (50Hz)

1. Parameter calculation schematic

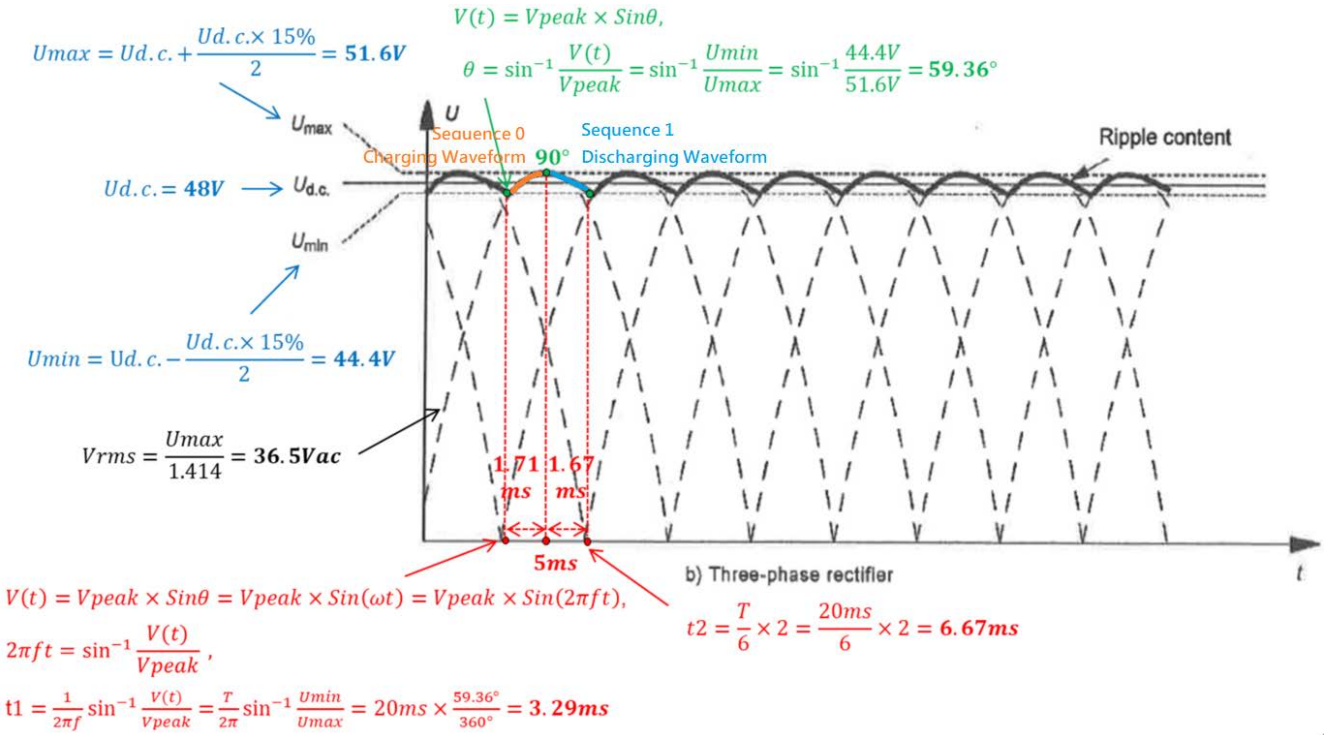

Figure 13 3-Phase Rectified Waveform (50Hz) –Parameter Calculation Schematic (voltage, phase angle, time)

2. Sequence 0 charging parameter calculation

   A. Ripple voltage RMS value

   The peak value of ripple is the base voltage 48V plus 15% amplitude = 51.6V. And let 51.6V divided by $\sqrt{2}$ to get the ripple voltage RMS value = 36.5Vac.

   B. Ripple frequency

   Test 3 frequency is 50Hz.

   C. Starting phase angle of ripple

   The start value of ripple is the base voltage 48V minus 15% amplitude = 44.4V. Use sine wave formula to calculate the starting phase angle θ.

   $V(t) = Vpeak \times Sin\theta;$
   $44.4 = 51.6 \times Sin\theta;$
   $\theta = 59.36°$

   D. The charging duration time

   Sequence 0 is to simulate the ripple caused by capacitor in charging. Use sine wave formula to calculate the starting time t1.

