3310F Series
Plug-In Electronic
Load module
Operation manual

S/N:9003310F02 REV:L

PRODIGIT
INSTRUMENT PROFESSIONAL

Material Contents Declaration

(材料含量宣称)

(Part Name) 零件名称	Hazardous Substance (有毒有害物质或元素)					
	铅(Pb)	汞(Hg)	镉(Cd)	六价铬 (Cr6+)	多溴联苯(PBB)	多溴二苯醚 (PBDE)
PCBA (印刷电路装配件)	X	○	X	○	○	○
Electrical part not on PCBA's 未在PCBA上的电子零件	X	○	X	○	○	○
Metal parts **金属零件**	○	○	○	X	○	○
Plastic parts 塑料零件	○	○	○	○	X	X
Wiring 电线	X	○	○	○	○	○
Package **封装**	X	○	○	○	○	○

对销售之日的所售产品,本表显示, PRODIGIT 供应链的电子信息产品可能包含这些物质。注意:在所售产品中可能会也可能不会含有所有所列的部件。This table shows where these substances may be found in the supply chain of Prodigit electronic information products, as of the date of sale of the enclosed product. Note that some of the component types listed above may or may not be a part of the enclosed product. ○：表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T 11363-2006 标准规定的限量要求以下。○：Indicates that the concentration of the hazardous substance in all homogeneous materials in the parts is below the relevant threshold of the SJ/T 113632006 standard. ×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T 11363-2006 标准规定的限量要求。×： Indicates that the concentration of the hazardous substance of at least one of all homogeneous materials in the parts is above the relevant threshold of the SJ/T 11363-2006 standard.

Note(注释):

1.Prodigit has not fully transitioned to lead-free solder assembly at this moment；However, most of the components used are RoHS compliant.
(此刻，Prodigit 并非完全过渡到无铅焊料组装；但是大部份的元器件一至于RoHS的规定。)

2. The product is labeled with an environment-friendly usage period in years.

The marked period is assumed under the operating environment specified in the product specifications.
(产品标注了环境友好的使用期限制(年)。所标注的环境使用期限假定是在此产品定义的使用环境之下。)

Example of a marking for a 10 year period:
(例如此标制环境使用期限为10年)

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. PRODIGIT assumes no liability for the *customer's failure to comply with these requirements.*

GENERAL

This product is a Safety Class 1 instrument (provided with a protective earth terminal). The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

ENVIRONMENTAL CONDITIONS

This instrument is intended for indoor use in an installation category I, pollution degree 2 environments. It is designed to operate at a maximum relative humidity of 80% and at altitudes of up to 2000 meters. Refer to the specifications tables for the ac mains voltage requirements and ambient operating temperature range.

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

GROUND THE INSTRUMENT

This product is a Safety Class 1 instrument (provided with a protective earth terminal). To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument must be connected to the ac power supply mains through a three conductor power cable, with the third wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury.

FUSES

Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired
Fuses or short circuited fuse holder. To do so could cause a shock or fire hazard.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power, discharge circuits and remove external voltage sources before touching components.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT EXCEED INPUT RATINGS.

This instrument may be equipped with a line filter to reduce electromagnetic interference and must be connected to a properly grounded receptacle to minimize electric shock hazard. Operation at line voltages or frequencies in excess of those stated on the data plate may cause leakage currents in excess of 5.0 mA peak.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a PRODIGIT ELECTRONICS Sales and Service Office for service and repair to ensure that safety features
are maintained.

Instruments which appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

DECLARATION OF CONFORMITY

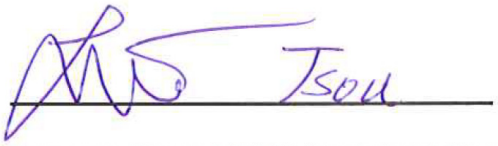
CE

Company Name: PRODIGIT ELECTRONICS CO., LTD
Address: 8/F,No.88, Baojhong Rd., Sindian District, New Taipei City,Taiwan.

Declares under sole responsibility that the product as originally delivered
Product Names: DC Electronic Loads
Model Numbers: 3310F, 3311F, 3312F, 3314F, 3315F, 3300F, 3302F, 3305F
(And other customized products based upon the above)
Product Options:
This declaration covers all options and customized products based on the above products.
Complies with the essential requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly.
EMC Information:
Class I a sample of the product has been assessed with respect to CE-marking according to the Low Voltage Directive (73/23/EEC& 93/68/EEC) and EMC Directive (89/336/EEC,92/31/EEC, & 93/68/EEC) and Found to comply with the essential requirements of the Directives.
The Standard(s) used for showing the compliance and the full details of the results are given in the Test Reports as detailed below:

Safety Information:
Safety standards following:
IEC 61010-1:2001 / EN 61010-1:2001

Feb, 21, 2009
Date



Larsson Tsou / R&D Assistant Manager

The holder of the verification is authorized to use this verification in connection with the EC declaration of conformity according to the Directives. The CE marking may only be used if all releveant and effective EC Directives are complied with. Together with the manufacturer's own documented production control, The manufacturer (or his European authorized representative) can in his EC Declaration of Conformity Verify compliance with the directives.

SAFETY SYMBOLS

 **Direct current (DC)**

 **Alternating current (AC)**

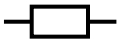
 **Both direct and alternating**

 **Three-phase alternating current**

 **Protective earth (ground)**

 On (Supply)

 **Off (Supply)**

 **Fuse**

 **Caution ! Refer to this manual before using the meter.**

 **Caution, risk of electric shock**

CAT IV – Is for measurements performed at the source of the low-voltage installation.

CAT III – Is for measurements performed in the building installation.

CAT II – Is for measurements performed on circuits directly connected to the low-voltage installation.

CAT I – Is for measurements performed on circuits not directly connected to Mains.

3310F series module load operation manual
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Chapter 1 Introduction

1-1. General description

The 3310F series of Electronic Load modules are designed to test and evaluate a wide range of DC Sources. They are often used in the burn-in and validation of DC power supplies and the testing of batteries. The 3310F series of electronic load modules are operated from within a suitable mainframe. The 3300F/3302F/3305F mainframes allow 1, 2 or 4 modules to be operated. The mainframes provide the necessary mains power conversion along with computer and analogue interfaces. A front panel memory function is provided. 150 memory locations are available to store the set-up of the load modules within the mainframe. It is also possible to program and recall a test sequence consisting of different steps against time. Please refer to the separate 3300F/3302F/3305F operating manuals for the mainframe functions.

Each load module is capable of sinking a wide range of voltage and current values. The load modules are limited by the maximum power they can sink. For example the 3310F can sink up to 30A and 60Vdc at a maximum of 150W. So if the maximum voltage of 60Vdc is present at the load's input terminals a maximum load current of 2.5A is possible. Conversely if the 3310F is required to sink 30A the voltage must be limited to 5V.

The power contour of each load module in the 3310F series is shown in Fig 1-1, to 1-5.

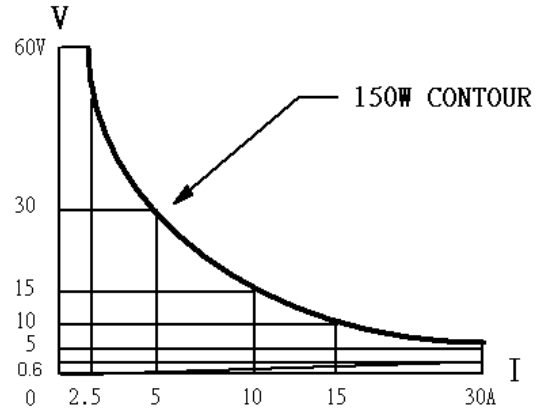


Fig 1-1 3310F 60V/30A/150W power contour

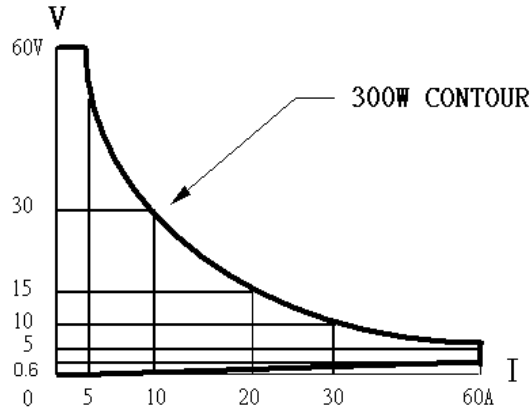


Fig 1-2 3311F 60V/60A/300W power contour

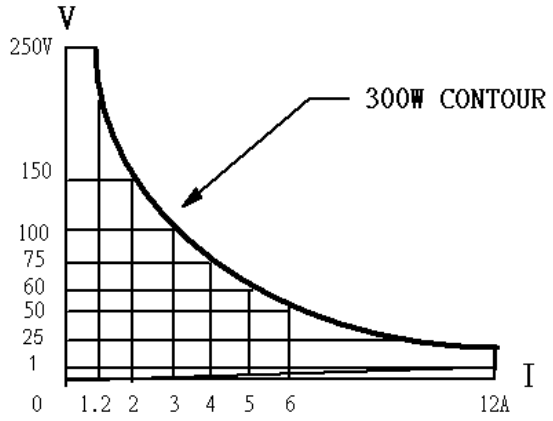


Fig 1-3 3312F 250V/12A/300W power contour

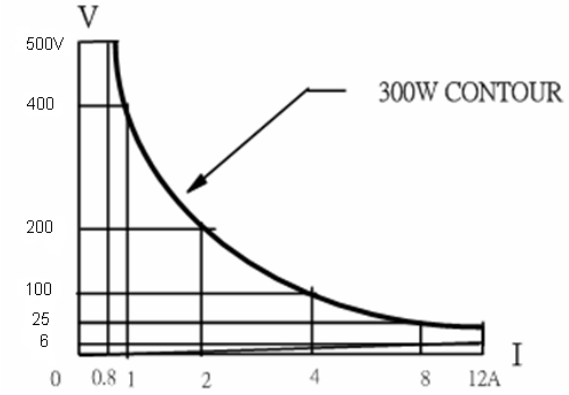


Fig 1-4 3314F 500V/12A/300W power contour

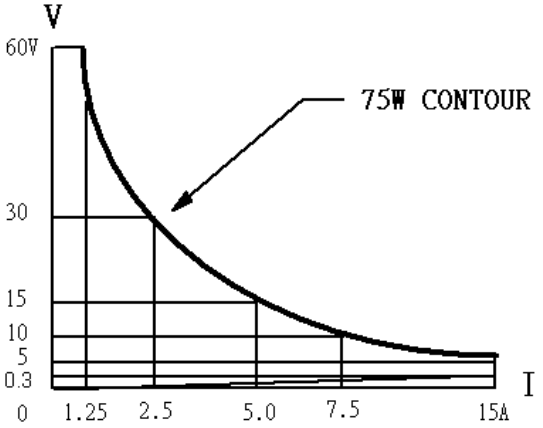


Fig 1-5 3315F 60V/15A/75W power contour

The 3310F series of electronic load modules feature 4 operating modes. These are Constant Current (CC) mode, Constant Resistance (CR) mode, Constant Voltage (CV) mode, and Constant Power (CP) mode.

Along with static operation the loads can also be programmed to operate dynamically in CC, CR or CP modes. An analogue programming input on the mainframe allows the 3310F series load module to track an external signal. For example a dynamic waveform can be set up on an external generator. The load will follow this signal assuming it is within it's range of dynamic response.

1.1.1. CC Mode

With the operating mode of Constant Current, the 3310F series electronic load will sink a current in accordance with the programmed value regardless of the input voltage (see Fig.1-6).

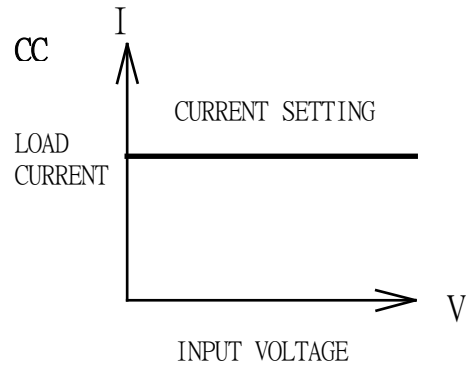


Fig 1-6 Constant Current mode

1.1.2. CR Mode:

At Constant Resistance mode, the 3310F series Electronic Load will sink a current linearly proportional to the load input voltage in accordance with the programmed resistance setting (see Fig 1-7).

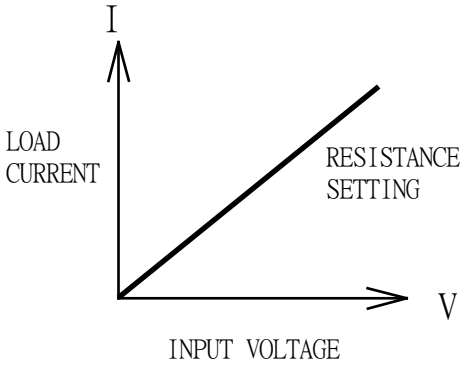


Fig 1-7 Constant Resistance mode

1.1.3. CV Mode:

At Constant Voltage mode, the 3310F series Electronic Load will attempt to sink enough current until the load input voltage reaches the programmed value (see Fig 1-8).

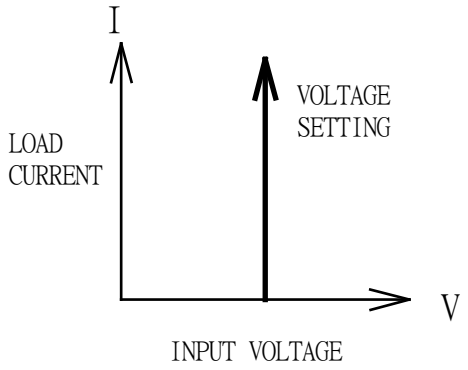


Fig 1-8 Constant Voltage mode

1.1.4. CP Mode:

At Constant Power mode, the 3310F series Electronic Load will attempt to sink load power (load voltage * load current) in accordance with the programmed power. (see Fig 1-9).

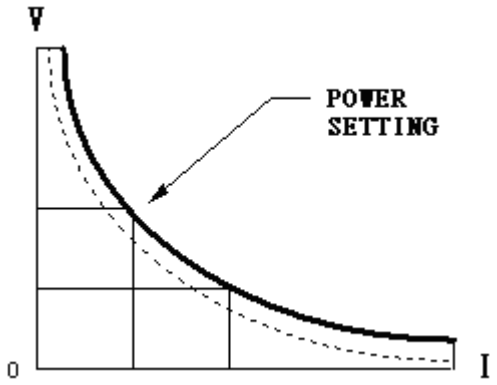


Fig 1-9 Constant Power mode

1.1.5. Dynamic Waveform Definition

Along with static operation the 3310F load modules are built with a Dynamic mode for operation in Constant Current (CC), Constant Resistance (CR) or Constant Power (CP). This allows the test engineer to simulate real world pulsing loads or implement a load profile that varies with time.

A dynamic waveform can be programmed from the front panel of the 3310F load module. The user would first set a High and low value of load current using the Level button. The Dynamic Setting then allows for the rise and fall time between these 2 current values to be adjusted. The time period that the waveform is high (Thigh) along with the time period that the waveform is low (Tlow) can also be set.

The dynamic waveform is illustrated below in Fig 1-10.

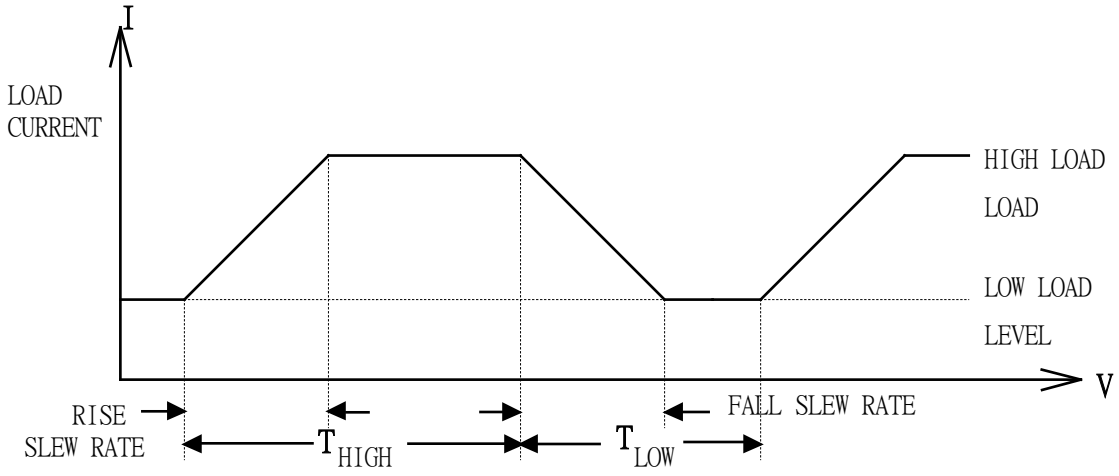


Fig 1-10 Dynamic Wave form

The dynamic waveform can also be set up via the optional computer interface. Dynamic waveform settings made from the front panel of the load module can also be saved in the memory of the mainframe. For the store/recall procedure and the computer command set please refer to the relevant operating manual for the 3300F/3302F/3305F mainframes.

Further dynamic waveform definitions are:

- The period of dynamic waveform is Thigh + Tlow
- The dynamic frequency = 1 /(Thigh + Tlow)
- The duty cycle = Thigh / (Thigh + Tlow)

The analogue programming input also provides a convenient method of implementing a dynamic waveform. Please see the section 3.1.26 titled ‘Analog Programming Input’ for further information.

1.1.6. Slew Rate

Slew rate is defined as the change in current or voltage over time. A programmable slew rate allows for a controlled transition from one load setting to another. It can be used to minimize induced voltage drops on inductive power wiring, or to control induced transients on a test device (such as would occur during power supply transient response testing).

In cases where the transition from one setting to another is large, the actual transition time can be calculated by dividing the voltage or current transition by the slew rate. The actual transition time is defined as the time required for the input to change from 10% to 90% or from 90% to 10% of the programmed excursion.

