How to test the LED Driver using the 3341G Series LED DC Electronic Load Simulator

To comply with the global trend of energy saving and reduce carbon emissions, LED lighting applications are increasingly used in consumer products (such as LED TV, mobile phones, flashlights, etc.), and for general lighting purposes, replacing inefficient incandescent bulbs. Other examples include automotive applications (headlamps, directional lights, brake lights, interior lights, fog lights, instrument lights and so on), public works (LED street lights, traffic lights, etc.) and office lighting (to replace fluorescent). While the use of LED lighting was initially limited to specific applications, it is now widely adopted by the market and attracts massive investments. To be competitive in this growing market and stand out from competitors, not only is the price and quality of the LED's used important, of equal importance are the supporting devices required , especially the LED driver power supply.

The LED current driver supply must support several combinations of up to dozens of LED, either in series or parallel in actual application in order to achieve the required number of lumens. The supply has to convert AC power into LED DC current. For these power supplies, energy efficiency is an important parameter. To maintain overall energy efficiency, low energy consumption and high efficiency LED lamps can reduce the amount of heat losses and also can extend the LED light service life. Efficiency improvement is the goal of any LED drive power design. The current trend in LED driver technology is towards higher voltage applications at higher power levels to reduce overall current. Not only can this improve the efficiency, is also saves cost of copper of materials used in wiring. In addition, in order to further save energy, as well as to allow lighting adjustment to the surrounding environment, dimming of LED lights can achieve further energy-saving. Thus, the LED driver must not only provide a stable DC current source, it must also satisfy the dimming control requirements.

Almost lighting manufacturers are investing heavily in development and production of constant current LED drive power supplies to meet the huge demands of lighting market. As LED prices continue to decrease, they will soon completely replace the incandescent light bulbs causing the market to expand rapidly in the future.

The output of an LED driver has a constant current profile. The output voltage is based on the LED equivalent on voltage Vd and the equivalent series resistance Rd. Unlike a traditional power supply, the output is a fixed voltage which necessitates the use of an LED electronic load to quickly simulate and verify performance and reduce the product development schedule for shorter time to market.

Prodigit introduced 3341G series LED dimmable DC electronic load, including 3341G (300V, 24A, 300W), 3342G (500V, 12A, 300W), 3343G (500V, 24A, 300W), 33401G (500V, 6A, 150Wx2) , LED drive power for testing and verification. These loads can simulate real LED characteristics, based on LED parameters inputs (including Vd threshold voltage, Rd series resistance, Vo output voltage, etc.). Thus, there is no longer any need to connect actual LEDs to the LED drive power supply. It also allows for easy changes in the LED parameters to simulate different number of LEDs in a string, LED specifications or LED brands. It also has the necessary control signal for dimming control of the LED driver, including a 0 to 12V Analog voltage and 0 to 1kHz, 0 to 100% duty cycle output signal which is the best tool to test and verify LED power drivers.

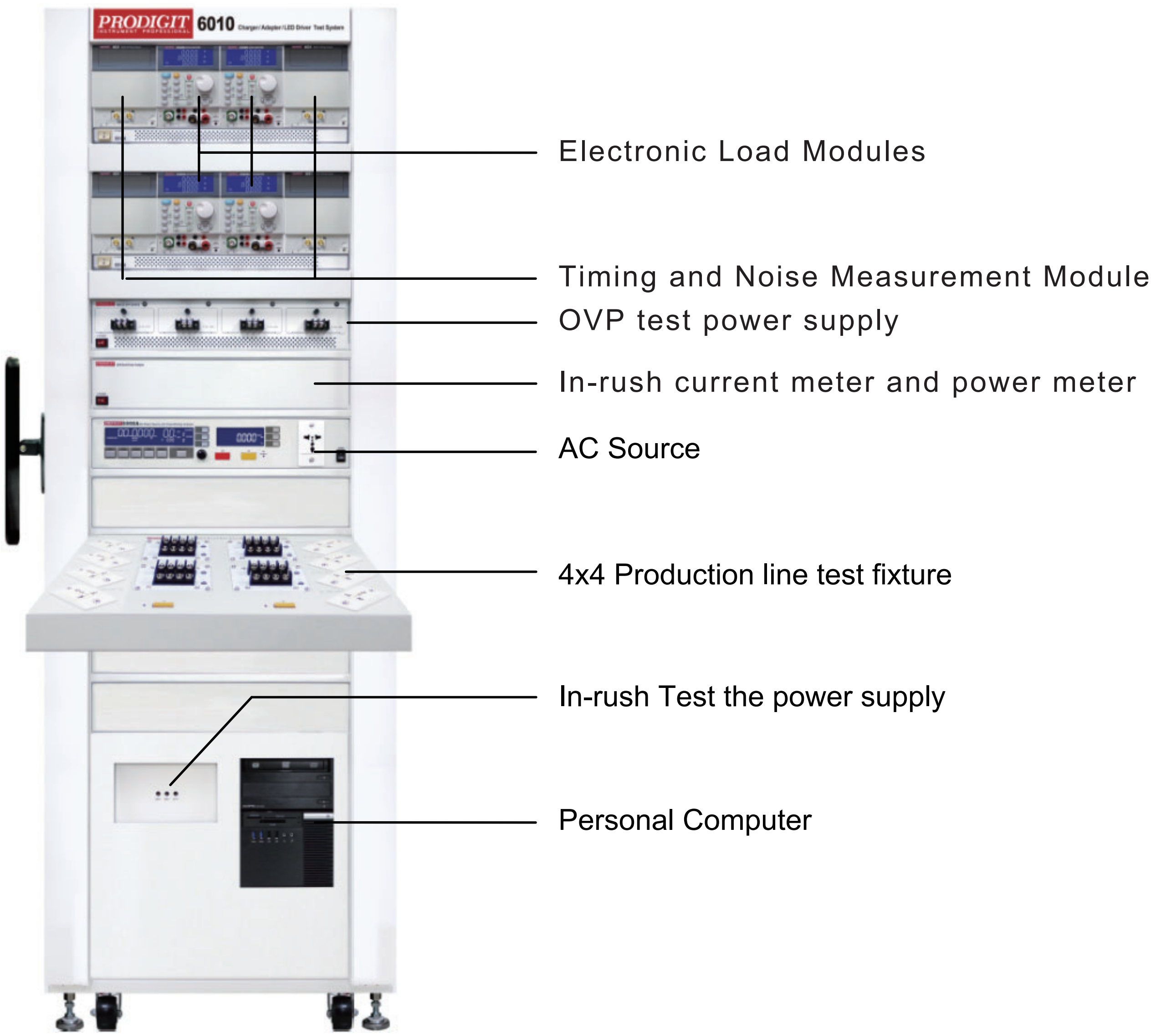
3341G Series LED mode DC Electronic Load Module

3341G	300V, 24A, 300W
3342G	500V, 12A, 300W (option for 600V)
3343G	500V, 24A, 300W (option for 600V)
33401G	500V, 6A, 150Wx2 (option for 600V)

3342G 300W LED mode DC Electronic Load Module + 3302F Single Mainframe

Features

- Suitable for LED power supply and general power supply。
- CC, CR, CV, CP, LED and Dynamic mode。
- Simulate LED Forward Bias Voltage (Vd) and Resistance (Rd) 。
- LED mode has six ranges, suitable for all kinds of LED series and parallel applications。
- >100KHz fast voltage / current response, to meet the PWM dimming test。
- Built-in isolated dimming control signal。
- Built-in short-circuit test relay to control voltage, optional short-circuit fixture board (containing high-voltage high-current short - circuit relays).
- Applicable to the 3300F / 3302F / 3305F Quad / Single / Dual module frame.
- Up to 600V LED load voltage is optional.