   $V(t) = Vpeak \times Sin\theta = Vpeak \times Sin(2\pi ft);$
   $Sin(2\pi ft) = \frac{V(t)}{Vpeak};$

$$t1 = \frac{1}{2\pi f}\sin^{-1}\frac{V(t)}{Vpeak} = \frac{T}{2\pi}\sin^{-1}\frac{44.4}{51.6} = 20 \times \frac{59.36°}{360°} = 3.29\ \text{ms}$$

The charging is end at the one quarter of period $= \frac{1}{4} \times 20 = 5ms$. So we can get the Sequence 0 duration time = 5 – 3.29 = 1.71ms.

E. Chroma 61509 List Mode operation menu

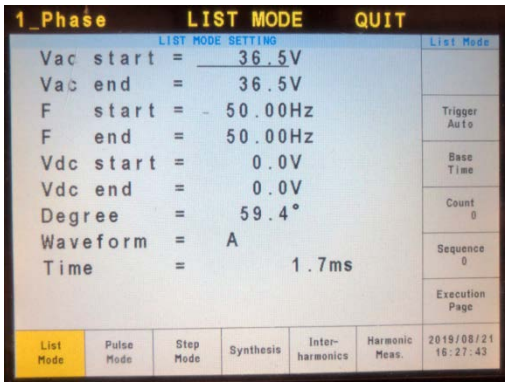

Figure 14 3-Phase Rectified Waveform (50Hz) - Sequence0 Edit Menu

3. Sequence 1 discharging parameter calculation

A. Discharging voltage

The charging starting voltage is the peak value of ripple = 51.6V. The ending voltage is equal to the start value of charging = 44.4V.

B. The discharging duration time

Take 3-phase rectified waveform diagram from standard for reference, and the discharging is end at the second one-sixth period point= $\frac{T}{6} \times 2 = \frac{20}{6} \times 2 = 6.67ms$. So we get the Sequence 1 duration time $= t2 - \frac{T}{4} = 6.67 - 5 = 1.67ms$.

C. Chroma 61509 List Mode operation menu

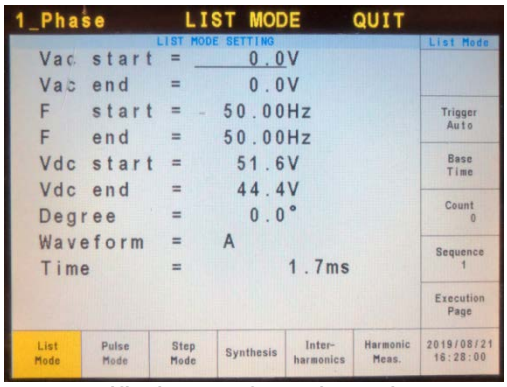

Figure 15 3-Phase Rectified Waveform (50Hz) – Sequence1 Edit Menu

4. Actual waveform

A. Charging waveform

Charging from 44.4V to 51.6V, and the charging time is approximately 1.71ms. Meet the definition of ripple waveform in the standard.

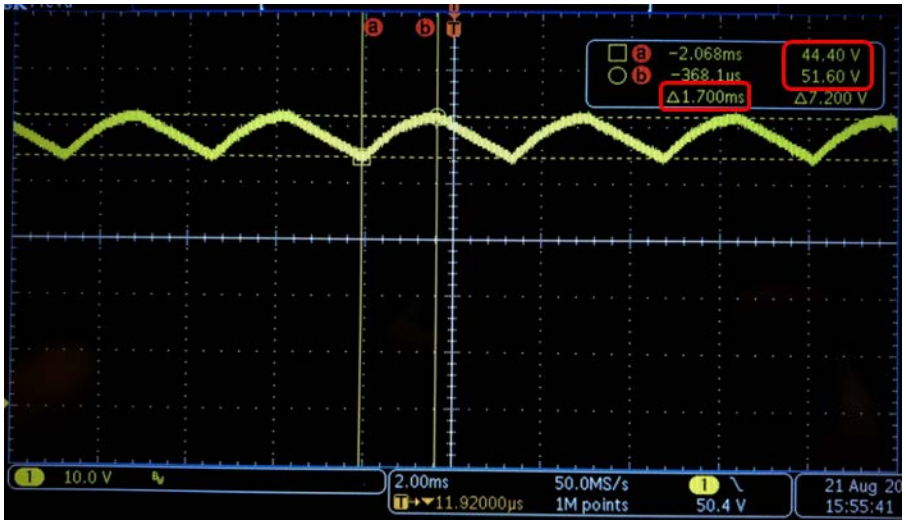

Figure 16 3-Phase Rectified Waveform (50Hz) – Actual Charging Waveform

B. Discharging waveform

Discharging from 51.6V to 44.4V, and the discharging time is approximately 1.67ms. Meet the definition of ripple waveform in the standard.