In cases where the transition from one setting to another is small, the small signal bandwidth (of the load) limits the minimum transition time for all programmable slew rates. Because of this limitation, the actual transition time is longer than the expected time based on the slew rate, as shown in Figure 1-11

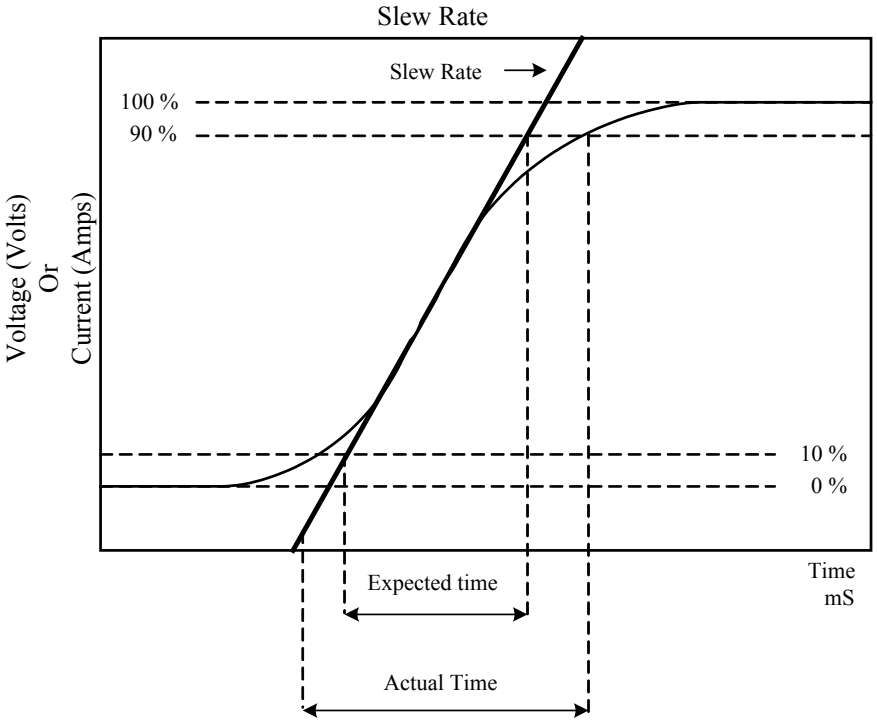


Fig 1-11 Rise Time Transition Limitation

Therefore, both minimum transition time and slew rate must be considered when determining the actual transition time.
Following detail description is exclude in operation manual.
The minimum transition time for a given slew rate as about a 30% or greater load change, The slew rate increases from the minimum transition time to the Maximum transition time at a 100% load change. The actual transition time will be either the minimum transition time, Or the total slew time (transition divided by slew rate), whichever is longer.
EX: 3311F 60V/60A/300W (CCH - CCL >60Ax 30%)

Use the following formula to calculate the minimum transition time for a given slew rate
Min transition time=18A/slew rate (in amps/second).
180uS (18A/0.1) x 0.8(10%~90%) =144uS

Use the following formula to calculate the maximum transition time for a given slew rate
Max transition time=60/slew rate (in amps/second).
600uS (60A/0.1) x 0.8(10~90%) = 480uS

EX. CCH=16A, CCL=0A Slew Rate =0.1A, the expected time is 128uS but the actual Transition Time will be limited to 144uS
160uS (16/0.1) x 0.8(10%~90%) = 128uS

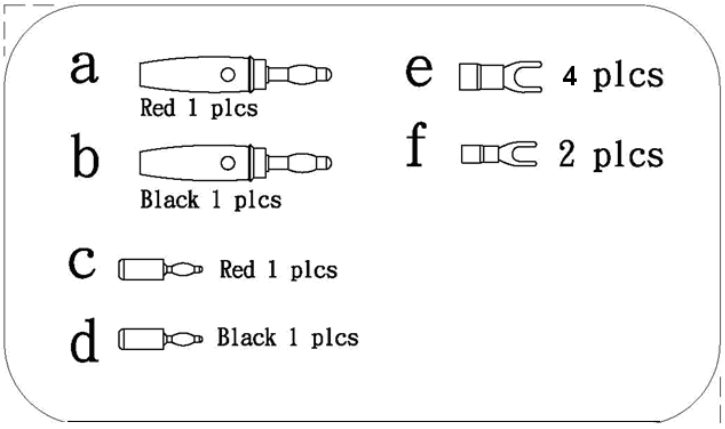
1-2. Features

The main features of the 3310F series of load modules are highlighted below.

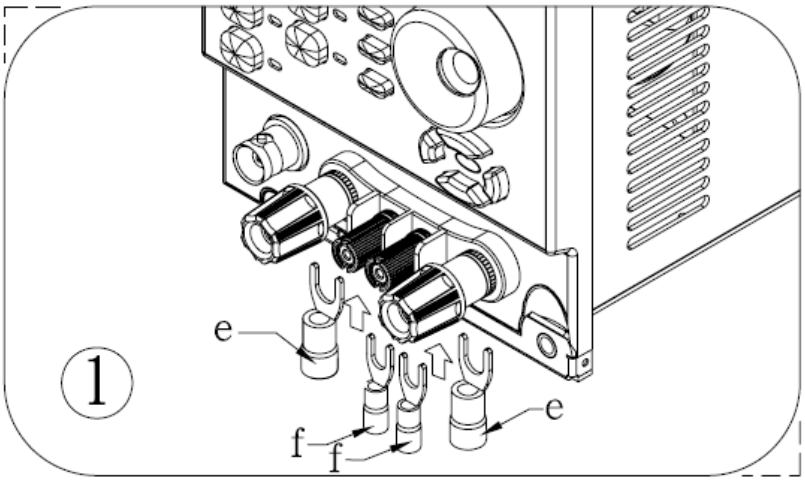
- Bench top and rack mounting flexibility with single, dual and 4 slot mainframes
- CC, CR, CV, CP, Dynamic, and Short Operating Mode.
- Remote control via a choice of computer interfaces.
- High accuracy & resolution with 16 bit voltage and current meter.
- Built in pulse generators for dynamic loading.
- Independently adjustable current rise and fall times.
- Short circuit test with current measurement
- Dedicated over current and overpower protection test functions
- Programmable voltage sense capability.
- Full protection from overpower, over-temperature, overvoltage, and reverse polarity.
- Analogue programming input for tracking an external signal
- Current Monitor with BNC (non-isolated) socket.
- Digital Calibration
- Advance Fan speed control
- Ability to save load set-ups via the mainframe memory (150 store/recall locations)
- Auto sequence function allowing test routines to be set from the mainframe

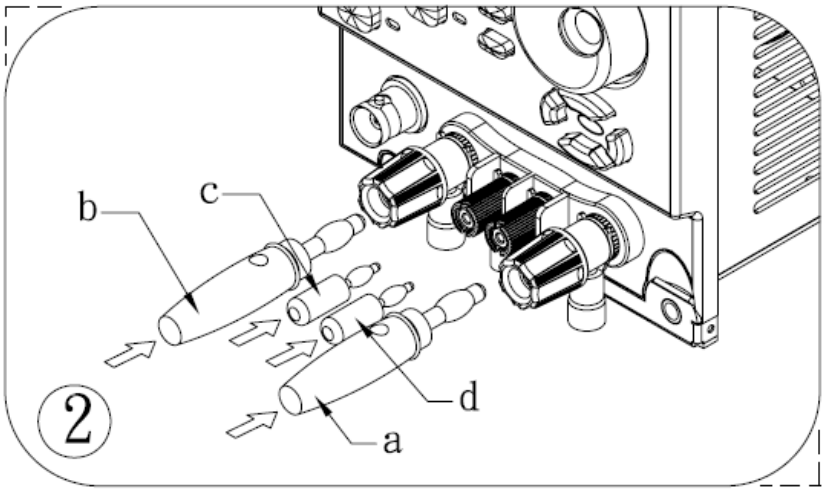
1-3. Standard Accessories

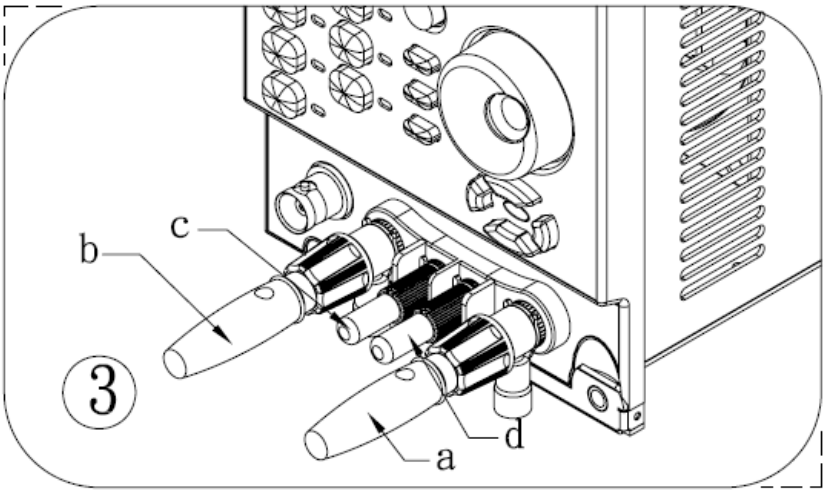
a	4mm Banana Plug (Red)	1 PC
b	4mm Banana Plug (Black)	1 PC
c	2mm Banana Plug (Red)	1 PC
d	2mm Banana Plug (Black)	1 PC
e	Hook Terminal Y type Large size terminal	4 PCS
f	Hook Terminal Y type small size terminal	2 PCS
g	3310F series operation manual	1 PC



1.3.1 Accessories Installation Description







1-4. Specifications

Model	3310F		3311F		3312F	
Power	150W		300W		300W	
Current	30A		60A		12A	
Voltage	60V		60V		250V	
Min. Operating Voltage	0.6V @ 30A		0.6V @60A		1V @ 12A	
Protections						
Over Power Protection(OPP)	105%		105%		105%	
Over Current Protection(OCP)	105%		105%		105%	
Over Voltage Protection(OVP)	105%		105%		105%	
Over Temp Protection(OTP)	YES		YES		YES	
Constant Current Mode						
Range	0 ~ 3A	0 ~ 30A	0 ~ 6A	0 ~ 60A	0 ~ 1.2A	0 ~ 12A
Resolution	0.05mA	0.5mA	0.1mA	1mA	0.02mA	0.2mA
Accuracy	± 0.05% of (setting + Range)					
Constant Resistance Mode						
Range	2 ~120KΩ	0.02Ω ~ 2Ω	1Ω ~ 60 KΩ	0.0083Ω ~ 1Ω	25Ω ~ 1500KΩ	0.08Ω ~ 25Ω
Resolution	0.00833mS	0.033mΩ	0.0166mS	0.0166mΩ	0.00066mS	0.4166mΩ
Accuracy	± 0.2% of (Setting + Range)					
Constant Voltage Mode						
Range	0 ~ 6V	0 ~ 60V	0 ~ 6V	0 ~ 60V	0 ~ 30V	0 ~ 250V
Resolution	0.0001V	0.001V	0.0001V	0.001V	0.001V	0.01V
Accuracy	± 0.025% of (Setting + Range)					
Constant Power Mode						
Range	0 ~ 15W	0 ~ 150W	0 ~ 30W	0 ~ 300W	0 ~ 30W	0 ~ 300W
Resolution	0.00025W	0.0025W	0.0005W	0.005W	0.0005W	0.005W
Accuracy	± 0.1% of (Setting + Range)					
MPPT Mode						
Algorithm	P & O					
Load mode	CV					
P&O interval	1000ms ~ 60000ms					
Dynamic Mode						
Timing						
Thigh & Tlow	0.050~9.999 / 99.99 / 999.9 / 9999mS					
Resolution	0.001 / 0.01 / 0.1 / 1mS					
Slew rate	2.0 ~ 125mA/uS	20 ~ 1250mA/uS	4 ~ 250mA/uS	40 ~ 2500mA/uS	0.8 ~ 50mA/uS	8 ~ 500mA/uS
Accuracy	± (5% of Setting) ±10uS					
Measurement						
Voltage Read Back						
Range (5 Digital)	6V	60V	6V	60V	30V	250V
Resolution	0.0001V	0.001V	0.0001V	0.001V	0.001V	0.01V
Accuracy	± 0.025% of (Reading + Range)					
Current Read Back						
Range (5 Digital)	3A	30A	6A	60A	1.2A	12A
Resolution	0.0001A	0.001A	0.0001A	0.001A	0.00002A	0.0002A
Accuracy	± 0.05% of (Reading + Range)					
Current Monitor	FULL SCALE 10V					
Accuracy	0.5% of (Setting + Range)					
Current Programming Input	FULL SCALE 10V					
Programmable Short	BUILT-IN					
Load ON Voltage	0.1 ~ 25V		0.1 ~ 25V		0.2 ~ 50V	
Accuracy	1% of (Setting + Range)					
Load OFF Voltage	0 ~ 25V		0 ~ 25V		0 ~ 50V	
Accuracy	0.025% of (Setting + Range)					
Typical Short Resistance	0.02 Ω		0.0083 Ω		0.08 Ω	
Maximum Short Current	30 A		60 A		12 A	

Model	3314F		3315F	
Power	300W		75W	
Current	12A		15A	
Voltage	500V		60V	
Min. Operating Voltage	6V @ 12A		0.3V @15A	
Protections				
Over Power Protection(OPP)	105%		105%	
Over Current Protection(OCP)	105%		105%	
Over Voltage Protection(OVP)	105%		105%	
Over Temp Protection(OTP)	YES		YES	
Constant Current Mode				
Range	0 ~ 1.2A	0 ~ 12A	0 ~ 1.5A	0 ~ 15A
Resolution	0.02mA	0.2mA	0.0254mA	0.25mA
Accuracy	± 0.05% of (setting + Range)			
Constant Resistance Mode				
Range	50 ~ 3000KΩ	0.5Ω ~ 50Ω	4Ω ~ 240 KΩ	0.02Ω ~ 4Ω
Resolution	0.000333mS	0.8333mΩ	0.04166mS	0.0666mΩ
Accuracy	± 0.2% of (Setting + Range)			
Constant Voltage Mode				
Range	0 ~ 60V	0 ~ 500V	0 ~ 6V	0 ~ 60V
Resolution	0.001V	0.01V	0.0001V	0.001V
Accuracy	± 0.025% of (Setting + Range)			
Constant Power Mode				
Range	0 ~ 30W	0 ~ 300W	0 ~ 7.5W	0 ~ 75W
Resolution	0.001W	0.01W	0.000125W	0.00125W
Accuracy	± 0.1% of (Setting + Range)			
MPPT Mode				
Algorithm	P & O			
Load mode	CV			
P&O interval	1000ms ~ 60000ms			
Dynamic Mode				
Timing				
Thigh & Tlow	0.050~9.999 / 99.99 / 999.9 / 9999mS			
Resolution	0.001 / 0.01 / 0.1 / 1mS			
Slew rate	0.8 ~ 50mA/uS	8.0 ~ 500mA/uS	1 ~ 62.5mA/uS	10 ~ 625mA/uS
Accuracy	± (5% of Setting) ±10uS			
Measurement				
Voltage Read Back				
Range (5 Digital)	60V	600V	6V	60V
Resolution	0.001V	0.01V	0.0001V	0.001V
Accuracy	± 0.025% of (Reading + Range)			
Current Read Back				
Range (5 Digital)	1.2A	30A	1.5A	15A
Resolution	0.0001A	0.001A	0.00001A	0.001A
Accuracy	± 0.1% of (Reading + Range)			
Current Monitor	FULL SCALE 10V			
Accuracy	0.05% of (Setting + Range)			
Current Programming Input	FULL SCALE 10V			
Programmable Short	BUILT-IN			
Load ON Voltage	0.4 ~ 100V		0.1 ~ 25V	
Accuracy	1% of (Setting + Range)			
Load OFF Voltage	0 ~ 100V		0 ~ 25V	
Accuracy	0.025% of (Setting + Range)			
Typical Short Resistance	0.5 Ω		0.02Ω	
Maximum Short Current	12A		15A	

Table 1-1 3310F Series Specification

Note *1: The range is automatically or forcing to range II only in CC mode

Note *2: Power F.S. = Vrange F.S. x Irange F.S.

Note *3 : Operating temperature range is 0~40℃, All specifications apply for 25℃±5℃

Chapter 2 Installation

This chapter details the installation and removal procedure of the 3310F series load module when used in conjunction with the 3300F (quad module mainframe). The same procedure is used for the 3302F (single module mainframe) and the 3305F (dual module mainframe).

Please note that the 3310F series load module does not need any user adjustment after it has been plugged in to the mainframe.

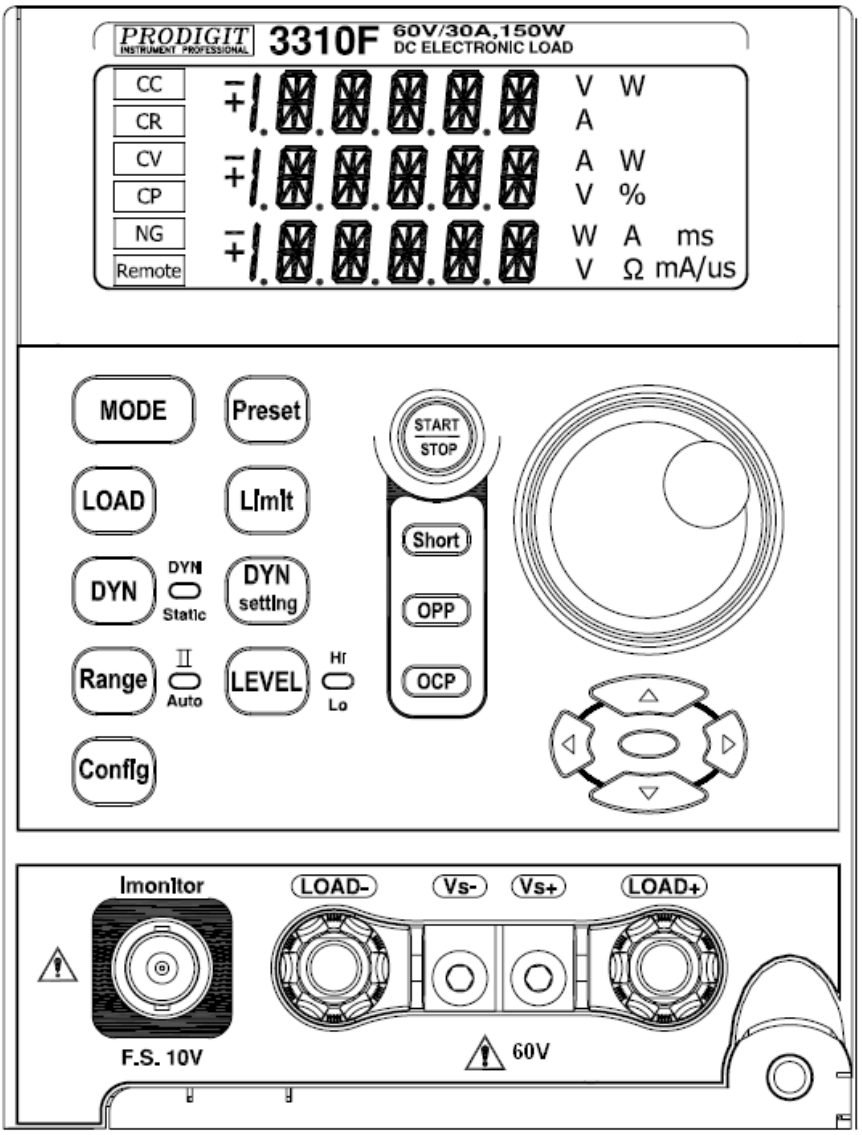


Fig 2-1 Binding post and withdraw handle on the front panel of 3310F series Plug-in load module

2-1. Installation and removal of 3310F series plug-in load module

The 3310F series Electronic load module operates from within the 3300F/3302F/3305F mainframe. The mainframe is required to provide power to the module's control circuitry. It is also needed for the computer interfaces, analogue programming input and the 150 store/recall memory.