6010 Power supply products automatic test system (ATE)

First of all, we need to determine the load characteristics of an LED : Figure 1 illustrates the use of a current source to drive LED lights. The LED equivalent circuit consists of two parts, a series resistance Rd and a series voltage Vd shown in Figure 2. The LED characteristic curve is shown in Figure 3. When the two ends voltage of the LED are greater than the LED equivalent series voltage Vd, the current flows through the LED Io is (V - Vd) / Rd that is the equivalent resistance.

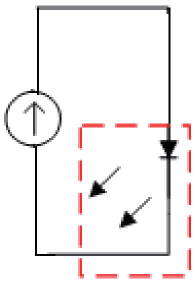


Figure 1
LED and drivers

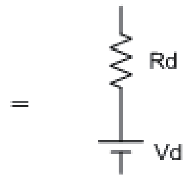


Figure 2
LED equivalent

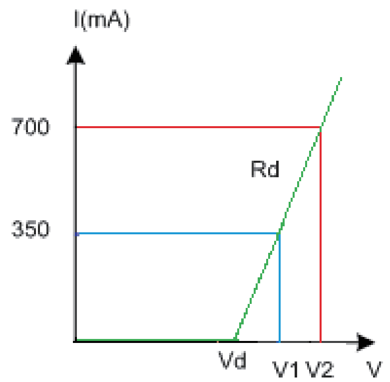
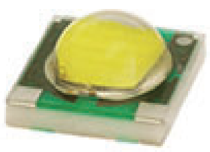


Figure 3
LED characteristics curve



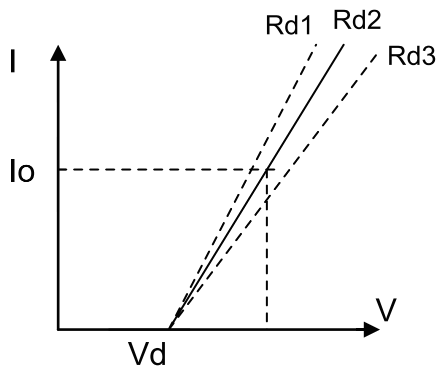
Actual LED element

The current rating of an actual lighting LED is generally 350mA to 700mA. High-power LED can demand as much as 1400mA to 2800mA. Forward voltage Vd is typically about 2.8V ~ 3.4V. An LED luminous flux value is proportional to the current flowing through the LED. As seen in Figure 3, the Vd voltage will increase the LED current and light output, producing not only more light but also more heat generation as a function of I x Rd.

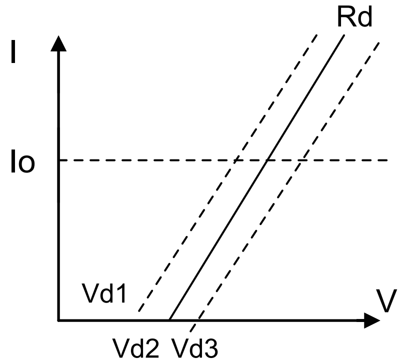
Since the LED driver is a constant current source, the voltage across the LED terminal is Vd + (IxRd) = Vo. The threshold voltage Vd has a negative temperature coefficient (about -2mV / ℃), which means Vd decreases with increasing temperature, resulting in a decrease in Vo with increasing temperature. Because of the negative temperature coefficient of LED characteristics, the LED power driver is a current source rather than a voltage source so the life span of the LED is not decreased.

For the actual LED Vd and Rd values and characteristics, refer to the LED manufacturer's specifications or use the actual test data of the LED components. For the latter approach, change the current values through the LED one by one and record the corresponding LED terminal voltage at each step so you can draw the entire characteristic curve of LED I / V current-voltage.

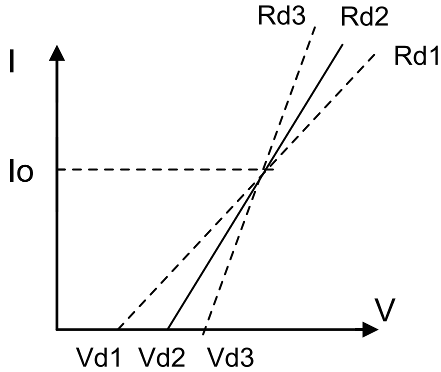
Although a schematic typically uses an LED symbol, in reality, due to LED lighting color difference between manufacturer's models, or different working temperature and other factors, the resulting in LED Vd and Rd differs. Thus, there are three different characteristics of LED respectively LED1, LED2, LED3, corresponding to Vd1, Vd2, Vd3 and Rd1, Rd2, Rd3.



The Vd of LED is same, but Rd is difference (Rd3 > Rd2 > Rd1)



The Vd of LED is difference, but Rd is same (Vd3 > Vd2 > Vd1)



The Vd and Rd of LED are all difference (Vd3 > Vd2 > Vd1) and Rd1 > Rd2 > Rd3

When the lumen output of a single LED is insufficient, you can choose a higher power LED or use multiple LEDs in series. Since multiple LEDs in series can increase the output brightness, multi-unit LED array packaged products are already available. In this case, Vd and Rd will be multiplied by the number of LEDs in series. Figure 4 through 6 show the equivalent circuit and the corresponding characteristic curve for a variety of LED series configurations and their various LED lighting applications :

Single LED

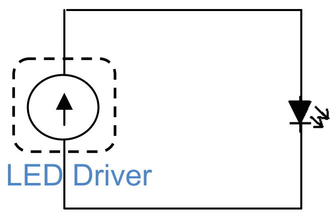
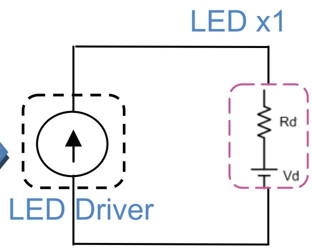
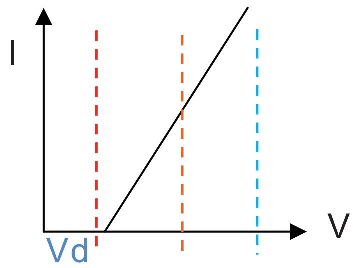


Figure 4 Single LED



Single LED equivalent circuit



The VI curve of a single LED

Three LEDs are connected in series

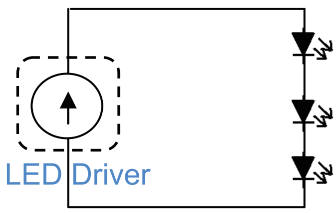
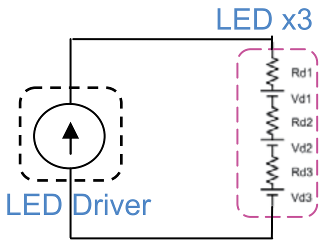
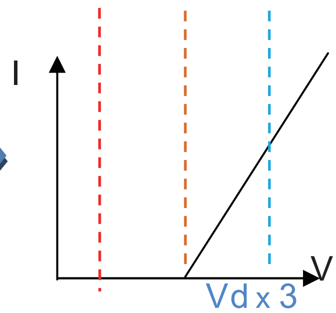