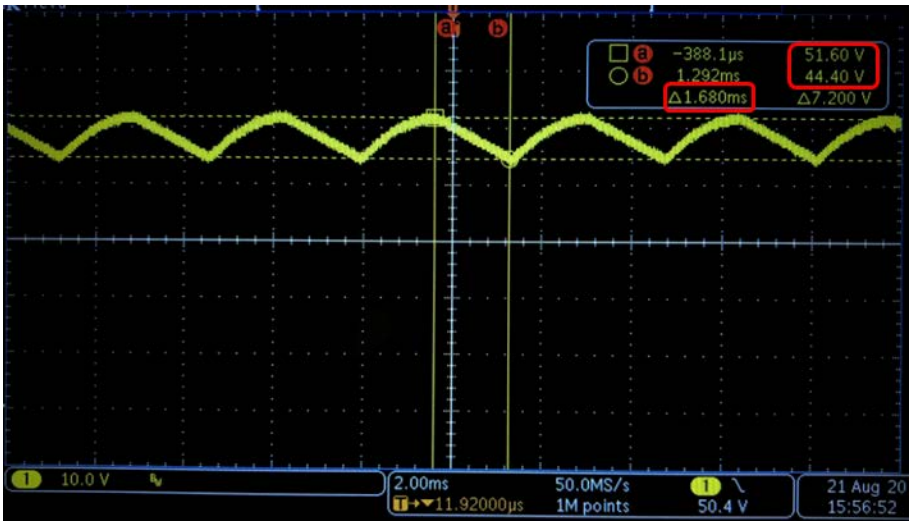

Figure 17 3-Phase Rectified Waveform (50Hz) – Actual Discharging Waveform

3.3.4 Test 4: 3-Phase Rectified Waveform (300Hz)

1. Parameter calculation schematic

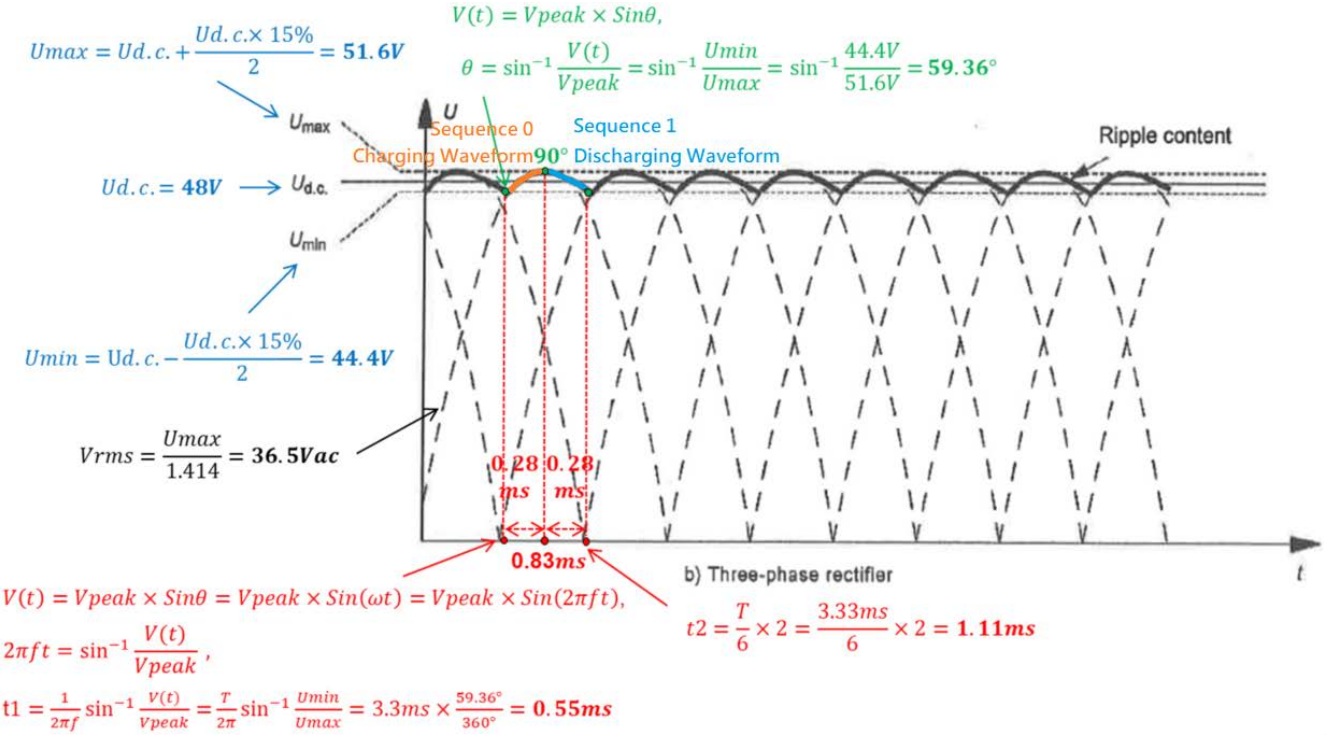

Figure 18 3-Phase Rectified Waveform (300Hz) –Parameter Calculation Schematic (voltage, phase angle, time)

2. Sequence 0 charging parameter calculation

   A. Ripple voltage RMS value

   The peak value of ripple is the base voltage 48V plus 15% amplitude = 51.6V. And let 51.6V divided by $\sqrt{2}$ to get the ripple voltage RMS value = 36.5Vac.

   B. Ripple frequency

   Test 4 frequency is 300Hz.

   C. Starting phase angle of ripple

   The start value of ripple is the base voltage 48V minus 15% amplitude = 44.4V. Use sine wave formula to calculate the starting phase angle θ.

   $V(t) = Vpeak \times Sin\theta;$
   $44.4 = 51.6 \times Sin\theta;$
   $\theta = 59.36°$

   D. The charging duration time

   Sequence 0 is to simulate the ripple caused by capacitor in charging. Use sine wave formula to calculate the starting time t1.

   $V(t) = Vpeak \times Sin\theta = Vpeak \times Sin(2\pi ft);$
   $Sin(2\pi ft) = \frac{V(t)}{Vpeak};$