Unless the 3300F/3302F/3305F mainframe and 3310F series Electronic load module were purchased separately, the 3310F series Electronic load module should be installed in the 3300F mainframe before shipment from Prodigit.

One of the benefits of the modular approach is that different models of load module can be operated from within the same mainframe. It is easy for the user to reconfigure the mainframes by changing or adding different load modules.

The following procedure should be followed for installing or removing the 3310F series load module in or out from the 3300F /3302F/3305F.

2.1.1. Installation of 3310F series plug-in load:

2.1.1.1 Turn the 3300F/3302F/3305F mainframe power OFF before inserting the 3310F series load module. Failure to switch the mains power off may result in Damage to the plug-in module's circuitry.

2.1.1.2 Align the upper and lower grooves of the 3300F mainframe with the upper and Lower guides of the selected compartment.

2.1.1.3 If correctly positioned the 3310F series load module will slide in easily until Some 30-40mm is left protruding from the mainframe. At this point a little more Force will be required to seat the load module's circuit board in the Interconnecting jack of the mainframe. It is recommended that the binding posts On the load module's front panel be used to push the module home.

2.1.1.4 Use the supplied screw to fasten the load module to the mainframe. The Screw hole is located at the end of the pull out handle at the bottom right hand Corner of the 3310F load module. The screw location is shown on Fig 2-1 and Is below and to the right of the LOAD + binding post.

2.1.1.5 Only after all the load modules are installed to the 3300F/3302F/3305F Mainframe should the mains power be switched ON.

2.1.2. Removal of 3310F series plug-in load:

2.1.2.1. Firstly ensure that the mains power to the 3300F/3302F/3305F mainframe is Switched off. Failure to do so may result in damage to the load module.

2.1.2.2. Take the screw out of the pull out handle in the lower right corner of the module.

2.1.2.3. After removal of the screw the handle can be pulled towards you to lever the Module out of the mainframe.

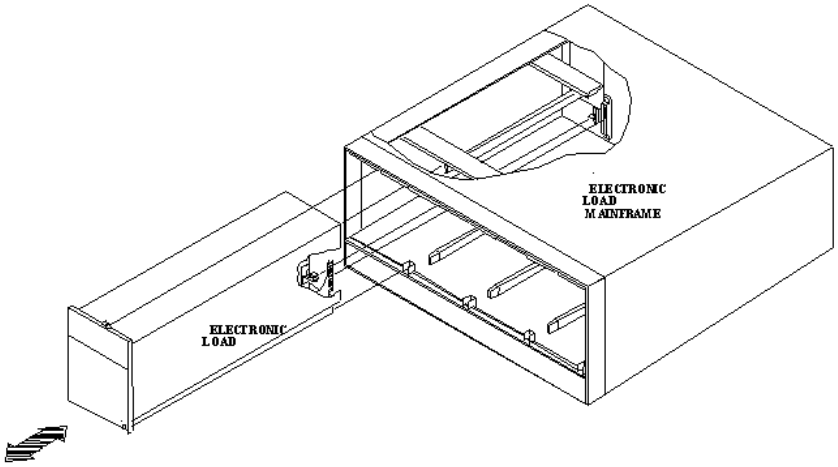


Fig 2-2 Plug-in installation and removal

2-2. Environmental requirements

- Indoor use.
- Measurement Category I.
- Pollution Degree 2.
- Relative Humidity 80% Max.
- Ambient Temperature 0 to +40°C
- Altitude up to 2000m.
- The equipment is not for measurements performed for CAT II, III and IV.
- Transient Overvoltage on the mains supply can be 2500V.

2-3. Observe the International Electrical Symbol listed below.

⚠ Warning ! Risk of electric shock

⚠ Caution ! Carefully read and understand the guidance in the operating manual Before performing any action.

2-4. Cleaning

Use a soft or slightly damp cloth to clean this product.

BEFORE you clean the unit, switch the mains power off and disconnect the input lead.

- Please do NOT use any organic solvent capable of changing the nature of the plastic such as benzene or acetone.
- Please ensure that no liquid is allowed to penetrate this product.

2-5. Power Up

The following procedure should be followed before applying mains power:

2.5.1 Check that the POWER switch is in the off (O) position
2.5.2 Check the rear panel voltage selector of the 3300F/3302F/33305F mainframe is Correctly set.
2.5.3 Check that nothing is connected to the DC INPUT (load input terminals) on the Front panel of the 3310F load module.
2.5.4 Connect correct AC mains lead to the 3300F/3302F/33305F mainframe
2.5.5 Turn on (I) the POWER switch.

The load module will now go through a short self-check cycle. All digits on the front panel will illuminate then the module's part number and firmware revision will be displayed. The screen Will then go to into the default state showing V, A & W. The load module is now ready for use.

2-6. Operating flow chart for each load module operation

The following flow chart shows the typical load current level and status setting procedures of each load module within 3300F mainframe, the load channel number 1 to 4 is from left to right compartment on 3300F mainframe respectively, please skip Channel setting if single load mainframe 3302F is used.

The string between "____" in the flow chart is a RS232 or GPIB programming commends.

Please follow the flow chart sequence to have proper and effective load settings.

The load mode (CC, CR, CV, CP) should be set first, where only Static mode is available for CR and CV mode, both Static and Dynamic modes are available for CC and CP mode, then choose high or Low load level and programming the load level for Static mode, or programming the six parameters for Dynamic mode.

The Limit key set the GO/NG check upper and lower limit for DVM, DAM, and DWM respectively, the system configure setting of V-sense control, Load ON voltage, and load OFF voltage is within the Limit key setting.
Others key (Load ON/OFF, Short ON/OFF) can be controlled independently.
Note:
3310F series electronic load Dynamic mode, when in CR Mode Range I only have this Feature.

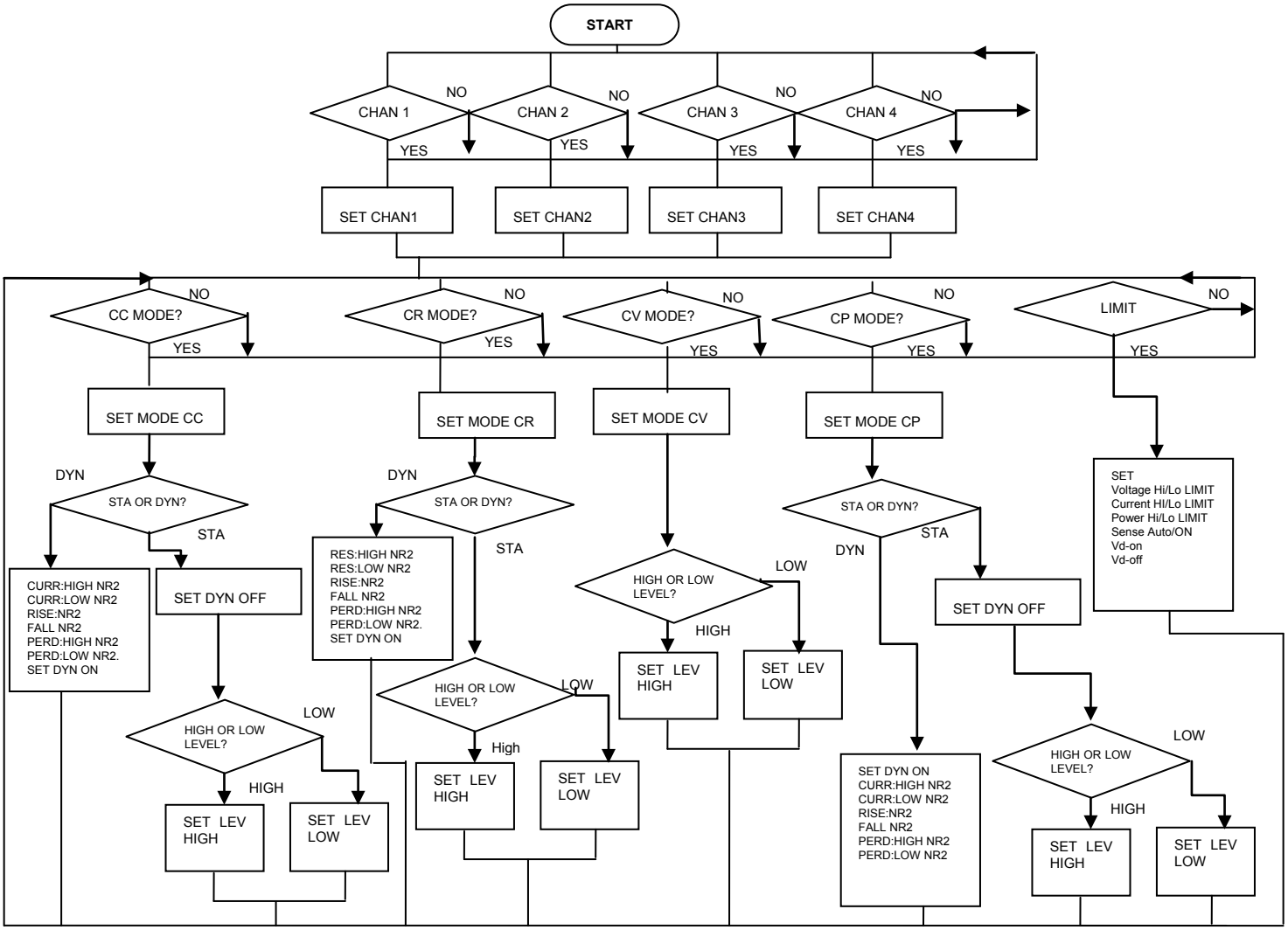


Fig 2-3 3310F series electronic load module load condition setting flow chart

Chapter 3 Operation

This chapter describes the front panel operation of each 3310F series load module. Please note that the memory store/recall function and the GPIB/RS-232C/USB/LAN remote programming terms are detailed in the separate 3300F/3302F/3305F mainframe operation manual.

3-1 Front panel description

The following sketch shows the layout of the front panel of the unit. Please refer to the relevant Section as indicated by the number assigned to a front panel function.

For example to understand more about the Imonitor function labeled 24 please refer to 3.1.24

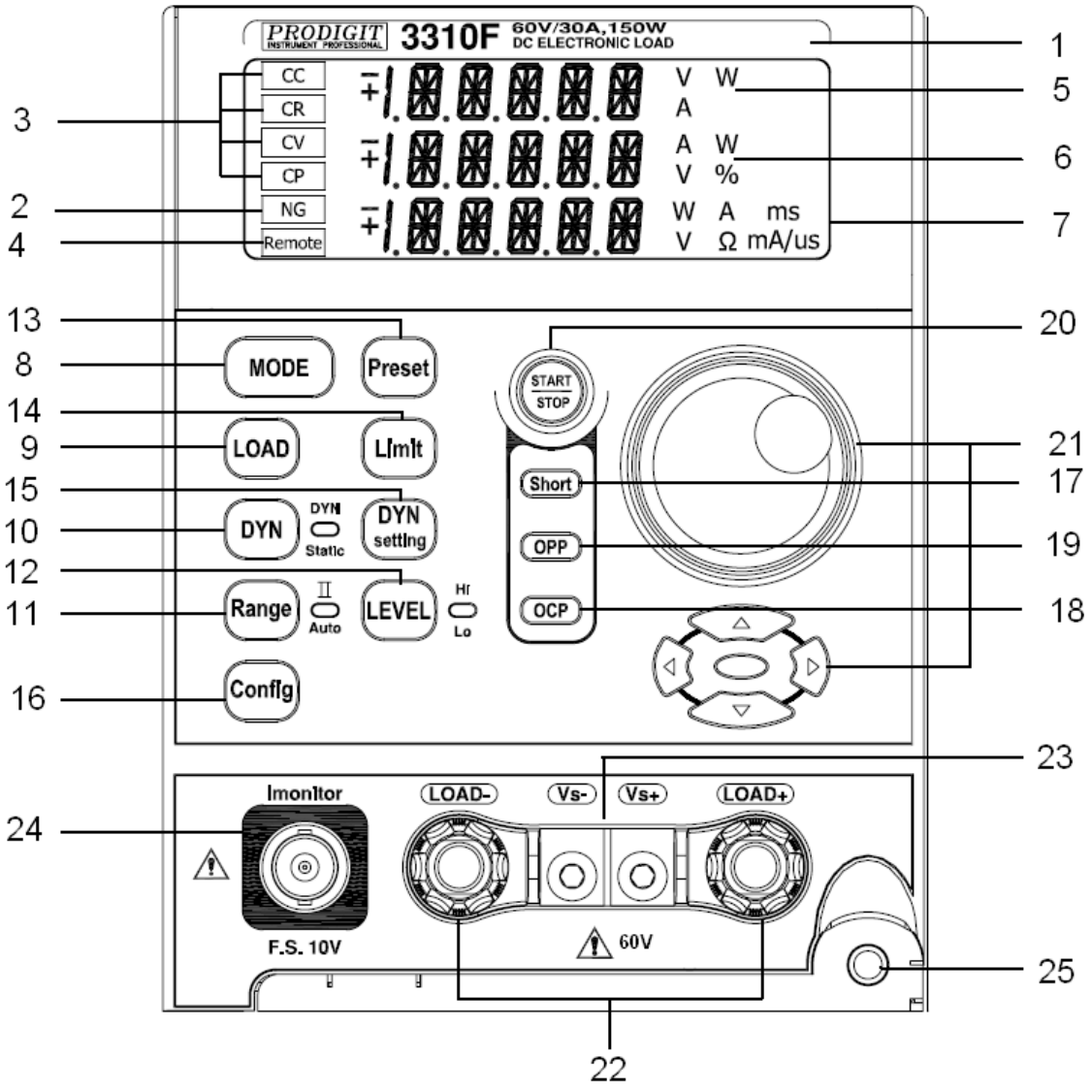


Fig 3-1 Front panel of 3310F plug-in module

3-2 .Instructions

3.2.1. Model number and sink ranges

The model number along with maximum voltage, current and power values are Detailed in this position at the top of the load module's front panel.

3.2.2. NG Indicator

The user can adjust upper and lower limits for voltage, current and power within the CONFIG menu and turn the NG Indicator ON. If a Voltmeter, Ammeter or Wattmeter measurement is outside these set limits then the NG indicator will illuminate.

3.2.3. MODE and CC , CR , CV , CP mode, LCD Indicator

There are four operating modes that can be selected by pressing the "MODE" key on the 3310F series Electronic Load module.

The sequence is Constant Current (CC), Constant Resistance (CR), Constant Voltage (CV), Constant Power (CP). Each time the "MODE" key is pressed the operating mode is changed. The actual operating mode selected is indicated on the left hand side of the LCD.

The operating theorem of CC, CR, CV and CP modes are described in Section 1-1. Common application examples for the different operating modes are described in Section 4-3 to 4-6 respectively.

3.2.4. Remote LCD Indicator

If the REMOTE LCD Indicator is illuminated this means that the unit is operating remotely via one of the optional interfaces. While REMOTE is lit it is not possible to make settings manually at the front panel. The LOCAL button on the mainframe can be used to revert back to front panel control. When the unit is operating from the front panel the REMOTE LCD will not be illuminated.

3.2.5. Upper 5 digit LCD display

The 5 digit LCD display is a multi-function display. The function of the display changes depending whether the user is in NORMAL mode or in a SHORT, OPP or OCP test modes:

Normal mode:

The upper 5 digit display displays the voltage present at the load's input terminals. The value displayed will include the automatic voltage compensation if the sense Terminals are also connected to the device under test (DUT)

Please note that if V-sense is set to 'AUTO' and the sense leads are connected to The DUT the losses need to be approx. 500mV (3310F, 3311F & 3315F) or 2.5V (3312F & 3314F) before the display compensates for the voltage loss.

If V-sense is set to 'ON' and the sense terminals are connected to the DUT the load will check and compensate for all voltage drops.

Test Mode:
If the SHORT, OPP or OCP buttons are pressed the upper display will show a text Message that correlates with the selected test function.

SHORT test selected: upper display will show "Short".
OPP test selected: upper display will show "OPP".
OCP test selected: upper display will show "OCP".

During the test the upper display will show the load Input voltage.

3.2.6. Middle 5 digit LCD display
The middle 5 digit displays also changes function depending if the user is in Normal mode or has entered a setting menu

Normal mode:
In normal mode the middle LCD display functions as a 5 digit ammeter. The 5 digit DAM shows the load current flowing into the DC load when the Load is ON.

Setting Mode:
If CONFIG, LIMIT, DYN, SHORT, OPP or OCP buttons are pressed the middle LCD show a text message according to the setting function it is in. Each subsequent press of the button moves the display to the next available function. The sequence of each setting menu is detailed below

- **CONFIG**: Sequence is "SENSE" → "LDon" → "LDoff" → "POLAR" →"MPPT" →"AVG".
- **LIMIT**: Sequence is "V_Hi" → "V_Lo" → "I_Hi" → "I_Lo" → "W_Hi" → "W_Lo" → "NG".
- **DYN setting**: Sequence is "T-Hi" → "T-Lo" → "RISE" → "FALL"
- **SHORT**: Sequence is "PRESS" → "TIME" → "V_Hi" → "V_Lo"
- **OPP**: Sequence is "PSTAR" → "PSTEP" → "PSTOP" → "Vth".
- **OCP**: Sequence is "ISTAR" → "ISTEP" → "ISTOP" → "Vth".

3.2.7. Lower 5 digit LCD display

The lower 5 digit display also changes function depending if the unit is in normal mode or one of the setting menus has been activated.

Normal mode:
In normal mode the lower 5 digit display shows the power consumption in Watts (W).

Setting Mode:
The lower display together with the rotary adjustment knob is used to set values. The value changes according to the setting function that is active. The middle LCD provides a text message to tell the user which part of the setting menu is active.

3.2.7.1. **PRESET** mode. The value of the setting entered on the lower display Changes depending on the operating MODE that has been selected

- If CC mode is selected the lower display provides setting in amps "A".
- If CR mode is selected the lower display provides setting in ohms “Ω”
- If CV mode is selected the lower display provides setting in volts “V”.
- If CP mode is selected the lower display provides setting in watts “W”.

3.2.7.2. **LIMIT.** Each press of the LIMIT button changes the middle LCD text. The Sequence and the corresponding setting value shown on the bottom Display are as follows:

➔ V_Hi (upper limit voltage) displays the set value in volts “V”
➔ V_Lo (lower limit voltage) displays the set value in volts “V”
➔ I_Hi (upper limit current) displays the set value in amps “A”
➔ I_Lo (lower limit current) displays the set value in amps “A”
➔ W_Hi (upper limit power) displays the set value in watts “A”
➔ W_Lo (lower limit power) displays the set value in watts “A”
➔ NG displays whether the NG flag is set to「ON」or「OFF」

3.2.7.3. DYN setting. Each press of the DYN setting button changes the text on The middle LCD. The sequence and the corresponding setting value Shown on the bottom display are as follows:

➔ T-Hi (time high) displays the set value in milliseconds “ms”
➔ T-Lo (time low) displays the set value in milliseconds “ms”
➔ Rise (current rise time/slew rate) displays the set value in “A/us” or “A/ms”
➔ Fall (current fall time/slew rate) displays the set value in “A/us” or “A/ms”

3.2.7.4. CONFIG. Each press of the CONFIG button changes the middle LCD Text.
The sequence and the corresponding setting value shown on the bottom Display are as follows:

➔ SENSE can be set to「AUTO」or 「ON」
➔ LDon (load ON voltage) displays the set value in volts “V”
➔ LDoff (load OFF voltage) displays the set value in volts “V”
➔ POLAR (load polarity) can be set to「＋LOAD」or「－LOAD」
➔ MPPT (load maximum power point tracking) can be set CC/CR/CV mode.
➔ AVG (load Measuring V.I Average)can be set 1 to 64.