Figure 5 Three LED series circuit



Three LED equivalent circuits



Three LEDs in series VI curve

Six LEDs (two LEDs in series are connected in parallel)

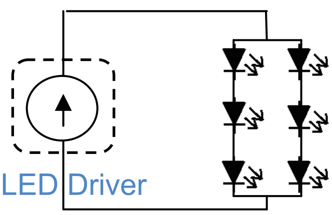
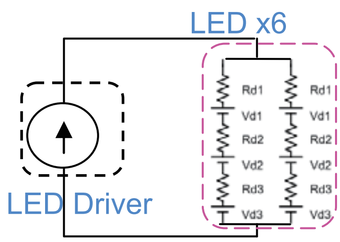
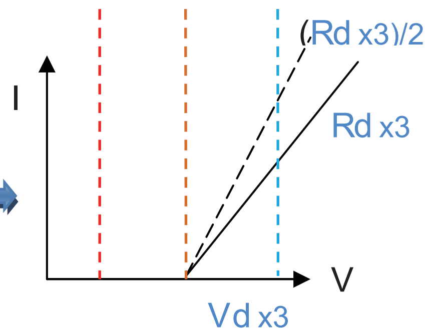


Figure 6
six LED series and parallel circuit



Six LED series - parallel equivalent circuit



Six LED series - parallel VI characteristic curve

When multiple LEDs are connected in series, the voltage of the LED drive power supply needs to be higher. In order to avoid high voltages (such as > 60V), resulting in the need for additional insulation and safety regulation requirements, a combination of multiple LEDs in series and parallel can increase the output brightness without excessive voltage requirements. The Vd will increase according to the number of LEDs in series, Rd is the result of the series and parallel network configuration. Figure 6 is representative of two strings of three LEDs in parallel and its equivalent circuit and characteristic curve.

Prodigit 3341G / 3342G / 3343G LED electronic load modules are designed for LED simulation and can simulate configurations from a single LED to multiple LED series. The series voltage can be as high as 500V. You can also simulate multiple LED in parallel. The parallel maximum current can up to 24A with power up to 300W. In addition, the 33401G module has two independent 150W x 2 LED electronic load channels, suitable for power up to 150W. This supports testing of two LED power supplies simultaneously.

For LED Driver output voltages higher than 500V, there is a 600V option available when placing the order. For more details please refer to Prodigit's website or contact Prodigit’s sales department.

The following sections describe the differences between the LED mode load and the general electronic load :

The purpose of an LED driver is to convert electricity into LED lighting suitable for driving the a light fixture according to the end-user needs. There can be special types and general types of lighting.

Specific type LED drivers are configured with LED lights such as E27 bulb, MR16 cup lamps, or T5 / T8 lamps and other smaller lighting devices. These devices have the circuitry that drives the LEDs integrated with a specific number of LEDs while still packaged into a standard lamp shape product.
For general configuration, the LED driver and LED lights are separated in two parts: the LED driver has a rated constant current output, where power and voltage can be an interval range. This means that the number of LED lighting on the environment can be adjusted. Usually these are higher power lighting units for commercial or industrial use.

SPECIFICATION

MODEL		PCD-25-350☐	PCD-25-700☐	PCD-25-1050☐	PCD-25-1400☐
OUTPUT	RATED CURRENT	350mA	700mA	1050mA	1400mA
	OPERATING VOLTAGE RANGE	40 ~ 58V	24 ~ 36V	16 ~ 24V	12 ~ 18V
	CURRENT RANGE	0 ~ 350mA	0 ~ 700mA	0 ~ 1050mA	0 ~ 1400mA
	RATED POWER	20.3W	25.2W	25.2W	25.2W
	RIPPLE & NOISE (max.) Note.1	4.6Vp-p	2.7Vp-p	2.2Vp-p	2Vp-p
	OUTPUT VOLTAGE (max.)	63V	50V	35V	25V
	SETUP TIME	1000ms / 230VAC 2000ms / 115VAC at full load			
INPUT	FREQUENCY RANGE	47 ~ 63Hz			
	POWER FACTOR	PF≧0.9 at full load and rated output voltage			
	EFFICIENCY(Typ.)	82%	81%	80.5%	80%
	AC CURRENT	0.6A/115VAC 0.3A/230VAC			
	INRUSH CURRENT(max.)	40A/230VAC			
	LEAKAGE CURRENT	<0.5mA / 240VAC			

Typical specification of general type LED driver

The following describes the actual LED load and electronic load test, using the electronic LED loads in CC, CR, CV, LED mode. The difference between the actual LED load (3W / 3.85V / 700mA LED string 10).

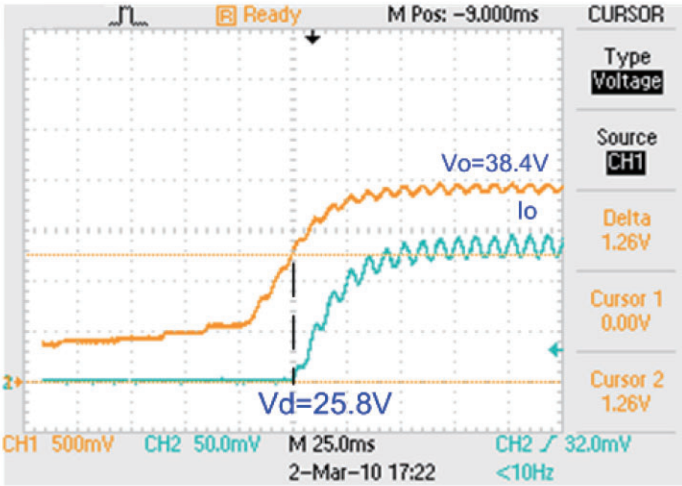
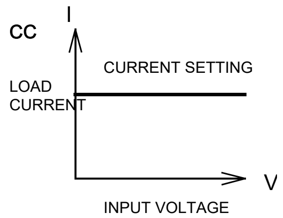
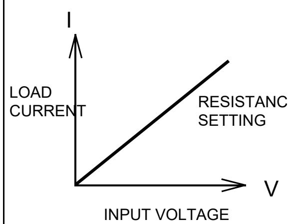
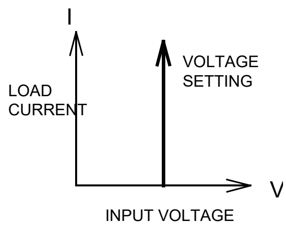
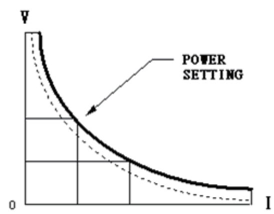
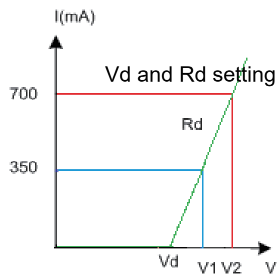


Figure 13 the actual LED's V, A waveform, where Vd = 25.8V, Rd = (Vo-Vd) / Io = 18Ω

Load Mode	Application	Load setting parameter	Characteristic Figure
CC Mode	Test voltage source For Adaptor, power supply	One Load current value (load current value of power supply) ◦	
CR Mode	Test voltage source or current source For Over-current or power-up	One Load resistance value ◦	
CV Mode	Test current source For Charger	One Load voltage value (terminal voltage of chargeable battery)	
CP Mode	Test the battery discharge capacity For Battery	One Load power value, the load current will vary with the battery terminal voltage, Constantly automatically adjusted to a fixed power value ◦	
LED Mode	Test the LED drive power For LED Driver	Two LED Vd and Rd values, Simulate LED ◦	

The various operating modes description of Electronic Load

The CC mode of electronic load; only needs to set one parameter required for use as the load of the voltage source. Since the LED Driver has a current source output, the load cannot used in CC mode (constant current).