$$t1 = \frac{1}{2\pi f}\sin^{-1}\frac{V(t)}{Vpeak} = \frac{T}{2\pi}\sin^{-1}\frac{44.4}{51.6} = 3.33 \times \frac{59.36°}{360°} = 0.55\ \text{ms}$$

The charging is end at the one quarter of period $= \frac{1}{4} \times 3.33 = 0.83ms$. So we can get the Sequence 0 duration time = 0.83 – 0.55 = 0.28ms.

E. Chroma 61509 List Mode operation menu

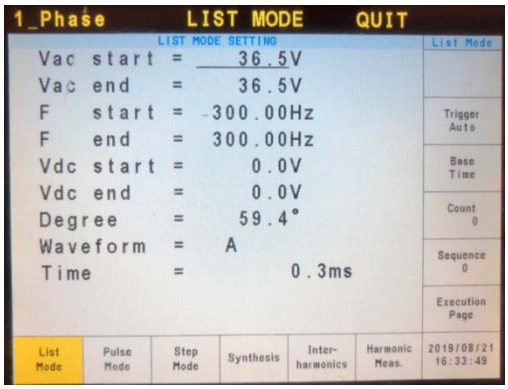

Figure 19 3-Phase Rectified Waveform (300Hz) - Sequence0 Edit Menu

3. Sequence 1 discharging parameter calculation

A. Discharging voltage

The charging starting voltage is the peak value of ripple = 51.6V. The ending voltage is equal to the start value of charging = 44.4V.

B. The discharging duration time

Take 3-phase rectified waveform diagram from standard for reference, and the discharging is end at the second one-sixth period point= $\frac{T}{6} \times 2 = \frac{3.33}{6} \times 2 = 1.11ms$. So we get the Sequence 1 duration time $= t2 - \frac{T}{4} = 1.11 - 0.83 = 0.28ms$.

C. Chroma 61509 List Mode operation menu

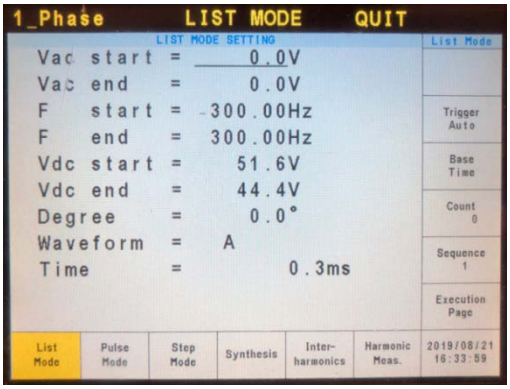

Figure 20 3-Phase Rectified Waveform (300Hz) – Sequence1 Edit Menu

4. Actual waveform

A. Charging waveform

Charging from 44.4V to 51.6V, and the charging time is approximately 0.28ms. Meet the definition of ripple waveform in the standard.