3.2.7.5. SHORT test. This allows the parameters of the short test to be set up. Each press of the SHORT button moves the setting function. The Sequence of the short test along with the setting value is as follows:

➔ Short Press Start (pressing the red START/STOP button starts the test)
➔ TIME shows the duration of the SHORT test. “CONTI”, on the bottom display indicates continuous. Time can be adjusted in “ms”.
➔ V-Hi (voltage high threshold) displays the set value in volts “V”
➔ V-Lo (voltage low threshold) displays the set value in volts “V”

When the test is started the lower display will show RUN. When the test Has finished the lower display will show END.

3.2.7.6. OPP test. This allows the parameters of the over power protection test to Be Set up. Each press of the OPP button moves the setting function. The Sequence of the OPP test along with the setting value is as follows:

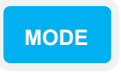
- ➔ OPP Press Start (pressing the red START/STOP button starts the test)
- ➔ PSTAR (power start point) lower display provides setting in watts “W”
- ➔ PSTEP (power steps) lower display provides setting in watts “W”
- ➔ PSTOP (power stop point) lower display provides setting in watts “W”
- ➔ VTH (voltage threshold) lower display provides setting in volts “V”

When the test is started the lower display will show the power value Being taken by the load. If the Device Under Test is able to supply the Load according to the values set then the middle display will show PASS And the lower display will show the maximum power taken during the OPP test. If, during the test, OTP is displayed the over temperature Protection has been engaged. Similarly if OPP is shown on the display The over power protection has been activated.

3.2.7.7. OCP test. This allows the parameters of the over current protection test To be set up. Each press of the OCP button moves the setting function. The sequence of the OCP test along with the setting value is as follows:

- ➔ OCP Press Start (pressing the red START/STOP button starts the test)
- ➔ ISTAR (current start point) lower display provides setting in amps “A”
- ➔ ISTEP (current steps) lower display provides setting in amps “A”
- ➔ ISTOP (current stop point) lower display provides setting in amps “A”
- ➔ VTH (voltage threshold) lower display provides setting in volts “V”

When the test is started the lower display will show the current value being Taken by the load. If the Device Under Test is able to supply the load According to the values set then the middle display will show PASS and the Lower display will show the maximum current taken during the OCP test. If, During the test, OTP is displayed the over temperature protection has been Engaged. Similarly if OPP is shown on the display the over power protection Has been activated.

3.2.8. 

and CC, CR, CV, CP Indicator

There are four operating modes. These can be selected in turn by pressing the "MODE" key on the 3310F series Electronic Load module. The sequence is:

- ➔ (CC) Constant Current
- ➔ (CR) Constant Resistance
- ➔ (CV) Constant Voltage
- ➔ (CP) Constant Power

The appropriate LCD will illuminate according to the operating mode is selected.

3.2.9. LOAD key and LED

The input to the 3310F series Electronic Load can be switched ON/OFF by using the “LOAD” button. Indication of the ON/OFF state is provided by illumination of the Button.

LOAD button lit	= LOAD ON	(load sinks according to the preset values)
LOAD button unlit	= LOAD OFF	(the load does not sink current)

Turning the LOAD OFF does not affect the preset values. When the LOAD ON state is enabled the unit will revert to sinking according to the preset values.

3.2.9.1. When the Load ON/OFF key is operated the current taken by load will follow The RISE or FALL with time according to the preset rate. The current RISE And FALL times can be adjusted in the DYN Setting button of the front panel.

3.2.9.2. In addition to the LOAD ON/OFF function the user can also adjust the Voltage level at which the unit will automatically start or stop sinking energy. The adjustable LDon and LDoff voltage levels are found within the CONFIG Menu. Please note that the LDoff level cannot be set higher than the LDon Level.

Please refer to table 1-4 for adjustment ranges.

3.2.10. DYN /STA key and LED

The DYN button allows the user to switch between DYNAMIC operation and STATIC operation. Dynamic operation is only possible in constant current (CC) or Constant power (CP) mode only. The LED next to the DYN button will become lit When DYNAMIC operation is selected. If you are in constant resistance (CR) or Constant voltage (CV) mode pressing the DYN button will have no effect.

3.2.11. Range key and LED

The 3310F series Load Module features 2 setting ranges for CC, CR, CV & CP Operation. This allows improved resolution for setting low values. When left in the Default AUTO mode the changeover between ranges is automatic depending on The setting value entered.

If desired the RANGE button can be pressed to force the unit to operate only in RANGE II. This is signaled by the accompanying LED becoming lit. Please note That it is only possible to force RANGE II in CC mode.

3.2.12. LEVEL key and LED

The LEVEL button is used to program a High or Low load value. The setting value Changes between current, resistance, voltage or power depending whether CC, CR, CV or CP mode has been selected. If the LED is lit then the High level value setting Has been enabled. If the LED is not lit then the low load level can be set using the Rotary switch in combination with the arrow keys.

In STATIC mode the user can switch between High and low load levels during Operation.

In DYNAMIC operation (CC & CP modes only) the preset high and low levels are Used to define the dynamic waveform.

Please note that the low level setting cannot exceed the high level. The converse is Also true in that the High level cannot be set below the low level.

3.2.12.1 In Constant Current mode:
The level is initial setting on High, LEVEL High / Low has two level, Low Current level setting must be lower than Level High.

3.2.12.2 In Constant Resistance mode:
The level is initial setting on High, LEVEL High / Low has two level, Low Resistance level setting must be lower than Level High.
P.S.：CR Mode Level High / Low level by current perspectives.

3.2.12.3 In Constant Voltage mode:
IF Low level load voltage value greater than High level load voltage value or opposite status，the load voltage value is equal.
P.S.：CV Mode Level High / Low has "automatic push function".

3.2.12.4 In Constant Power mode:
The level is initial setting on High, LEVEL High / Low has two level, Low Power level setting must be lower than Level High.

P.S Automatically Push Function
Level setting, Level High must be higher or equal than Level Low; When Level High equal to than LEVEL Low, it can not be adjusted anymore.

when Level High equals to lower low, the Automatic push function can push down the level Low value.
Therefore, the Level High can continue adjusting.

3.2.13. Preset Key and LED

If the PRESET key is pressed the button will become lit indicating that the PRESET mode has been accessed. The lowest 5 digit display will change from showing the power consumption in watts to displaying the value to be preset. The value that can be programmed changes according to the operating mode that has been selected.

3.2.13.1. Constant Current (CC) mode:
The High and Low levels of load current can be preset at lower 5 digit LCD. The "A" LED will be lit indicating the setting value is amps.

3.2.13.2. Constant Resistance (CR) mode:
The High and Low levels of load resistance can be preset on the lower 5 Digit LCD. The "Ω" LED will be lit indicating the setting value is ohms.

3.2.13.3. Constant Voltage (CV) mode:
The High and Low levels of load voltage can be preset on the lower 5 Digit LCD. The “V" LED will be lit indicating the setting value is volts.

3.2.13.4. Constant Power (CP) mode:
The High and Low levels of load power can be preset on the lower 5 digit LCD. The "W" LED will be lit indicating the setting value is watts.

3.2.13.5. Dynamic mode (CC, CR or CP modes only):
Each press of the DYN button cycles through the dynamic load settings. The DYN settings are used in conjunction with the High and Low levels Of load current to define the dynamic waveform. Each press of the DYN Button switches from T_Hi (time high), to T_Lo (time low), to Rise time And then to fall time. The middle LCD shows the section of the dynamic Waveform which is programmed with the rotary knob and read from the l ower display. The “ms” LED shows that the settings are programmed in Milliseconds.

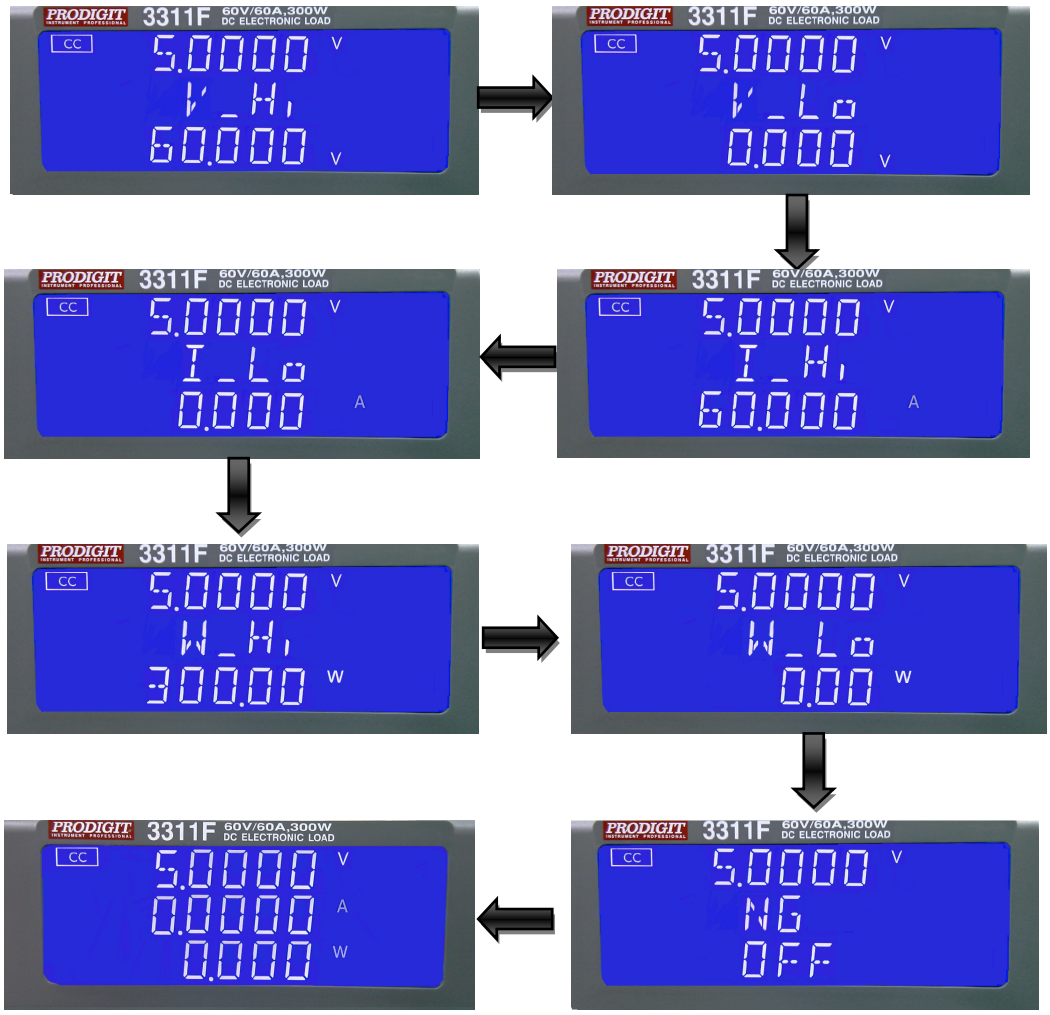
3.2.14. Limit key

The LIMIT button allows the user to set upper and lower thresholds for voltage, Current or power. These threshold settings are used in conjunction with the NG function to flag when the load is operating outside the desired limits

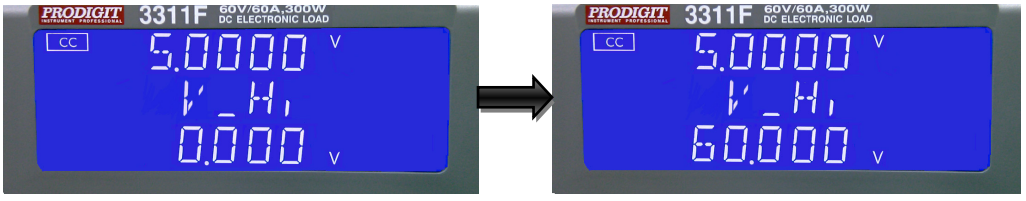
Each press of the LIMIT key enables a different value to be entered. On first press of the LIMIT key the button will illuminate and V-Hi will be displayed on the middle LCD. The setting is made with the rotary knob and can be read from the lower LCD during setting. The setting sequence is shown below:

V_Hi (DVM upper limit) →
V_Lo (DVM lower limit) →
I_Hi (DAM upper limit) →
I_Lo (DAM lower limit) →
W_Hi (DWM upper limit) →
W_Lo (DWM lower limit) →
NG OFF/ON (No Good Flag) →
LIMIT setting function OFF

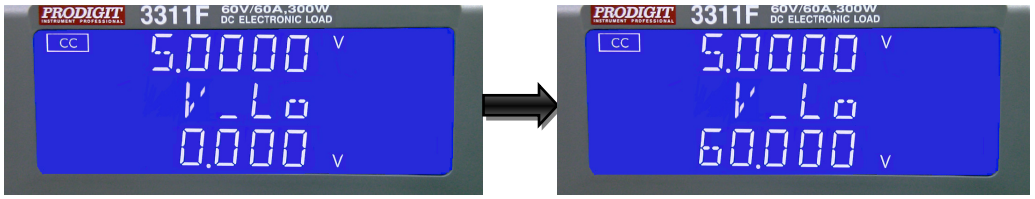
The engineering unit is “V”, “A” or “W” depending on the threshold LIMIT being set.



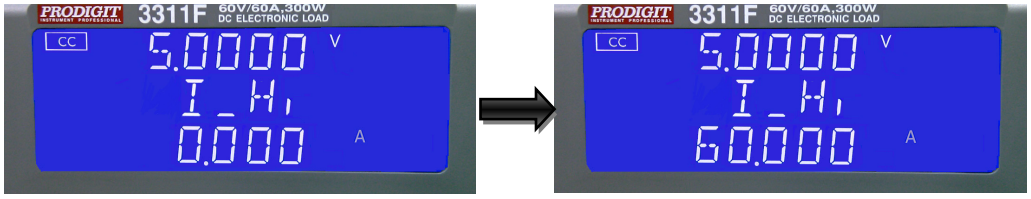
- Setting Upper limit voltage VH , Middle 5 digit LCD display「V-Hi」,lower 5 digit LCD display the unit is "V" ,The V-Hi set range from 0.000 V to 60.000V step 0.001V by rotating the Setting knob.



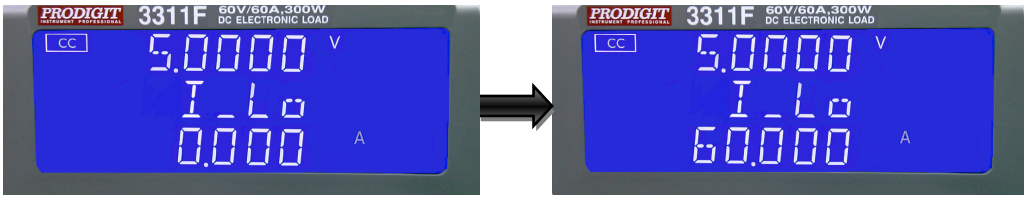
- Setting lower limit voltage VL, Middle 5 digit LCD display「V-Lo」,lower 5 digit LCD display the unit is "V",The V-Lo set range from 0.000 V to 60.000V step 0.001V by rotating the Setting knob.



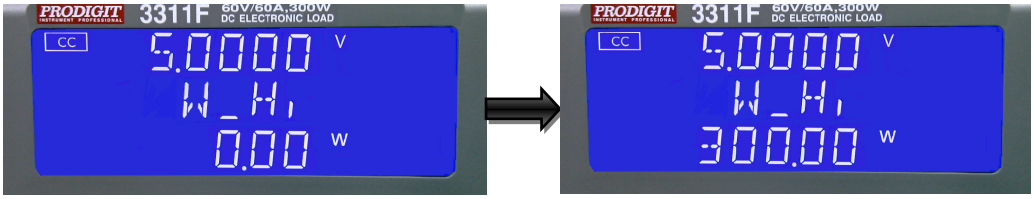
- Setting Upper limit current IH , Middle 5 digit LCD display「I-Hi」,lower 5 digit LCD display the unit is "A", The I-Hi set range from 0.000 A to 60.000A step 0.001A by rotating the Setting knob.



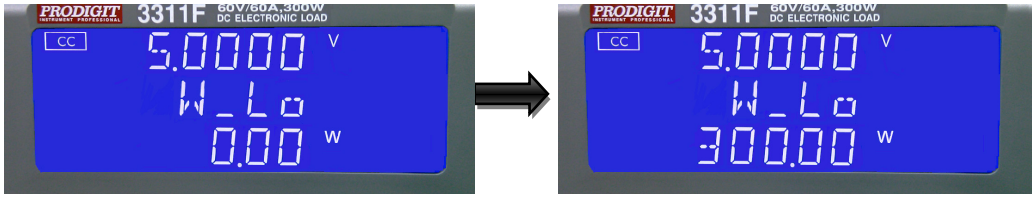
- Setting lower limit current IL , Middle 5 digit LCD display「I-Lo」,lower 5 digit LCD display the unit is "A" ,The I-Lo set range from 0.000 A to 60.000A step 0.001A by rotating the Setting knob.



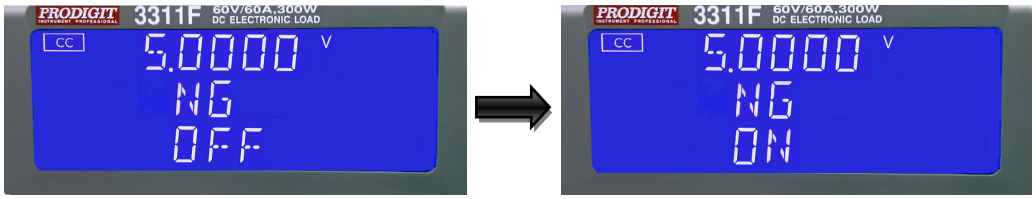
- Setting Upper limit power WH, Middle 5 digit LCD display「W-Hi」lower 5 digit LCD display the unit is "W", The W-Hi set range from 0.00 W to 300.00W step 0.01W by rotating the Setting knob.