The CR mode of electronic load; only need to set one parameter, setting CR mode and R = Vo / Io, is used as a voltage source or current load, although the CR mode may be used to test LED Driver, but the equivalent circuit is different from the same characteristics as the LED and cannot achieve the effectiveness of LED simulation.

The CV mode of electronic load; only need to set one parameter, setting CV mode and V = Vo are used as the current source of the load, although the CV mode may be used to test the LED Driver, the equivalent circuit is different from the same characteristics as the LED and cannot achieve the effectiveness of LED simulation.

LED mode : LED mode is for the simulation the equivalent circuit diagram Figure 2 of the LED, Integration of the above CR mode + CV mode, 3341G series LED mode must also set two parameters simultaneously, they are Vd and Rd respectively. Figure 14 shows the current waveform and the actual LED load, same as those in Figure 13.

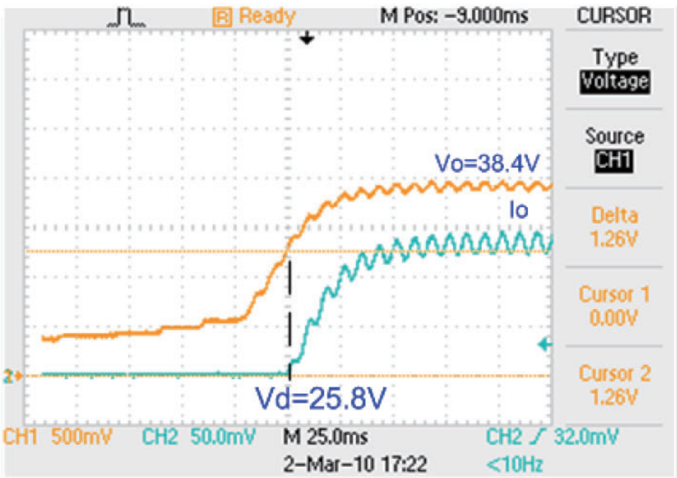


Figure 14 is 3341G LED MODE electronic load voltage Vo and current Io waveform, when the output voltage reaches 25.8V, Io current begin to increase, the same as the LED equivalent circuit.

As the general type LED drive power supply can be used with a variety of combinations of LED lights, so one by one the parameters of LED mode load must be set, including Vd, Rd, Vo, Io, etc.. As the actual LED driver connected LED will be in accordance with the brand, specifications, series, parallel and other conditions to have different load, doing so one by one will results in expensive test costs. The use of an electronic LED load to simulate the combination of different LED to test results in time and cost savings.

Prodigit 3341G series LED mode load simulator provides two kinds of settings to simulate the actual LED light. These settings are very convenient and can save a lot of computing procedures and time.
The first : Vo, Vd, Rd (details show the Left hand side below)
The second : Vo, Vd, Io (details show the Right hand side below)

Config and LED monitor

Press the Config key to enter Config mode, LED indicator ON , it operates to set the order to display Rd and Io。
As shown below：

Rd setting

Io setting

At this time, press Mode key to LED Mode, then Preset ON.

Set Q'ty

Set Vo

Set Vd

Set Rd

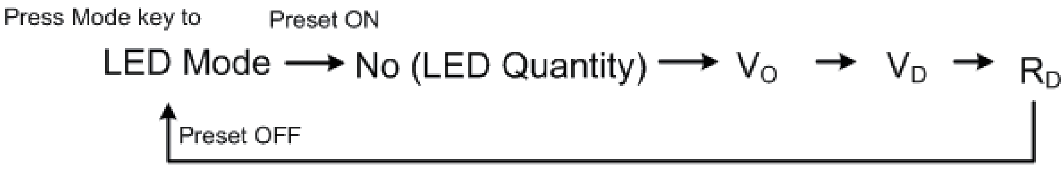
Set Q'ty

Set Vo

Set Vd

Set Io

How to set 3341G series Vo, Vd, Rd, No



As shown above, at first select LED MODE
Press the PRESS key to set the LED series or
LED strings in parallel quantity (initial value is 1,
in general LED Driver output specification
have been listed in the final value of Vo,
it is generally set to 1).

Press PRES key to set Vo
According to the CREE LED specification to set Vo = 25.000V
then press the PRES key to set the Vd, 3341G series default
Vd value is 80% of Vo value (i.e. 20V), CREE LED specification
Vd value is 90% of Vo value, this time can adjust Vd to 22.5V.

Then press PRES to set Rd
Set Rd = 16.666Ω according to (Vo-Vd) / Io

Press the LOAD button to start loading after connecting
the load Terminal, and then power ON the U.U.T
(Note: LED Driver is a constant current output device,
it can not boot without load).

Vo & Io setting and actual output :

3341G series LED mode load requires setting of Vo, Io and Rd so as to simulate the LED characteristics curve shown in Figure 3, so it is not the actual LED load value.

An LED load equivalent circuit is composed of two parameters Vd and Rd. Because Io is provided by the LED Driver which is presented on the LED the voltage value Vo = Vd + Io x Rd, the actual output current and setting value will have a deviation. The relative value of Vo will not be the same. This can be verified by reading the ammeter of the 3341G series LED electronic load or using the actual LED Lamp + ammeter.

LED Driver short-circuit test :

The LED Driver output is constant current. As such, unlike other voltage sources using the same general electronic load short circuit function, for short-circuit test the short-circuit impedance of an electronic load is not low enough. This means the led to LED Driver short-circuit protection cannot be used.

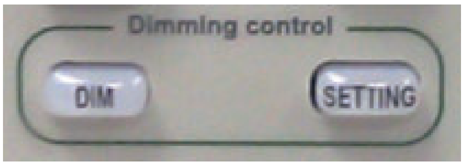
To overcome this, the 3341G series LED mode Load specifically provides a 12V power supply and Short Relay output interface to control the external 12V shorting relay. It also provides an optional short-circuit-specific fixture board. The circuit board can be installed on the corresponding LED load module short-circuit relay, for use with 3341G, 3342G / 3343G and 33401G three models respectively.

The 3341G series LED load module short output on the panel will drive the installed fixture board of the relay. The relay control of the contact point will cause the load's positive and negative input to short-circuit. This happens directly on the LED Driver's output to provide only a few mΩ of short-circuit resistance. It is used to verify correct operation of the test short circuit protection function.