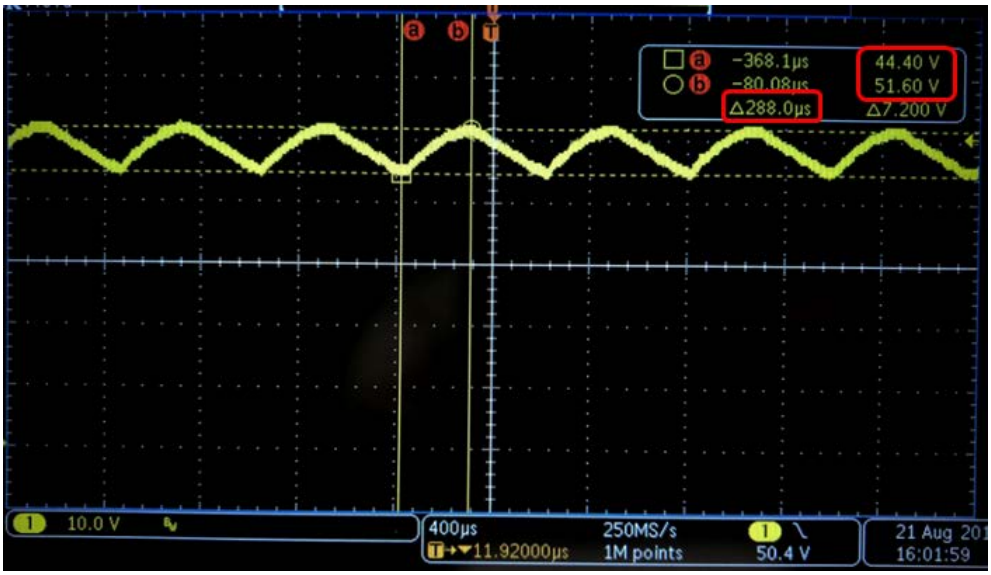

Figure 21 3-Phase Rectified Waveform (300Hz) – Actual Charging Waveform

B. Discharging waveform

Discharging from 51.6V to 44.4V, and the discharging time is approximately 0.28ms. Meet the definition of ripple waveform in the standard.

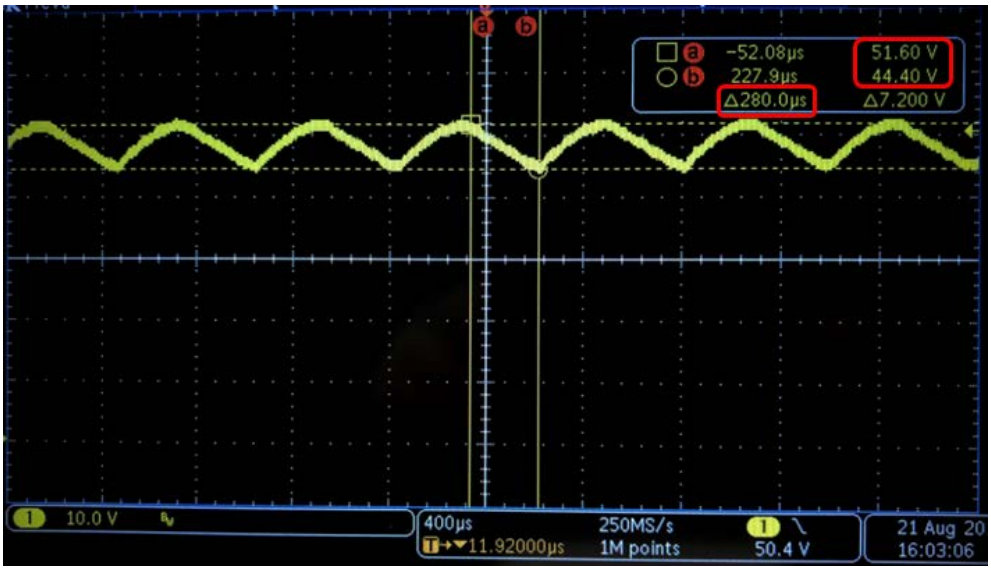

Figure 22 3-Phase Rectified Waveform (300Hz) – Actual Discharging Waveform

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