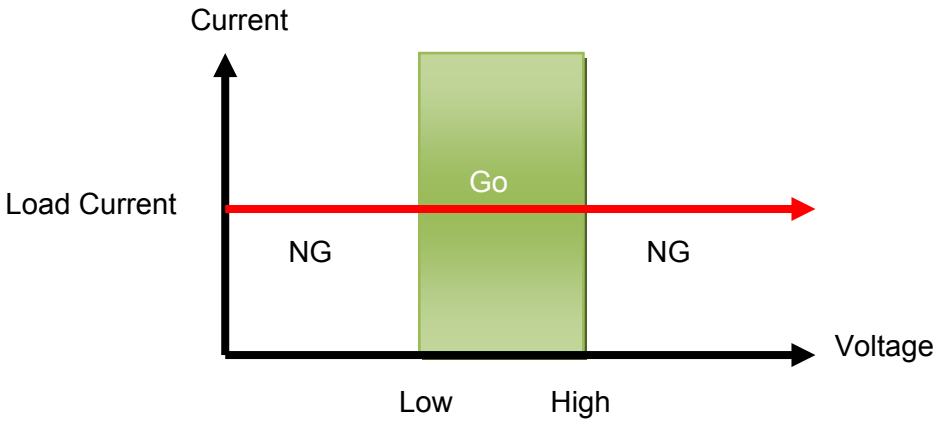
- Setting lower limit power WL, Middle 5 digit LCD display「W-Lo」lower 5 digit LCD display the unit is "W", The W-Lo set range from 0.00 W to 300.00W step 0.01W by rotating the Setting knob.



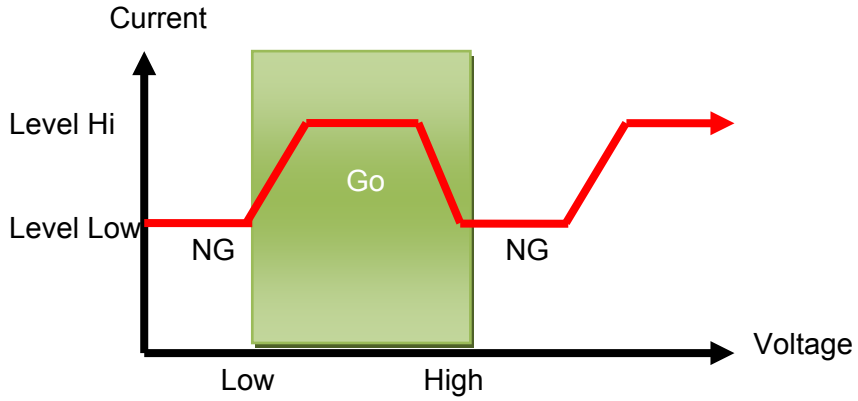
- Setting NG ON/OFF, When exceed VH、VL、IH、IL、WH、WL One of these Whether NG on LCD display.



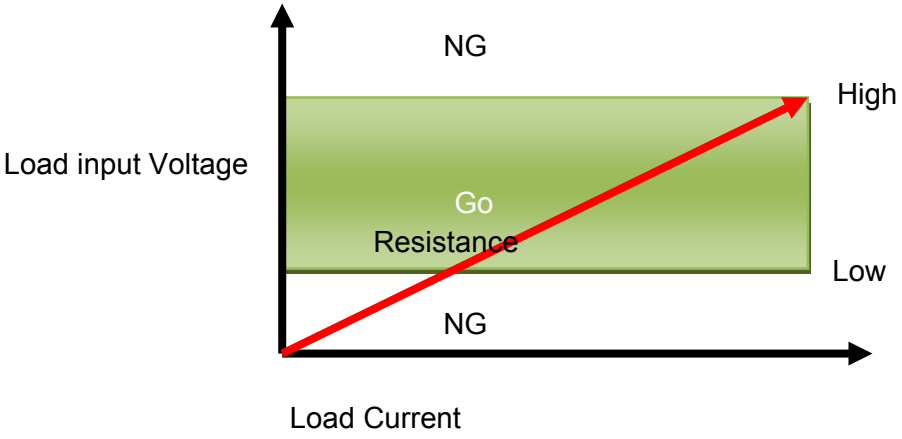
- CC mode, press limits key to set the V-Hi and V-Lo voltage upper and lower limits of the GO / NG.



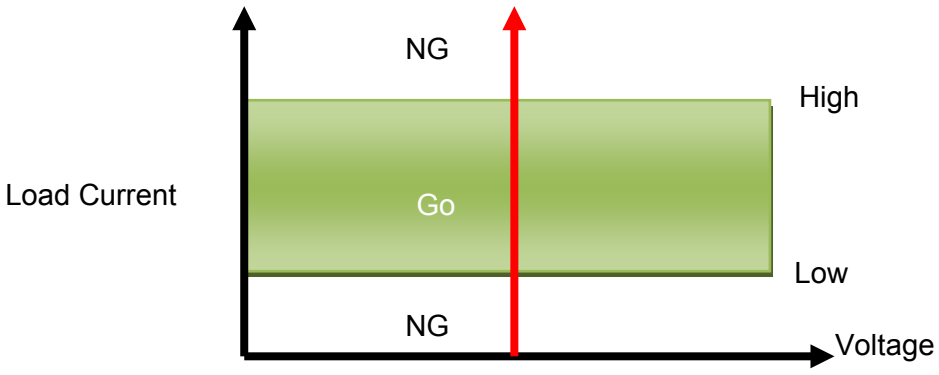
- CC Dynamic Mode, press key to set the Level Hi and Level Low voltage upper and lower limits of the GO / NG.



- CR mode, press limits key to set the V-Hi and V-Lo voltage upper and lower limits of the GO / NG.

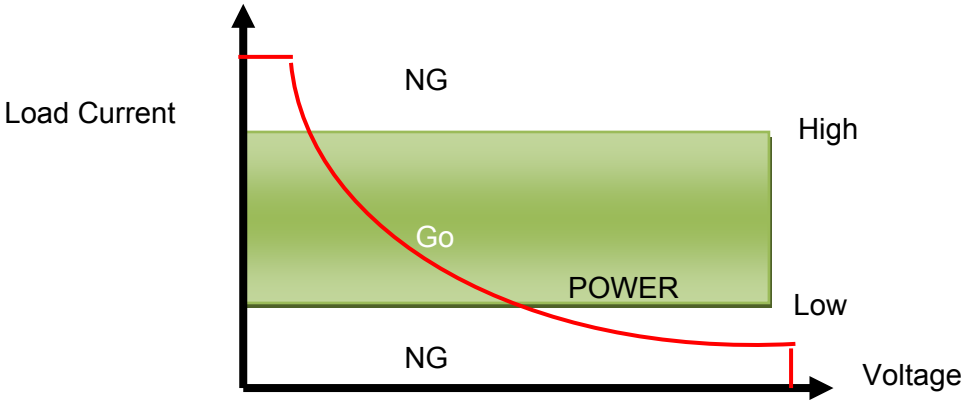


- CV mode, press limits key to set the I-Hi and I-Lo Current upper and lower limits of the GO / NG.



Load Input Voltage

- CP mode, press limits key to set the W-Hi and W-Lo power upper and lower limits of the GO / NG.



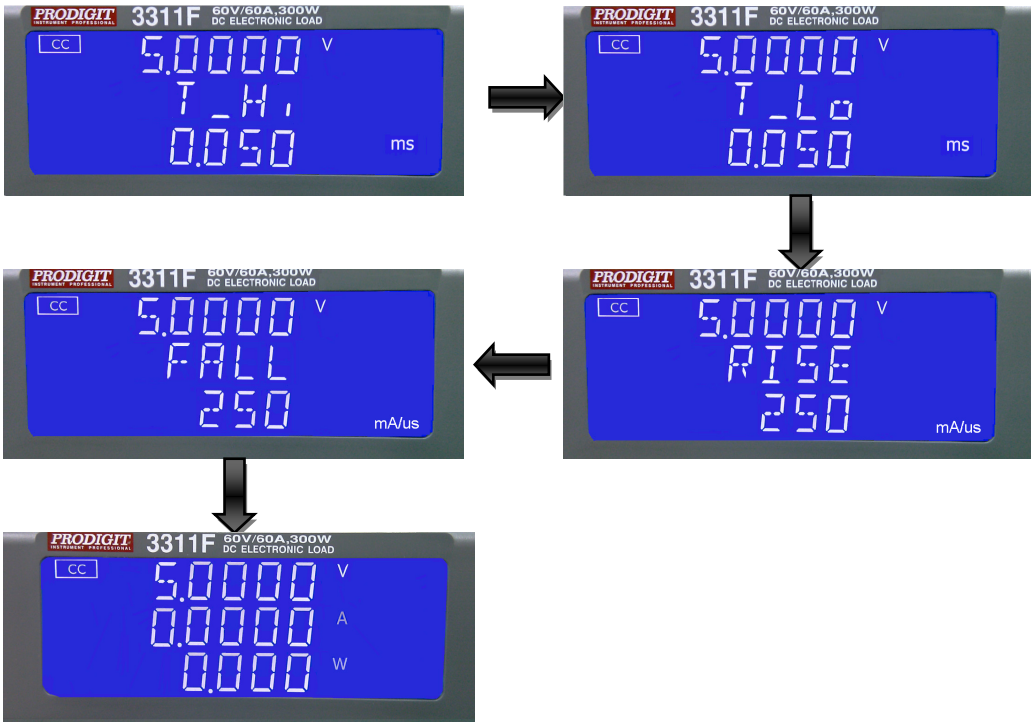
3.2.15. DYN setting Key

The DYN button allows the user to define the timings of the dynamic load Waveform. Firstly the high and low levels of load current will need to be set via the LEVEL switch. The RISE and FALL times between the low load current and the high load current along with the TIME the waveform is HIGH and the TIME LOW Can be set via the DYN menu.

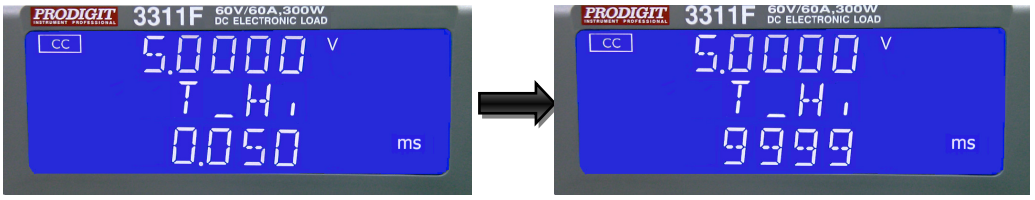
Each press of the DYN key enables a section of the DYNAMIC waveform to be set. On first press of the DYN key the button will illuminate and T-Hi will be displayed On the middle LCD. The value is adjusted with the rotary knob and can be read From the lower LCD during setting. The setting sequence is shown below:

T_Hi (time the waveform is high) →
T_Lo (time the waveform is low) →
RISE (rise time) →
FALL (fall time) →
DYN setting function OFF →

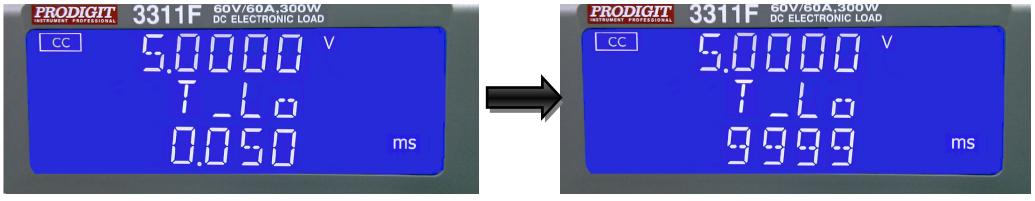
The time that the waveform is high includes the rise time and is set in “ms”
The time that the waveform is low includes the fall time and is set in “ms”
The RISE and FALL time is set in “mA/μs” or “A/μs”. The actual engineering unit is Shown on the right of the lower 5 digit display



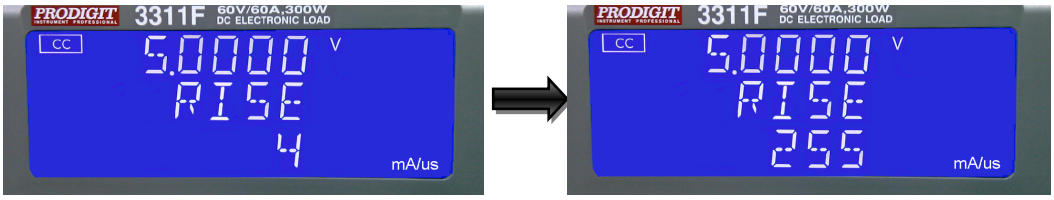
- Press DYN setting key, LED will ON
  Setting level High Period, Middle 5 digit LCD display will show 「T-Hi」
  Lower 5 digit LCD display will show setting value, the unit is “ms” , The T-Hi Set range from 0.050 ms to 9999 ms step 0.001ms by rotating the setting Knob.



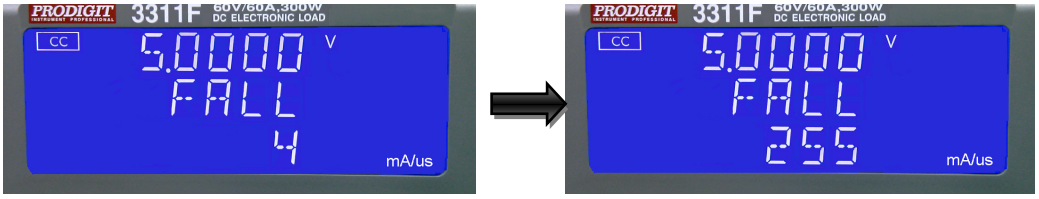
- Setting level Low period, Middle 5 digit LCD display will show 「T-Lo」, Lower 5 digit LCD display will show setting value, the unit is “ms” , The T-Lo set range from 0.050 ms to 9999 ms step 0.001ms by rotating the Setting knob.



- Setting rise time, Middle 5 digit LCD display will show 「RISE」, Lower 5 digit LCD display will show setting value, the unit is “mA/μs” , The RISE time set range from 4 mA/us to 255 mA/us step 1mA/us by rotating the Setting knob.



- Setting fall time, Middle 5 digit LCD display will show 「FALL」, Lower 5 digit LCD display will show setting value, the unit is “mA/μs” , The FALL time set range from 4 mA/us to 255 mA/us step 1mA/us by rotating the Setting knob.

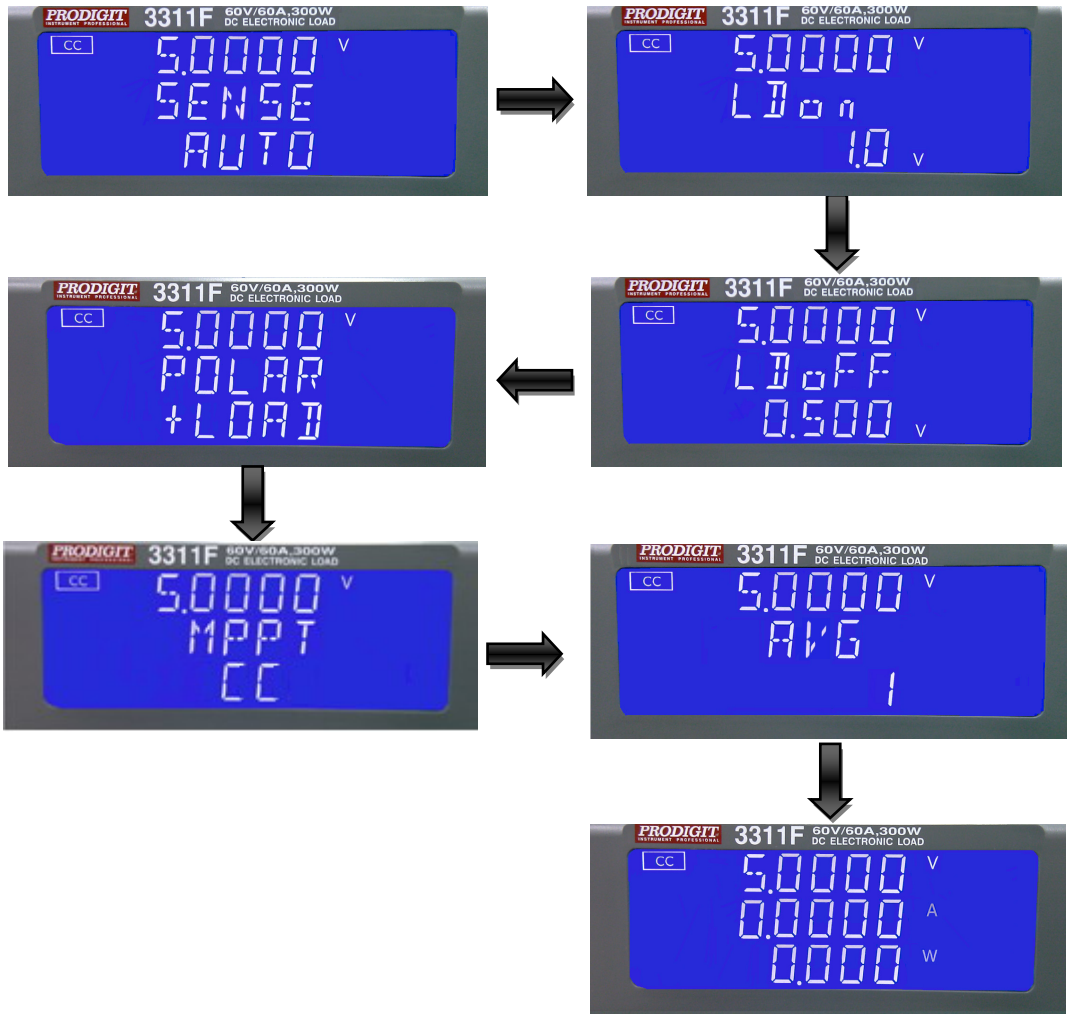


3.2.16. Config key

The CONFIG key allows the sense function to engage automatically or switched ON. The CONFIG key also enables the LOAD to automatically turn ON/OFF When a voltage level is reached. The polarity symbol can also be switched via the CONFIG menu.

Each press of the CONFIG key moves the menu on one step. On first press of the CONFIG key the button will illuminate and SENSE will be displayed on the middle LCD. The value is adjusted with the rotary knob and can be read from the lower LCD during setting. The setting sequence is shown below:

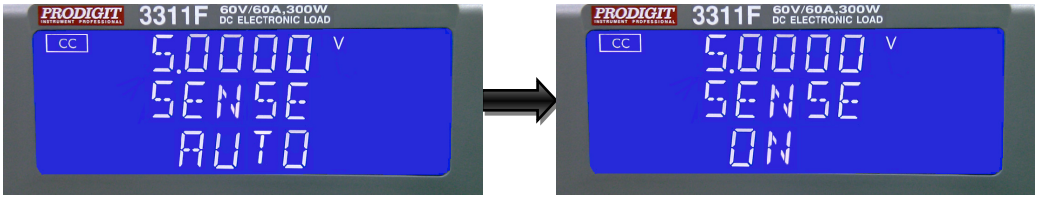
SENSE (AUTO or ON) →
LDon (Voltage at which LOAD turns ON) →
LDoff (Voltage at which LOAD turns OFF) →
POLAR (change polarity symbol) →
MPPT(maximum power point tracking) →
AVG(Measuring V.I of Average) →
exit CONFIG options



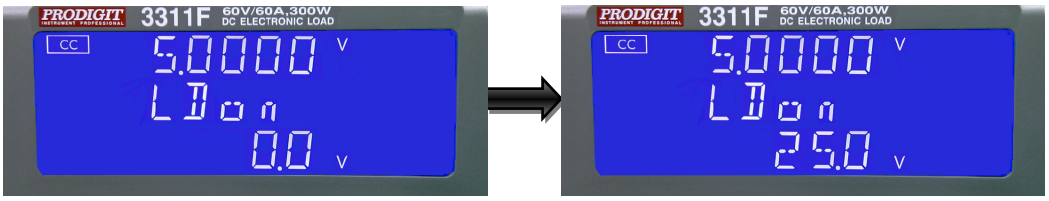
Note 1: The adjustable LDon (LOAD ON) voltage is valid for CC, CR & CP operating Modes. The adjusted LDon voltage will not operate in CV mode.