Fixture for short test

Short test fixture is installed on load input by plug-In operation

Next, when the LED Driver has dimming function, Prodigit provides the test solution for the dimming :



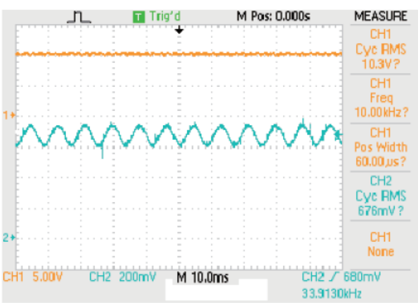
LED Driver dimming device can be divided into TRIAC dimming and Analog/PWM dimming modes.

TRIAC dimming is the use of TRIAC dimmer (currently on the market has been used for many years for incandescent bulb dimmers. The TRIAC is used to adjust the voltage phase and thus change the brightness of incandescent light bulb. When the input is connected to the dimmer, the output current of the LED bulb can be adjusted according to the voltage phase change of the TRIAC dimmer to adjust the brightness of the LED lamp.

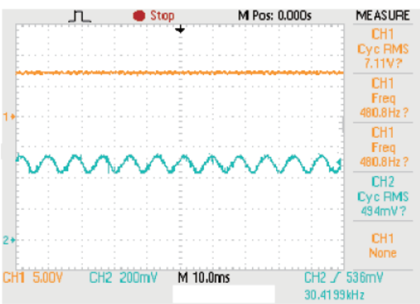
The dimming test of Analog/PWM dimming mode is to use a set of control signals to the LED Driver's dimming control input to control the LED Driver output current working cycle to achieve LED dimming, the LED Driver verification test must have a set of control signals to do dimming control, 3341G series LED mode Load provides a set of DIM control output voltage signal which is isolated from the electronic load module, adjustable voltage level 0 ~ 12V, Duty Cycle 1 ~ 99%, Frequency DC ~ 1KHz, by using the module to achieve the function of the system that can be simulated 0 ~ 12V analog dimming voltage signal or digital PWM dimming signal, these can be adjusted and controlled by 3341G series load module, operation is very convenient, when the verification test the dimming capacity of LED Driver, the use of the standard dimming control, you do not need an additional signal generator as the dimming control signal.

Generally, the electronic load which is not dedicated to LEDs is too slow for the LED driver to adjust the output current modulation. The dimming test of LED driver can not be performed. Through specially processed, Prodigit 3341G series LED mode load has up to 100 kHz or higher bandwidth, with sufficient response speed that can be stable operation in the dimmer, and configuration up to 6 Vd and Rd range design, can simulate a variety of LED combination conditions.

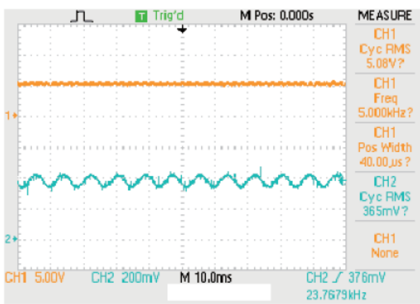
- DIM : Io (Level) control by analog voltage control



Dim Output 10V



Dim Output 7V

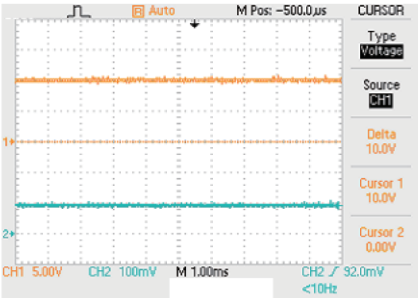


Dim Output 5V

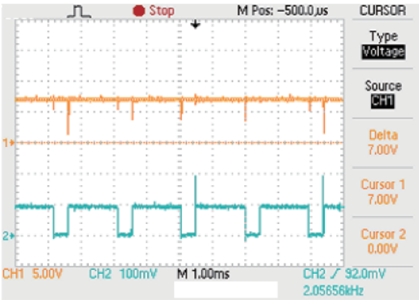
Upper trace Analog VDIM

Lower trace LED Driver Io

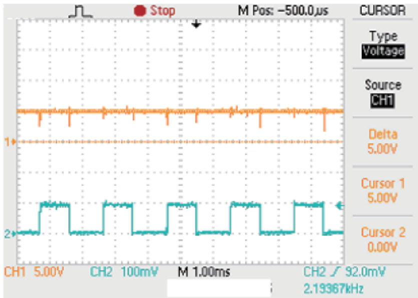
- DIM : PWM Io by analog voltage control



Dim Output 10V



Dim Output 7V

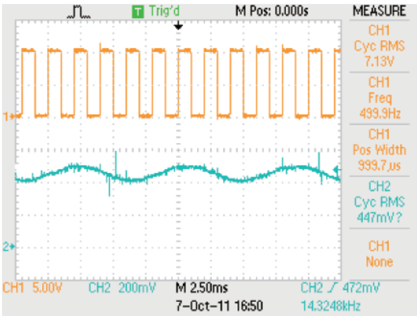


Dim Output 5V

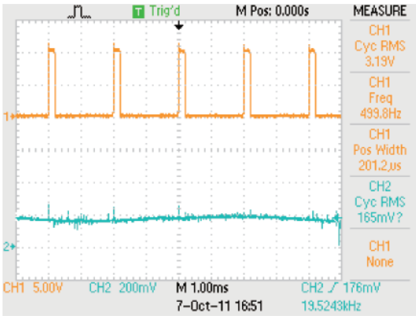
Upper trace
Analog VDIM

Lower trace
LED Driver Io

- DIM : Io (Level) by PWM control



10V, 500Hz Duty 0.5



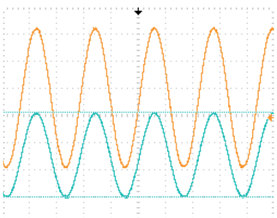
10V, 500Hz Duty 0.1

Upper trace
PWM VDIM

Lower trace
LED Driver Io

With the implementation of PWM dimming, the LED Driver output voltage and current are variable. This may lead to the meter reading of 3341G series LED electronic load to be not stable enough. However, the 3341G series LED electronic load has built-in voltmeter and ammeter averaging. The user can freely set 1, 2, 4, 8, 16, 32, 64 times averaging reading value of the meter. Of course, the more readings are selected, the value of the average reading value will be more stable, but the relative reaction time will be longer. Set the averaging value so that the value can be stable and the reaction speed can be acceptable.