Note 2: The LDon (LOAD ON) voltage setting cannot be lower than the LDoff (LOAD OFF) voltage. If 0V is required for both LOAD ON and LOAD OFF make the LOAD OFF adjustment first.

- Setting Vsense and load input switching methods, the middle of the 5 digit LCD display will show "SENSE", Lower 5 digit LCD display will show "AUTO" or "ON".



- Set Load ON voltage, the middle of the 5 digit LCD display will show "LDon", Lower 5 digit LCD display will show setting value, the units is V, The Load ON Voltage set range from 0.0V to 25.0V step 0.1V by rotating the setting knob. If the load is greater than the input voltage Load ON voltage setting, the Electronic load current begin to load on.

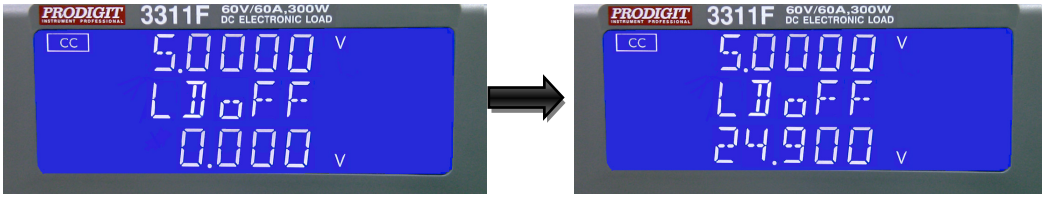


NOTE1: CC/CR/CP MODE is controlled by Load ON voltage, CV MODE is not Controlled by Load ON voltage.

NOTE2: If Load ON voltage Setting 0V, load OFF voltage has to setting to 0V.

NOTE3: The programmed load ON voltage for model 3310F, 3311F, 3315F Load module is from 0 to 25V, model 3312F is from 0 to 50V, and Model 3314F is from 0 to 100V.

- Setting Load OFF voltage, the middle of the 5 digit LCD display will show "LDoFF", lower the 5 digit LCD display will show settings value, the units is V, The Load OFF Voltage set range from 0.0V to 24.9V step 0.1V by rotating the Setting knob.
  if the load input voltage is less than Load OFF setting voltage, the electronic load to load off.



- Set Load polarity, the middle of the 5 digit LCD display will show "POLAR", lower the 5 digit LCD display "will show + LOAD" or "-LOAD", use the knobs and key settings "+ LOAD" or "-LOAD".
- Setting MPPT , the middle of the 5 digit LCD display will show "MPPT", lower the 5 digit LCD display will show settings value

The MPPT set CC/CR/CV mode by rotating the Setting knob, Detailed parameters required by the REMOTE input (see 330XF manual).

The MPPT algorithm for 3310F series DC Load

Many photovoltaic (PV) devices, such as PV panels and concentrated photovoltaic (CPV) modules, require outdoor testing for design verification, durability, and safety. A low cost means of testing the output power of PV devices outdoors is to use DC electronic load; it provides high power-handling capability at a low cost.

Often one of the main functions of outdoor PV testing is maximum power-point tracking (MPPT). But because eloads are general-purpose instruments, it is up to the PV test engineer to implement an algorithm in test software to perform MPPT.

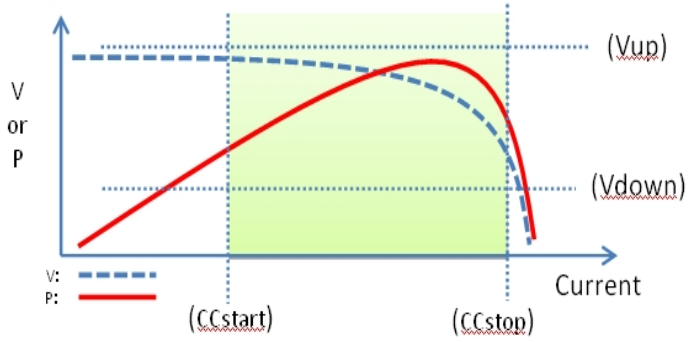
Fortunately, there are a lot of MPPT algorithm you can choose from, with more than 19 published papers on the implementation and performance of different MPPT algorithm.

However, these algorithms were designed for solar inverters. Inverter are different fro test systems, so a MPPT algorithm that performs well in an inverter may not necessarily perform well in a PV test system. This article introduces a MPPT algorithm that is a good fit for PV testing with an eload. We discuss how the algorithm is implemented and why it's a good fit for MPPT in outdoor PV test systems.

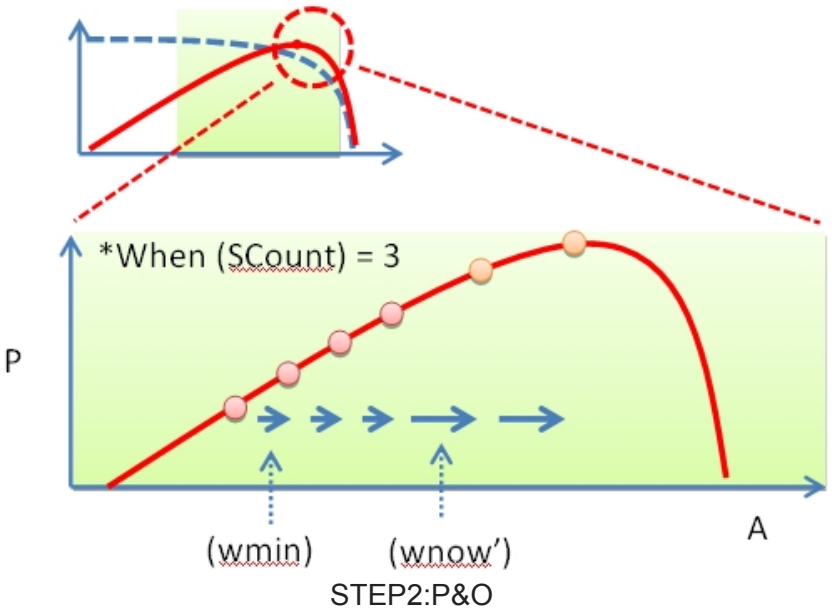
The main difference between implementing a given MPPT algorithm in an inverter and an eload is in the I/O latency. In inverters, the MPPT algorithm runs on an internal microprocessor that can measure and compute and make load adjustments in microseconds. To perform the same set of operations with custom software and an eload could easily take tens of milliseconds due to the unavoidable I/O latency between the computer and the eload. This I/O latency is the main bottleneck affecting tracking speed. With that in mind, we chose and modified the MPPT algorithm discussed in this article to meet the needs of a PV test system using the 3310F series eload.

An eload is an instrument that can sink and measure the output power of a power source, such as a power supply or a PV device. Like a variable resistor, an eload can be adjusted to control the amount of power it is sinking. Eloads can measure the voltage drop across them and the current they are sinking. Eloads typically have four modes of operation: constant current, constant resistance, constant voltage and constant power. The eload will maintain its mode setting even when the power output of the source it is connected to changes. For instance, if the eload is connected to the output of a PV panel and has a constant-voltage (CV) mode setting of 30V, it will adjust its internal resistance to remain at 30V as the I-V curve of the panel varies. If the maximum voltage of the panel (Voc) drop below 30V, the eload will act like an open and the voltage across it will be whatever Voc is. In photovoltaic test, eloads are typically used in CV mode, so we will use this mode for defining the algorithm.

3310F series ELOAD MPPT algorithm：Case in CC MODE, It is divided into two steps，The first step on the basis of an input conditions scanning CCstart => CCstop identify the MPP point，The second steps in accordance with MPP point perturbation (P & O) to find out the true value of MPP，At the end of P&O time, recording an MPP value, and then repeat steps 1 & 2.



STEP1: scanning



STEP2:P&O

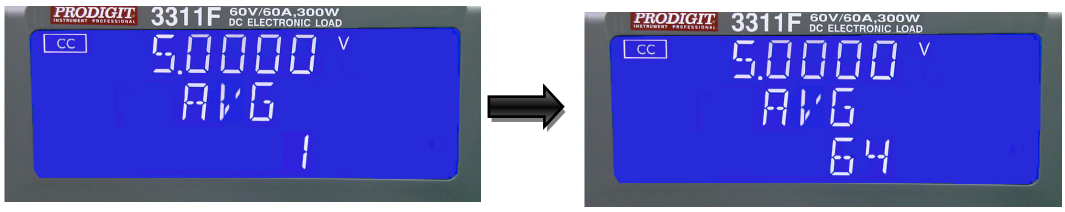
How to operating MPPT in 3310F series load

Remote Operation with remote command:

1. Power ON 3310F series Load
2. Connecting UUT (PV panel) to load input terminal
3. Sent MPPT parameters,.
4. Sent command MPPT ON to start tracking MPP of UUT, the record data is no limitation in 3310F series internal memory
5. Sent MPP? command to read back the voltage, current and power (MPP)
6. Sent MPPT OFF to stop tracking the MPP of UUT

- CR DYN function version of the following
  a. 3310F at r1.11 version above is enabled.
  b. 3311F at r1.11 version above is enabled.
  c. 3312F at r1.11 version above is enabled.
  d. 3314F at r1.11 version above is enabled.
  e. 3315F at r1.11 version above is enabled.
- MPPT CC/CR/CV function version of the following
  a. 3310F at r2.08 version above is enabled.
  b. 3311F at r2.08 version above is enabled.
  c. 3312F at r2.08 version above is enabled.
  d. 3314F at r2.08 version above is enabled.
  e. 3315F at r2.08 version above is enabled.

- Setting AVG , the middle of the 5 digit LCD display will show "AVG", lower the 5 digit LCD display will show settings value,the AVG set range from 1 to 64 steps 1 by rotating the setting knob.



- AVG function version of the following
  a. 3310F at r2.05 version above is enabled.

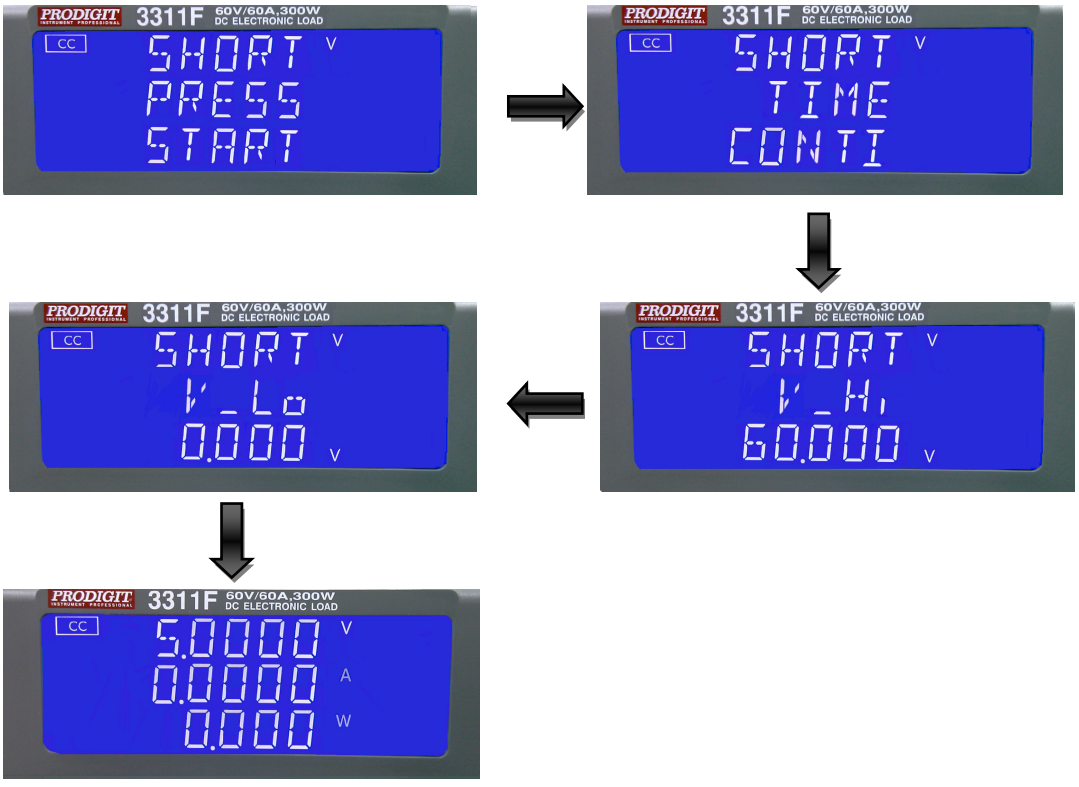
b. 3311F at r2.05 version above is enabled.
c. 3312F at r2.05 version above is enabled.
d. 3314F at r2.05 version above is enabled.
e. 3315F at r2.05 version above is enabled.

3.2.17. Short key

The SHORT key allows the parameters of a SHORT circuit test to be entered. The SHORT test will attempt to sink high current up to the 3310F load module's maximum current in order to check the power source's protection and behavior. The test time can be adjusted and threshold values for the High and low voltage limits set.

Pressing the SHORT key once will cause the button to illuminate. The Message "SHORT PRESS START" will be shown across the 3 displays.
Each press of the SHORT key moves the menu on one step. The upper and Middle LCDs show the currently selected test parameter as text. The value is adjusted by the rotary knob and can be read from the lower display during Setting.
The setting sequence is shown below:

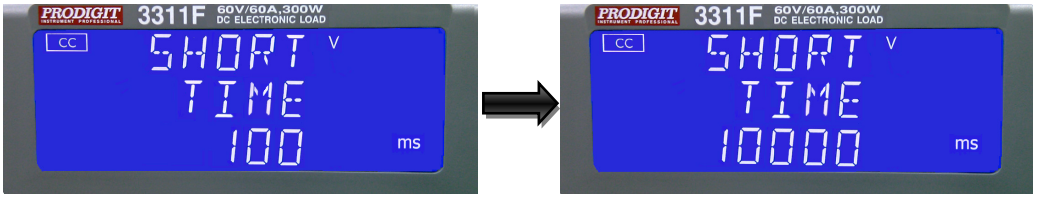
SHORT PRESS START (pressing the red start/stop key starts test) →
SHORT TIME (CONTI = Continuous or 100ms to 10,000ms possible) →
SHORT V_Hi (High voltage threshold setting) →
SHORT V_Lo (Low voltage threshold setting →
Exit SHORT test set-up



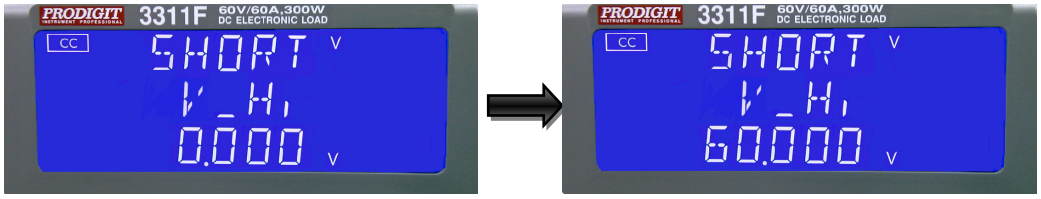
- setting the short test time，The LCD display show 「SHORT」 on upper 5 digits LCD display，shows 「TIME」on middle 5 digits LCD display，

lower 5 digit LCD display 「CONTI」, the unit is "ms".

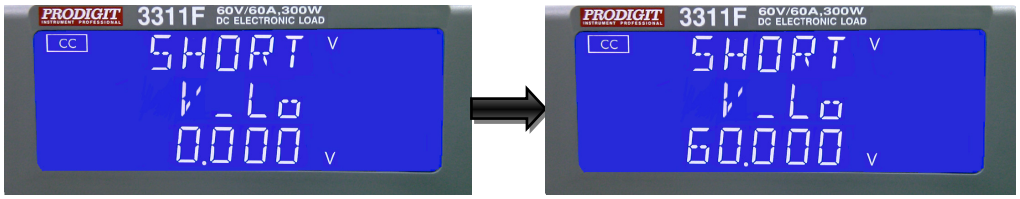
- TIME: setting the short test time, The LCD display show 「SHORT」 on upper 5 digits LCD display, shows 「TIME」on middle 5 digits LCD display the unit is “ms” ,and shows 「CONTI」 on lower 5 digits LCD display, the Setting range is “CONTI” means continue, 100mS to 10000mS step 100mS by clockwise rotate the setting knob.
  The short test will be no time limitation when setting to CONTI until press “START/STOP” key to stop the short test.



- V-Hi : Short test voltage check upper limitation setting, The LCD display shows 「SHORT」on upper 5 digit LCD display, Middle 5 digit LCD display「V-Hi」,lower 5 digit LCD display setting value, the unit is "V", The V-Hi setting range from 0.000V to 60.000V step 0.001V by rotating the setting knob.



- V-Lo : Short test voltage check lower limitation setting, The LCD display shows 「SHORT」on upper 5 digit LCD display, Middle 5 digit LCD display「V-Lo」,lower 5 digit LCD display setting value, the unit is "V", the V-Hi setting range from 0.000V to 60.000V step 0.001V by rotating the setting knob.



Once the test parameters have been entered the test is started by pressing The red START/STOP button while the SHORT PRESS START text is Displayed. During the test the bottom LCD will show run and the actual short Current will be displayed on the middle LCD.

Note 1: The message PASS END will be displayed if the measured voltage levels stays within the V_Hi and V_Lo threshold levels during the test

Note 2: The message FAIL END will be displayed if the measured voltage levels

falls outside the V_Hi and V_Lo threshold levels during the test. The NG flag will also illuminate.

Note 3: If continuous short time is selected the test is ended by pressing the red START/STOP button.