Set meter average times

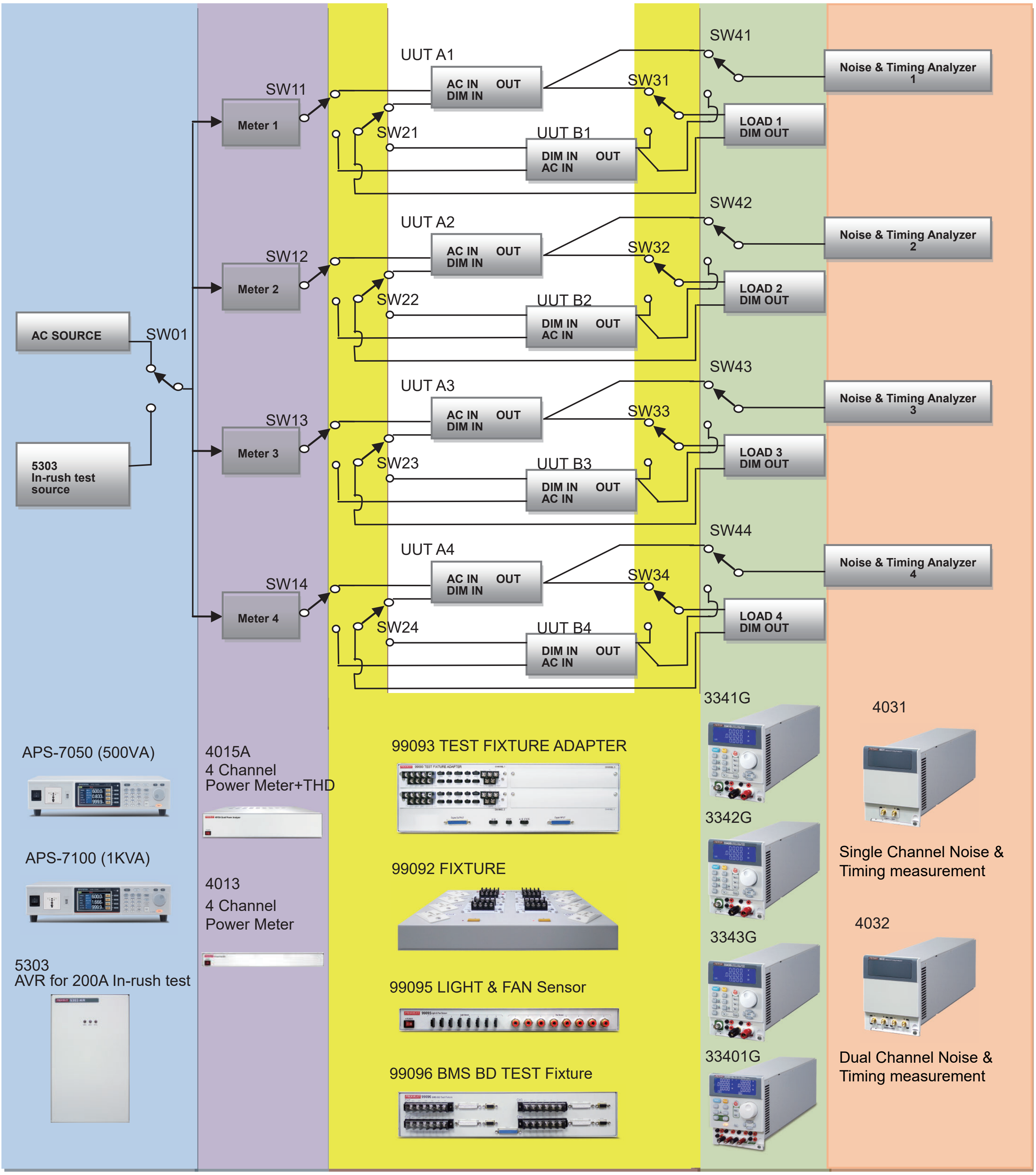


Current Waveform: 1.56Ap-p 100Hz

AVG Setting	1	2	4	8	16	32	64
DAM	0.7513 ~ 0.7649	0.7565 ~ 0.7620	0.7598 ~ 0.7622	0.7613 ~ 0.7623	0.7618 ~ 0.7624	0.7628 ~ 0.7630	0.7636 ~ 0.7637

The above detailed description is 3341G series LED load for LED Driver test, in addition, you can refer to another special article of our company to discuss dimming LED lighting dimming test, can get more test information. For high throughput manufacturing testing Prodigit provides the 6010 ATE test system, The 6010 ATE test system is a flexible, high-speed, high-quality test system, the following is detailed description of 6010 LED ATE test system hardware architecture:
(Note: This structure is with a 4 * 4 test fixture, to provide the required large and fast production line of four U.U.T simultaneously test)

6010 ATE for LED Driver System Diagram



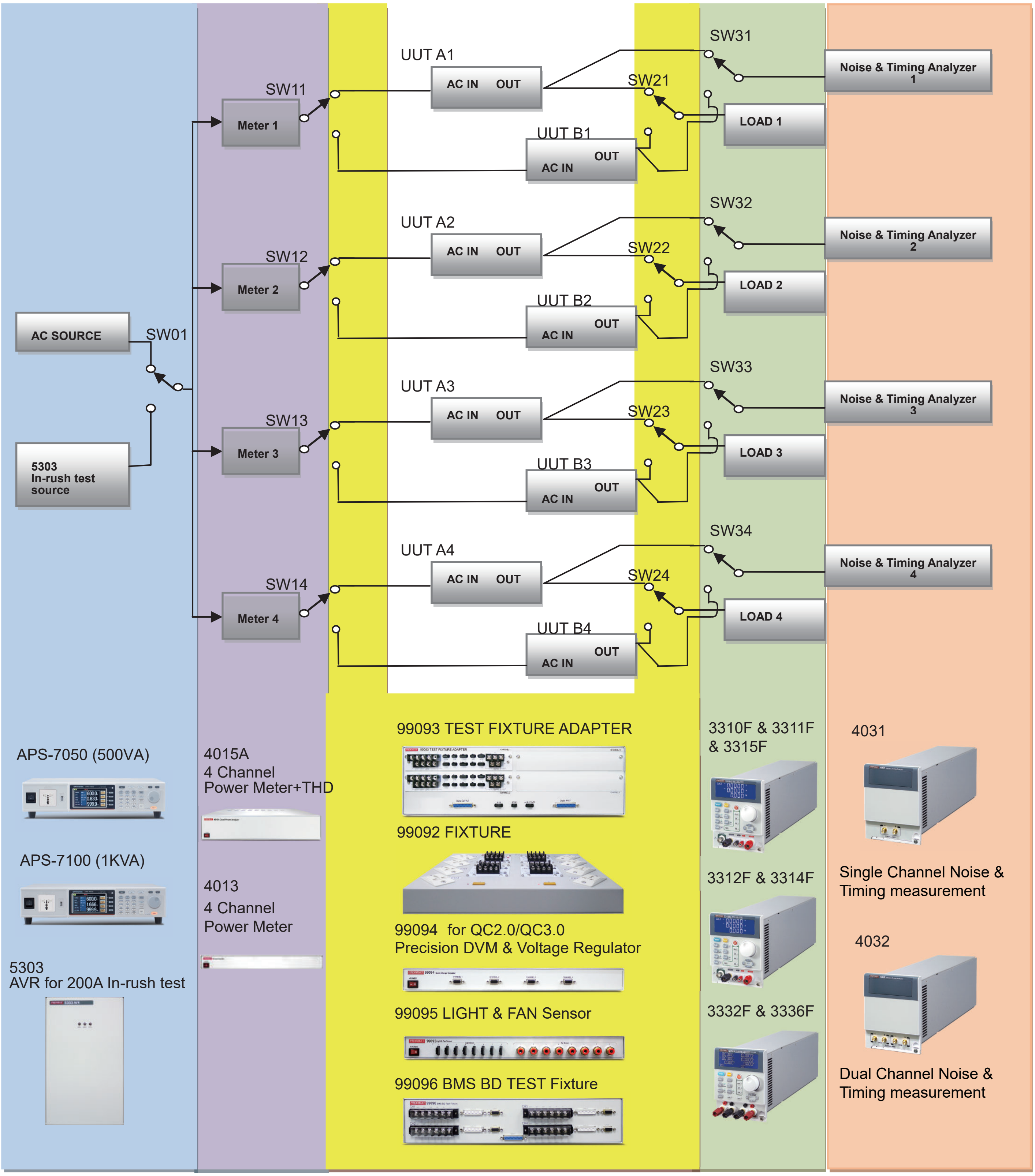
SW01 : General test or
In-rush Current test

SW11 ~SW14 : AC Voltage select Switch for UUT A/B AC Input
SW21~ SW24 : DC Load Dim select Switch for UUT A/B Dim
SW31 ~SW34 : DC Load select Switch for UUT A/B Output.
SW41~ SW44 : Noise & Timing Meter select Switch for UUT A/B Output.