3.2.18. OCP key

The OCP key allows the parameters of an Over Current Protection test to be entered. The OCP test will ramp up the load current in steps to validate the Device Under test's (DUT) protection and behavior. A voltage threshold level can be set. If the voltage measured during the test is lower than the set Threshold voltage then the test will fail and the display will signal OCP ERROR. Similarly a current Threshold (I STOP) can be set. If the measured

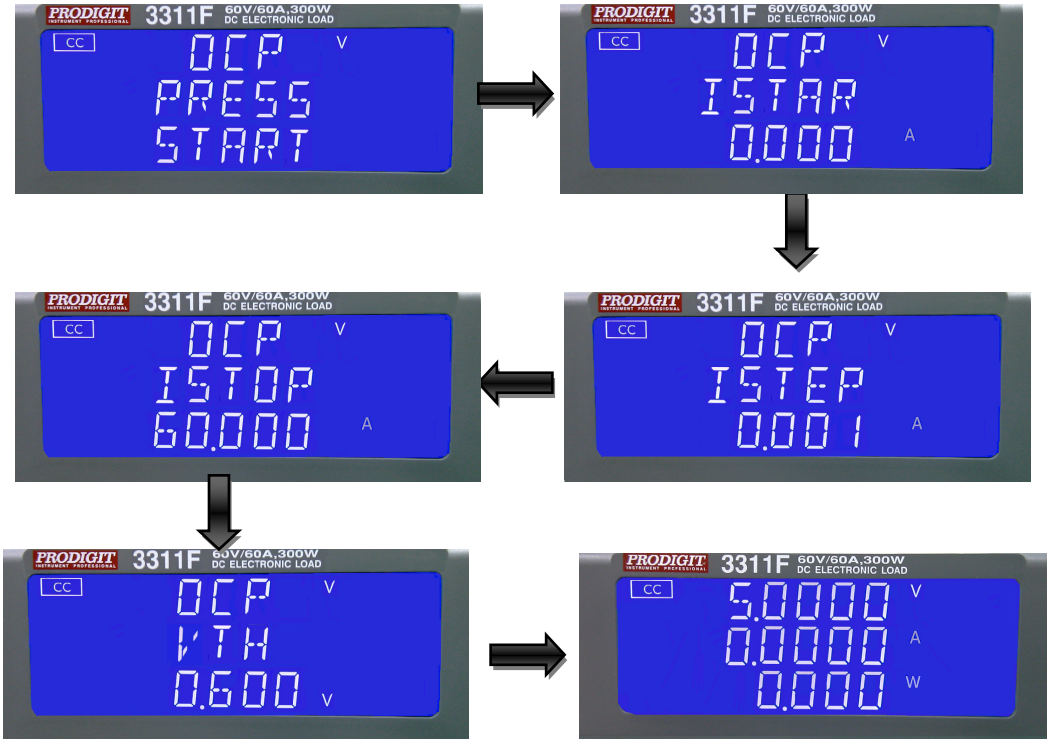
Current reaches the I STOP Threshold the test will be discontinued and the OCP ERROR message will be displayed.

Pressing the OCP key once will cause the button to illuminate. The message "OCP PRESS START" will be shown across the 3 displays.

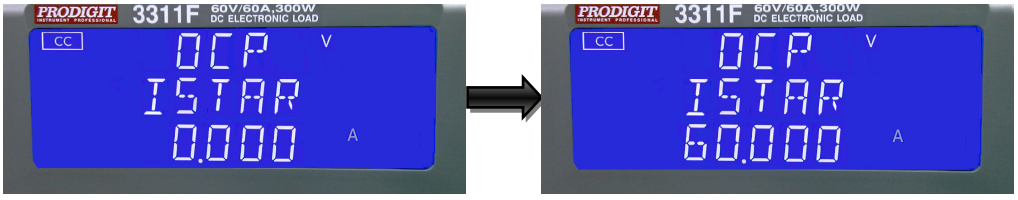
Each press of the OCP button moves the menu on one step. The upper and Middle LCDs show the currently selected test parameter as text. The value is adjusted by the rotary knob and can be read from the lower display during Setting.

The setting sequence is shown below:

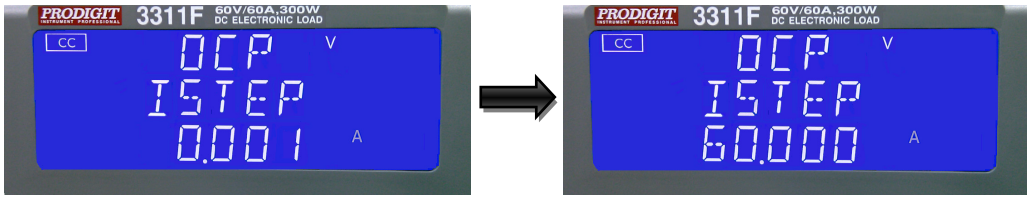
OCP PRESS START (pressing the red start/stop key starts test) →
OCP I STAR (current starting point of the OCP test) →
OCP I STEP (value of incremental current steps from I START) →
OCP I STOP (the OCP test's upper current threshold →
OCP Vth (the voltage threshold setting) →
Exit OCP test set-up



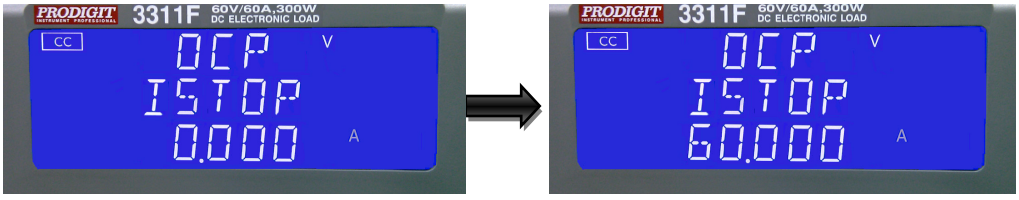
- ISTAR: setting the start current point, The LCD display shows 「OCP」on upper 5 digit LCD display, Middle 5 digit LCD display「ISTAR」,lower 5 digit LCD display setting value, the unit is "A".
  The setting range is 0.000A to the full scale of the CC mode specification.
  The setting is by rotating the setting knob.



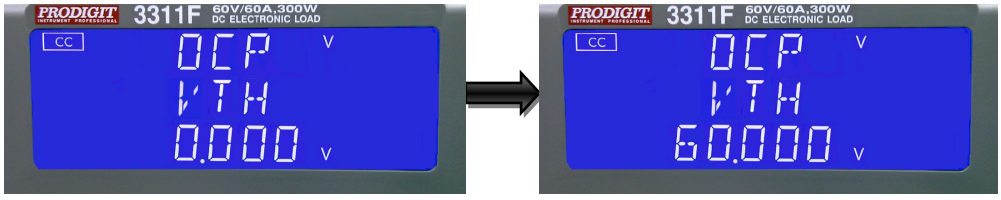
- ISTEP: setting the increment step current point, The LCD display shows 「OCP」on upper 5 digit LCD display, Middle 5 digit LCD display「ISTEP」,lower 5 digit LCD display setting value, the unit is "A".
  The setting range is 0.001A to the full scale of the CC mode specification.
  The setting is by rotating the setting knob.



- ISTOP: setting the stop current point, The LCD display shows 「OCP」on upper 5 digit LCD display, Middle 5 digit LCD display「ISTOP」,lower 5 digit LCD display setting value, the unit is "A", the setting range is 0.000A to the full scale of the CC mode specification. The setting is by rotating the setting knob.



- Vth: Setting threshold voltage; The LCD display shows 「OCP」on upper 5 digit LCD display, Middle 5 digit LCD display「Vth」,lower 5 digit LCD display setting value, the unit is "V", the setting range is 0.00V to the full scale of the Voltage specification. The setting is by rotating the setting knob.



Once the test parameters have been entered the test is started by pressing the red START/STOP button while the OCP PRESS START text is displayed. During the Test the middle LCD will show run and the actual current being Taken will be Displayed on the lower LCD

Note 1: The message OCP ERROR will be displayed if the DUT fails the test. The reasons for failure are due to one of the following conditions:

(a) the voltage level of the DUT falls below the set voltage threshold (OCP Vth) during the test
(b) The current taken from the DUT reaches the OCP I STOP setting.

Note 2: The message PASS will be displayed if the DUTs voltage stays above The set threshold. Also to PASS the OCP test the current taken from the DUT cannot equal the I STOP setting.

Note 3: If the DUT passes the OCP test the maximum current taken during the Test is displayed on the lower LCD.

Upon PASS or OCP ERROR the test will automatically stop. The red START/STOP button can be used during the test to immediately cease operation.

3.2.19. OPP key

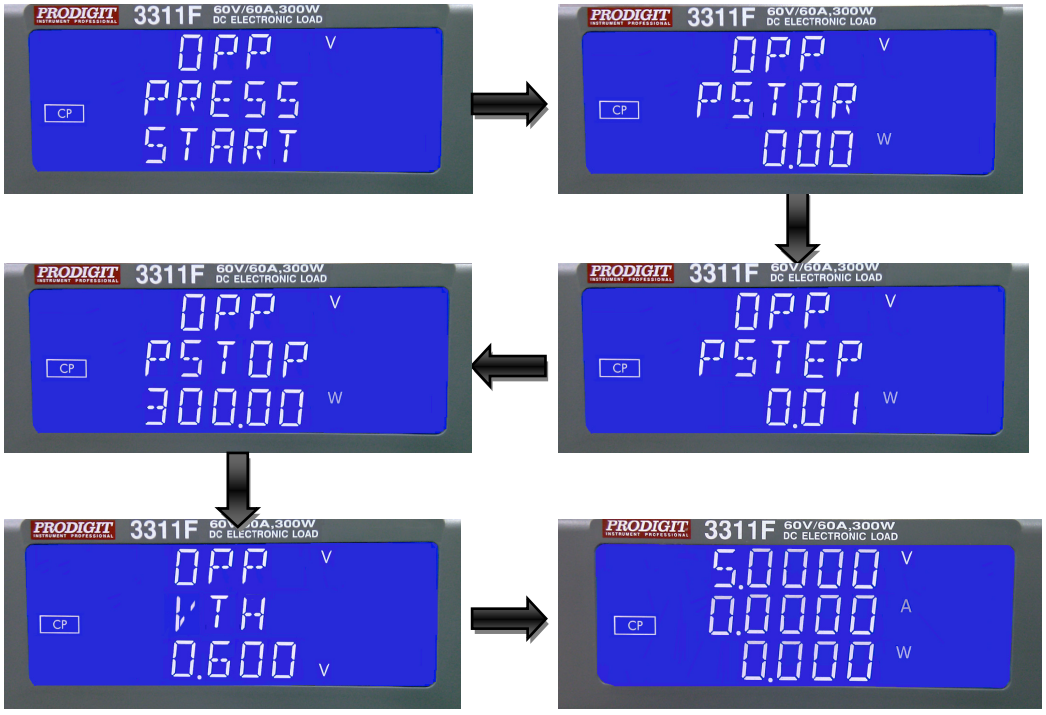
The OPP key allows the parameters of an Over Power Protection test to be entered. The OPP test will ramp up the load power in steps to validate the Device under Test's (DUT) protection and behavior. A voltage threshold level can be set. If the voltage measured during the test is lower than the set Threshold voltage then the test will fail and the display will signal OPP ERROR. Similarly a power threshold (P STOP) can be set. If the measured power reaches the P STOP threshold the test will be discontinued and the OPP ERROR message will be displayed.

Pressing the OPP key once will cause the button to illuminate. The message "OPP PRESS START" will be shown across the 3 displays.

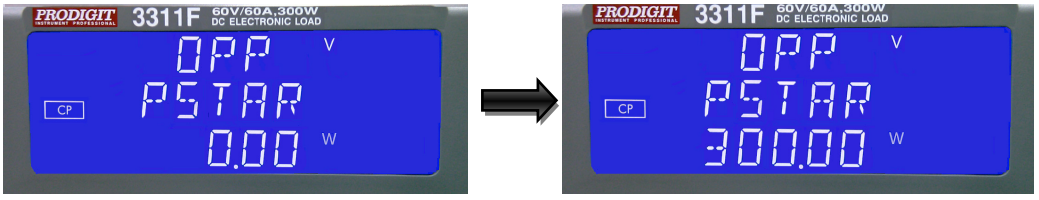
Each press of the OPP button moves the menu on one step. The upper and Middle LCDs show the currently selected test parameter as text. The value is adjusted by the rotary knob and can be read from the lower display during Setting.

The setting sequence is shown below:

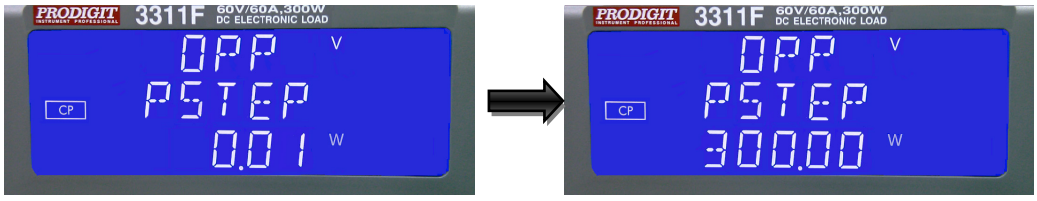
OPP PRESS START (pressing the red start/stop key starts test) →
OPP P STAR (power starting point of the OPP test) →
OPP P STEP (value of incremental current steps from P START) →
OPP P STOP (the OPP test's upper threshold power limit) →
OPP Vth (the voltage threshold setting) →
Exit OPP test set-up



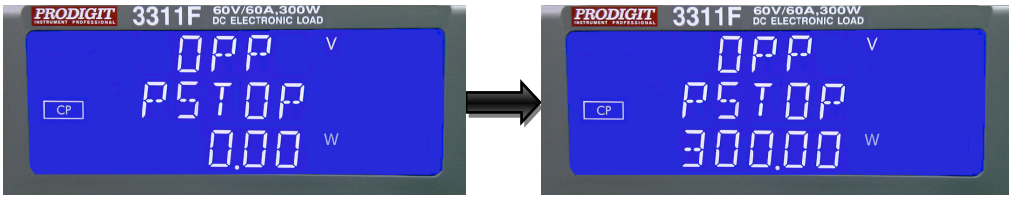
- PSTAR: setting the start power, The LCD display shows 「OPP」on upper 5 digit LCD display, Middle 5 digit LCD display「PSTAR」,lower 5 digit LCD display setting value, the unit is "W", the setting range is 0.00W to the full scale of the CP mode specification. The setting is by rotating the setting knob.



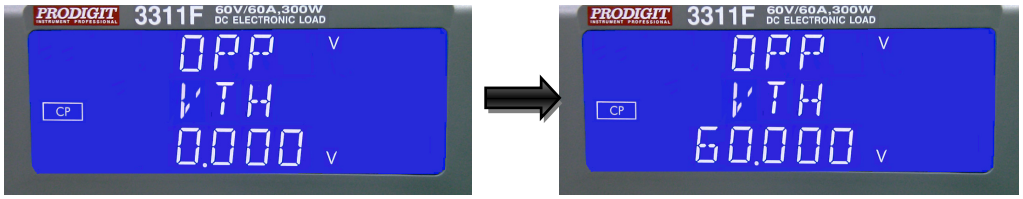
- PSTEP: setting the increment step power, The LCD display shows 「OPP」on upper 5 digit LCD display, Middle 5 digit LCD display「PSTEP」,lower 5 digit LCD display setting value, the unit is "W", the setting range is 0.00W to the full scale of the CP mode specification. The setting is by rotating the setting knob.



- PSTOP: setting the stop power, The LCD display shows 「OPP」on upper 5 digit LCD display, Middle 5 digit LCD display「PSTOP」,lower 5 digit LCD display setting value, the unit is "W", the setting range is 0.00W to the full scale of the CP mode specification. The setting is by rotating the setting knob.



- Vth : Setting threshold voltage; The LCD display shows 「OPP」on upper 5 digit LCD display, Middle 5 digit LCD display「Vth」,lower 5 digit LCD display setting value, the unit is "V", the setting range is 0.000V to the full scale of the Voltage specification. The setting is by rotating the setting knob.



Once the test parameters have been entered the test is started by pressing the red START/STOP button while the OPP PRESS START text is displayed. During the test the middle LCD will show run and the actual power being taken will be displayed on the lower LCD.

Note 1: The message OPP ERROR will be displayed if the DUT fails the test. The reasons for failure are due to one of the following conditions:

(a) The voltage level of the DUT falls below the set voltage threshold (OPP Vth) during the test
(b) The current taken from the DUT reaches the OPP P STOP setting.

Note 2: The message PASS will be displayed if the DUTs voltage stays above the set threshold. Also to PASS the OPP test the current taken from the DUT cannot equal the I STOP setting.

Note 3: If the DUT passes the OPP test the maximum power taken during the test is displayed on the lower LCD.

Upon PASS or OPP ERROR the test will automatically stop. The red START/STOP button can be used during the test to immediately cease operation.

3.2.20. 

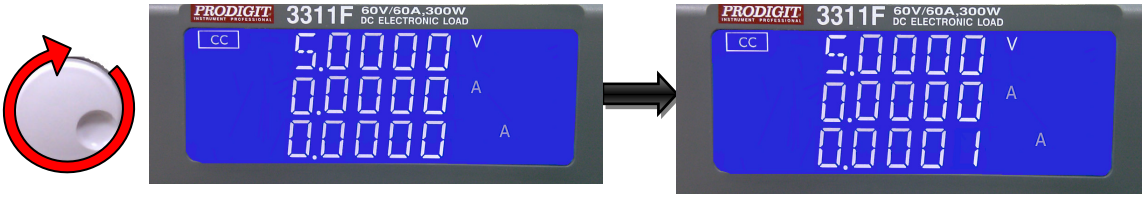
key

The red START/STOP key is used in conjunction with the SHORT, OCP or OPP test functions. It is used to START a test according to the set parameters or to STOP a test before PASS or FAIL is signaled. Please refer to the preceding sections for more information on the SHORT, OCP & OPP tests.

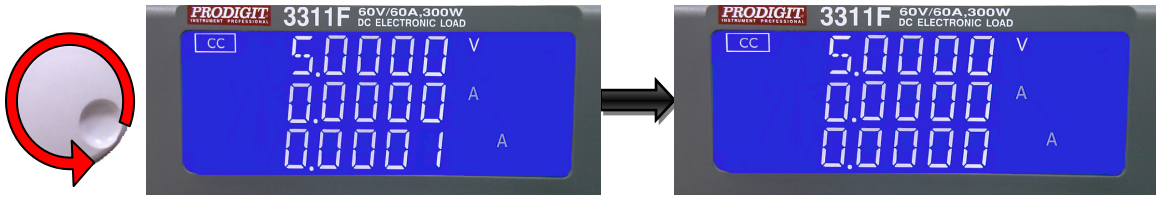
3.2.21. ROTARY Knob and ARROW Keys

The ROTARY knob and ARROW keys are used to increase or decrease the set values.

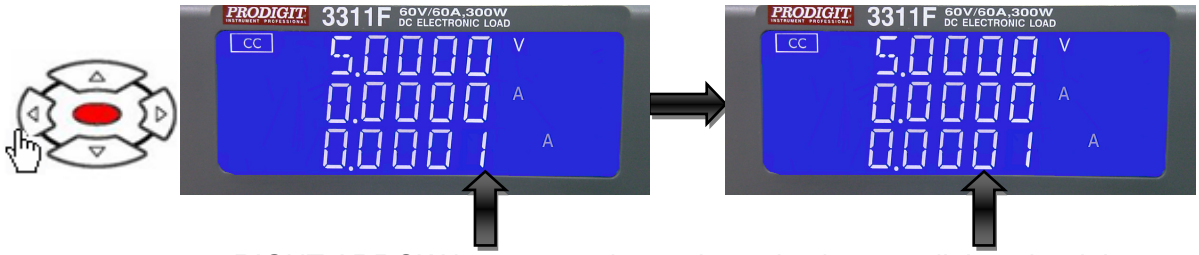
- CLOCKWISE operation of the ROTARY Knob increases the setting value.