60104+3342G+4031

60104 is the mainframe for modules

6010 ATE for Adapter / Charger System Diagram



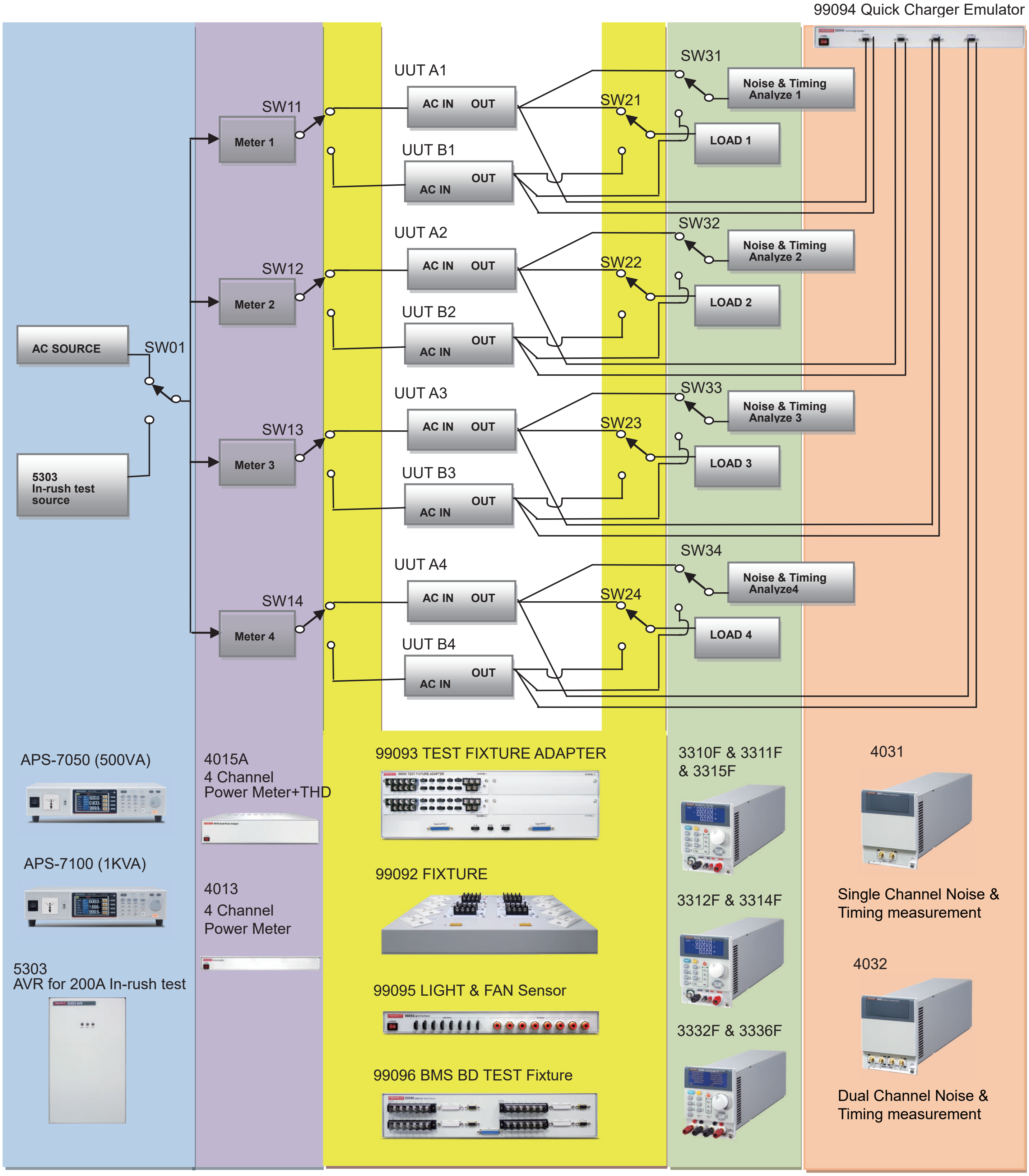
SW01 : General test or In-rush Current test

SW11 ~SW14 : AC Voltage select Switch for UUT A/B AC Input
SW21 ~SW24 : DC Load select Switch for UUT A/B Output.
SW31~ SW34 : Noise & Timing Meter select Switch for UUT A/B Output.

60104+3311F+4031

60104 is the mainframe for modules

6010 ATE for Quick Charger System Diagram



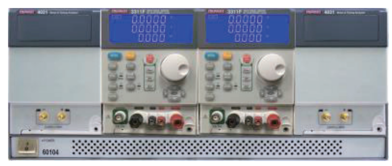
SW01 : General test or In-rush Current test

SW11 ~SW14 : AC Voltage select Switch for UUT A/B AC Input

SW21 ~SW24 : DC Load select Switch for UUT A/B Output.

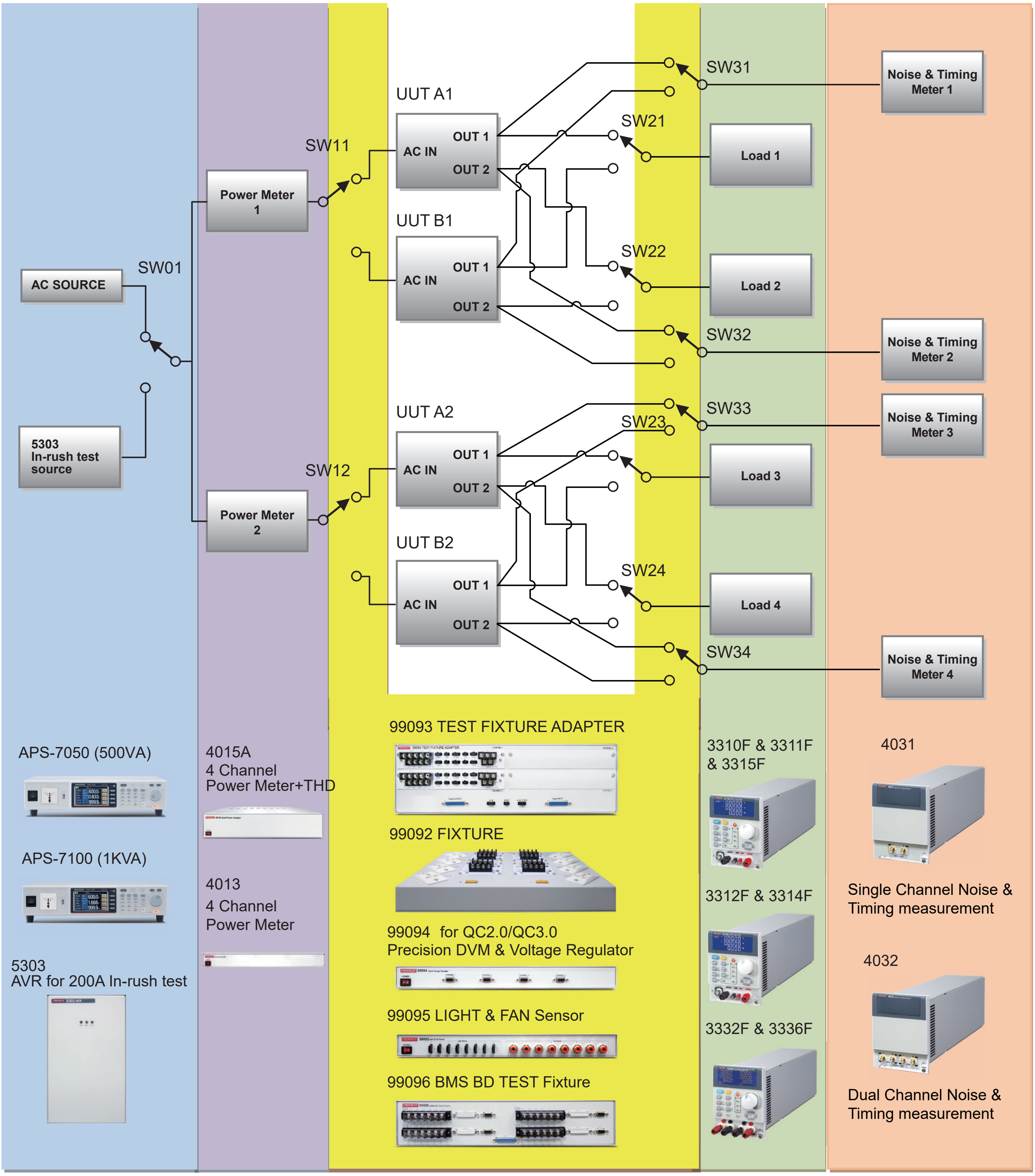
SW31~ SW34 : Noise & Timing Meter select Switch for UUT A/B Output.

60104+3311F+4031



60104 is the mainframe for modules

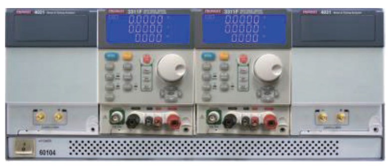
6010 ATE for 2 paths output AC / DC power supply System Diagram



SW01 : General test or
In-rush Current test

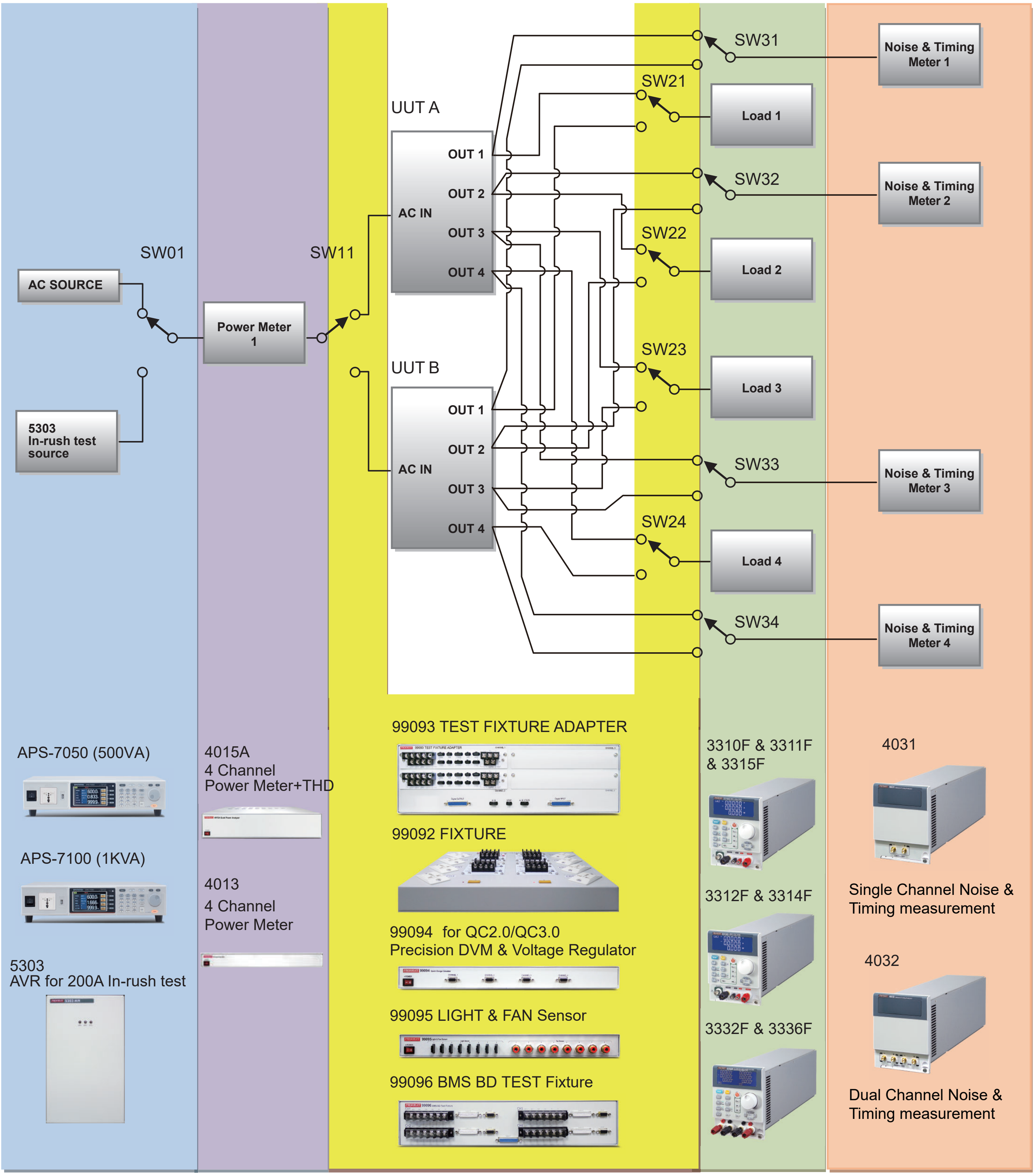
SW11 ~SW14 : AC Voltage select Switch for UUT A/B AC Input
SW21 ~SW24 : DC Load select Switch for UUT A/B Output.
SW31~ SW34 : Noise & Timing Meter select Switch for UUT A/B
Output.

60104+3311F+4031



60104 is the mainframe for modules

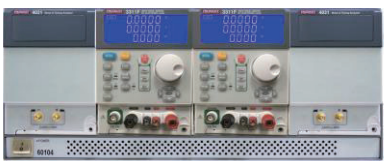
6010 ATE for 4 paths output AC / DC power supply System Diagram



SW01 : General test or
In-rush Current test

SW11 ~SW14 : AC Voltage select Switch for UUT A/B AC Input
SW21 ~SW24 : DC Load select Switch for UUT A/B Output.
SW31~ SW34 : Noise & Timing Meter select Switch for UUT A/B Output.

60104+3311F+4031



60104 is the mainframe for modules