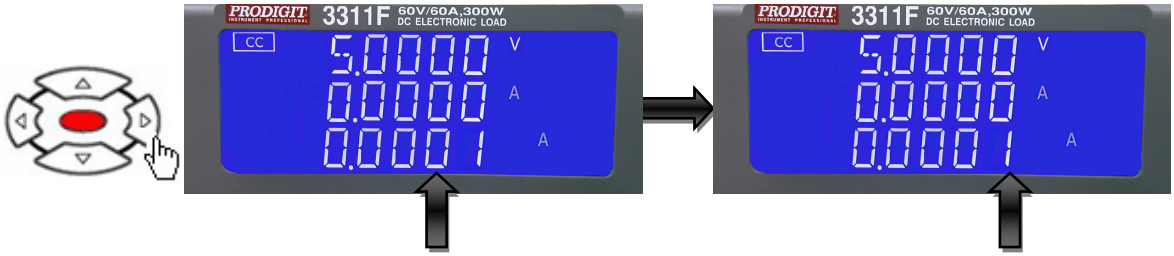
- ANTI-CLOCKWISE operation of the ROTARY Knob decreases the setting value.



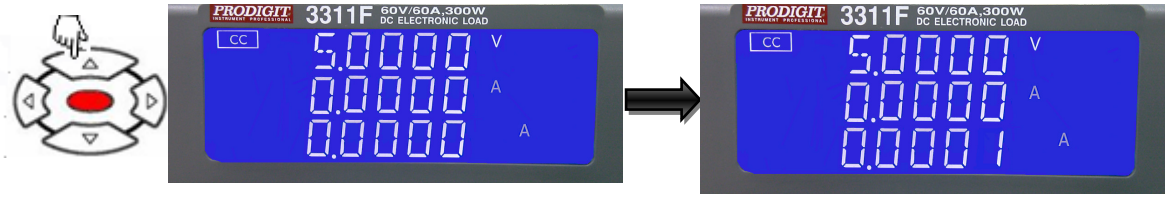
- LEFT ARROW key: Moves the setting selection one digit to the left.



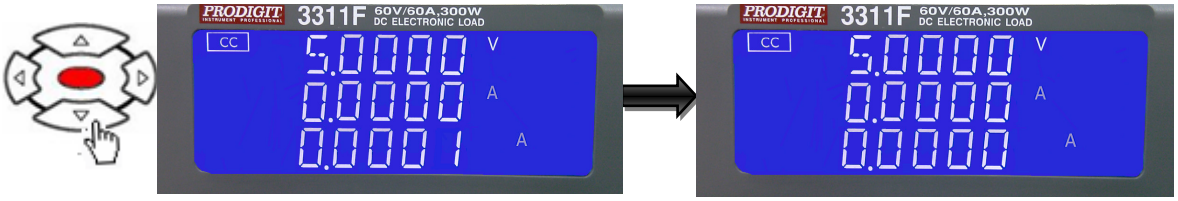
- RIGHT ARROW key moves the setting selection one digit to the right.



- UP ARROW key increases the setting value.



- DOWN ARROW key reduces the setting value.



Note 1: In CR MODE the UP ARROW key and CLOCKWISE operation of The ROTARY Knob reduces the resistance.

Note 2: In CR MODE the DOWN ARROW key & ANTI-CLOCKWISE Operation of the ROTARY Knob increases the resistance.

3.2.22. DC INPUT Terminal.

The positive (LOAD +) and negative (LOAD -) power input terminals are clearly marked. DO NOT confuse them with the smaller SENSE terminals.

Please ensure that the voltage and current rating of the DUT do not exceed the maximum rating of the 3310F load module being used. Please also check the output polarity of the DUT prior to connection and testing.

The negative load terminal should be connected to ground if testing a positive output power supply. This is normally achieved when the negative output of the power supply is grounded.

Similarly if a power supply with a negative output is to be tested then the positive load terminal should be grounded. This is normally achieved when the positive output of the power supply under test is grounded.

3.2.23. V-sense input terminal

The V-sense terminals can be used to compensate for a voltage drop in the load lines between the power supply and the 3310F series Electronic Load. This is a useful feature useful when the load current is relatively high.

If remote sense is required the V-sense terminals are connected to the appropriate positive and negative terminals of the power supply as shown in Fig 3-2.

In the CONFIG menu the V-sense function can be set to AUTO or ON.

Please note that if V-sense is set to AUTO and the sense leads are connected to the DUT the losses need to be approx. 500mV (3310F, 3311F & 3315F) or 2.5V (3312F & 3314F) before the display compensates for the voltage loss.

If V-sense is set to ‘ON’ and the sense terminals are connected to the DUT the load will check and compensate for all voltage drops.

The maximum voltage sense compensation is the same as the rating of the 3310F series electronic load module. For example the 3315F is capable of sinking current at up to 60Vdc. Therefore the maximum V-sense is also 60Vdc.

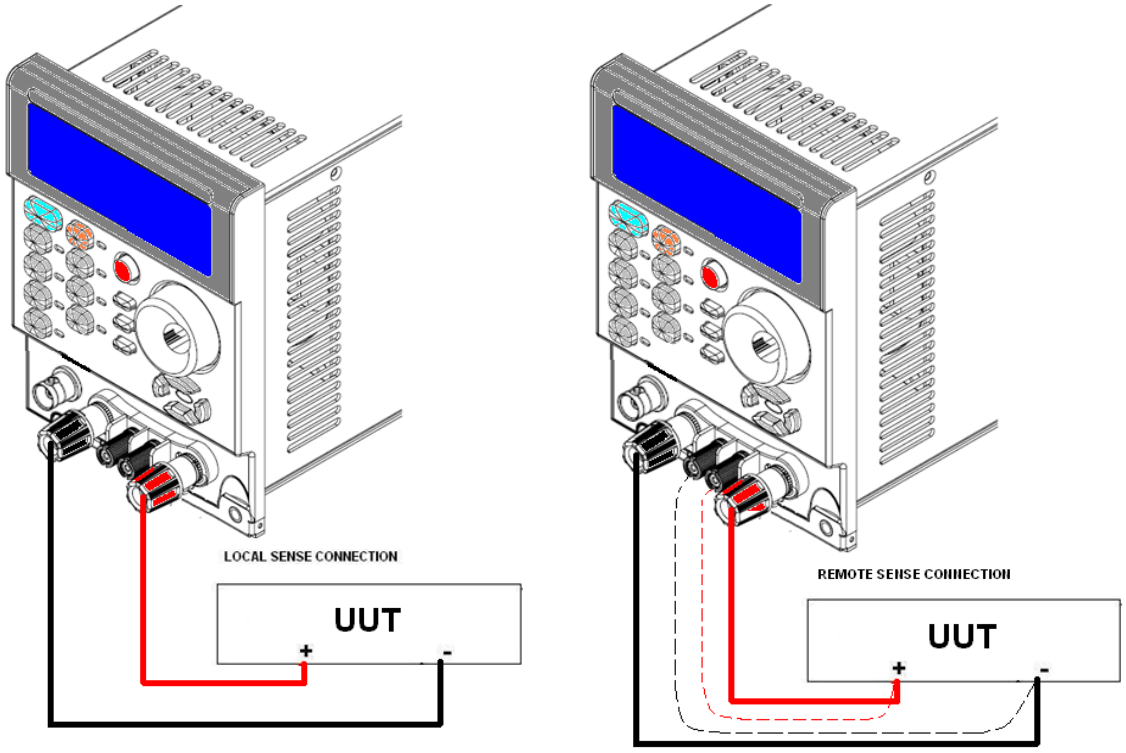


Fig 3-2 typical connection of 3310F series load module

3.2.24. I-monitor

The I-monitor is provided as a BNC socket. It is designed to enable the user to Monitor the Electronic Load's input current or short current. The I-monitor's signal Is 0V to 10V. This signal is proportional to the full scale current that the particular Electronic Load module is capable of.

For example. 3311F: Imax = 60A therefore I-monitor 10V = 60A so 1V = 6A

Please refer to the specification Table 1-1 for the maximum current that each 3310F series module is capable of.

CAUTION

The current monitor of this unit is NOT isolated. Please be careful when you connect an oscilloscope. Improper connections are likely to cause damage. Please follow the connection rule on the following page.

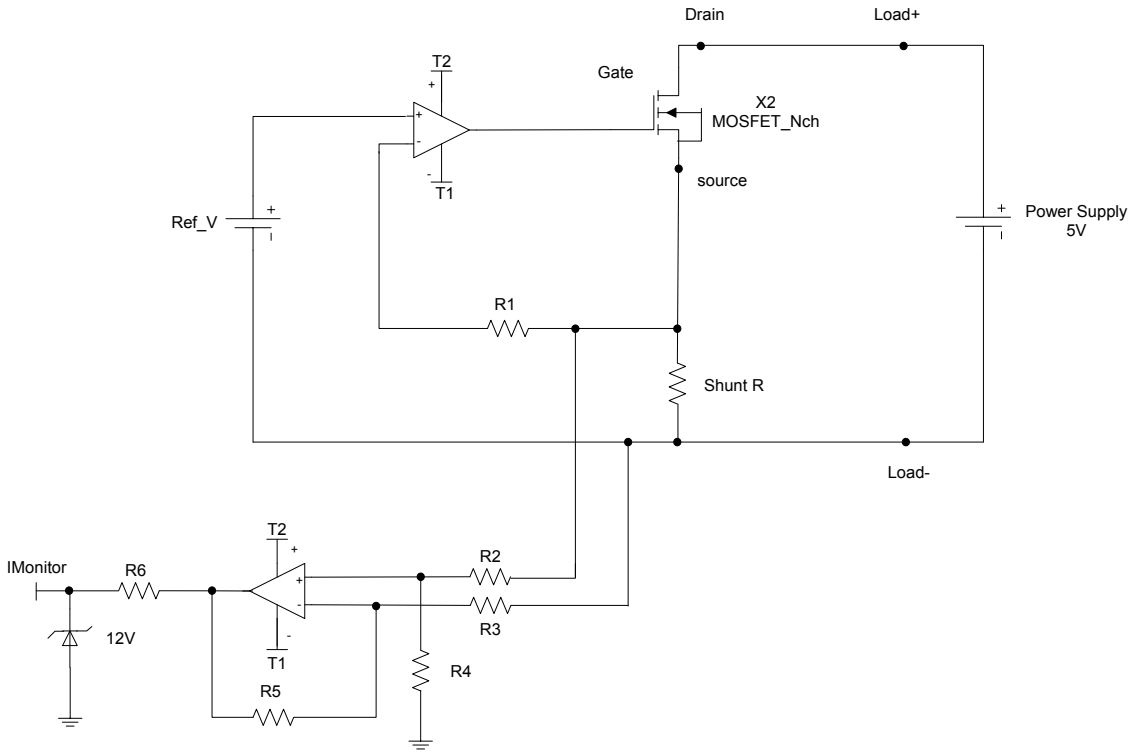


Fig 3-3 An equivalent circuit in terms of the current monitor

Connecting the I-monitor to an oscilloscope

When you connect this product to an oscilloscope, please ensure the correct polarities of the connecting probes as shown in Fig. 3-4.

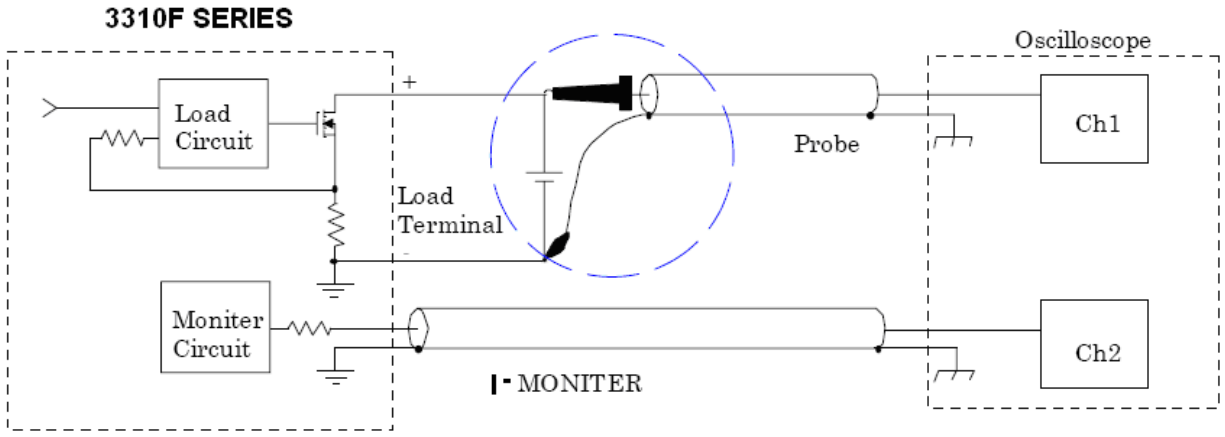


Fig 3-4 (Correct) Connections to an oscilloscope

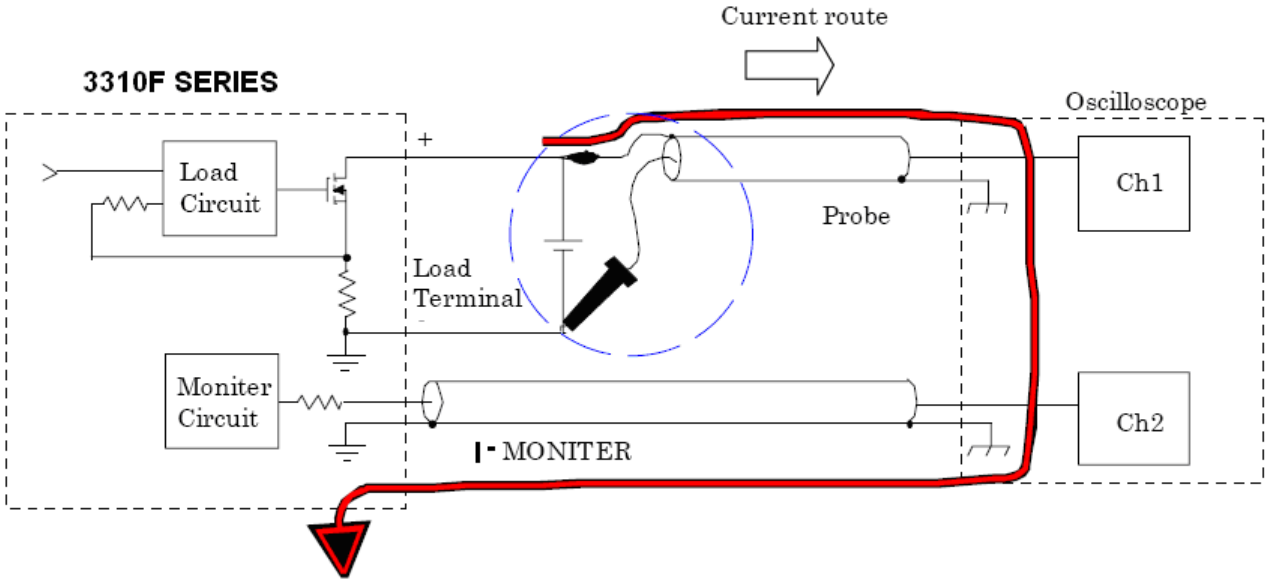


Fig 3-5 (Wrong) Connections to an oscilloscope

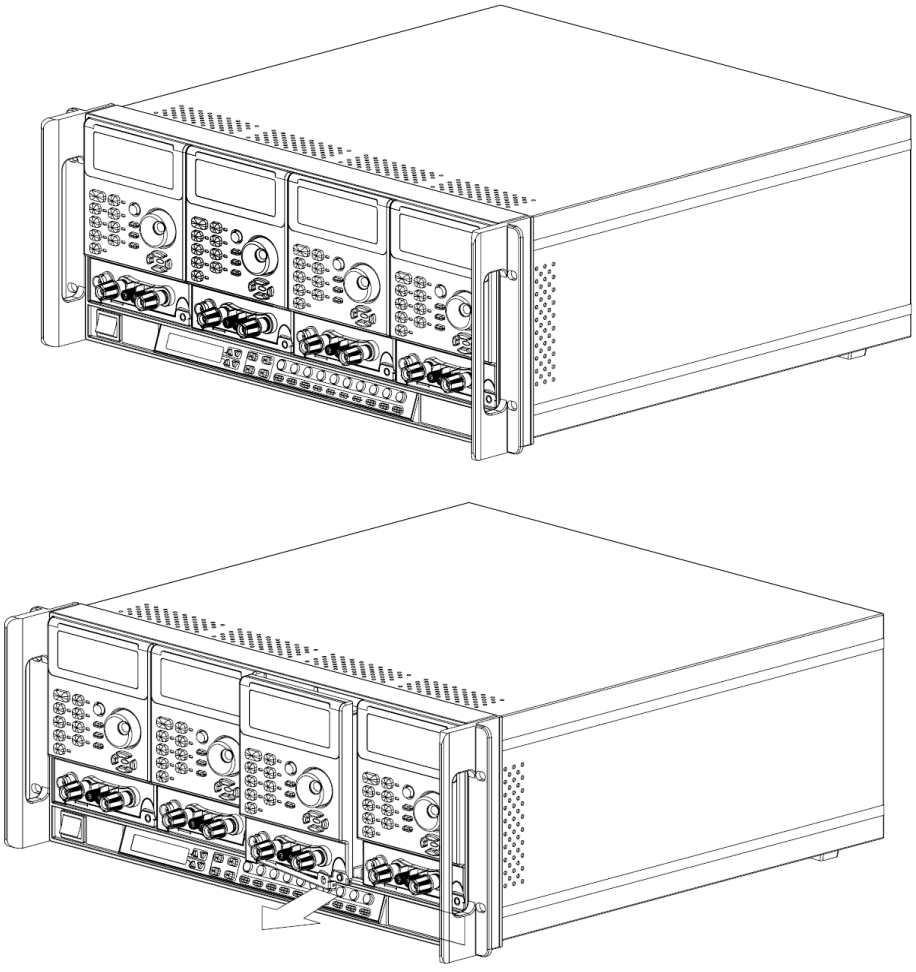
If the probes connection is reversed as shown in Fig 3-5, a large current would flow through the probe and the internal circuitry of the oscilloscope is likely to be damaged.

3.2.25. The withdraw handle

The following procedure details how to remove the 3310F series Load Module from the mainframe.

- Firstly ensure that the mains power to the 3300F/3302F/3305F mainframe is Switched off. Failure to do so may result in damage to the load module.
- Take the screw out of the withdraw handle in the lower right corner of the Module.
- After removal of the screw the handle can be pulled towards you to lever the Module out of the mainframe.

The picture below illustrates the handle operation in the 3300F. The procedure is the same for the 3302F and 3305F mainframes.



3.2.26. Analog programming input

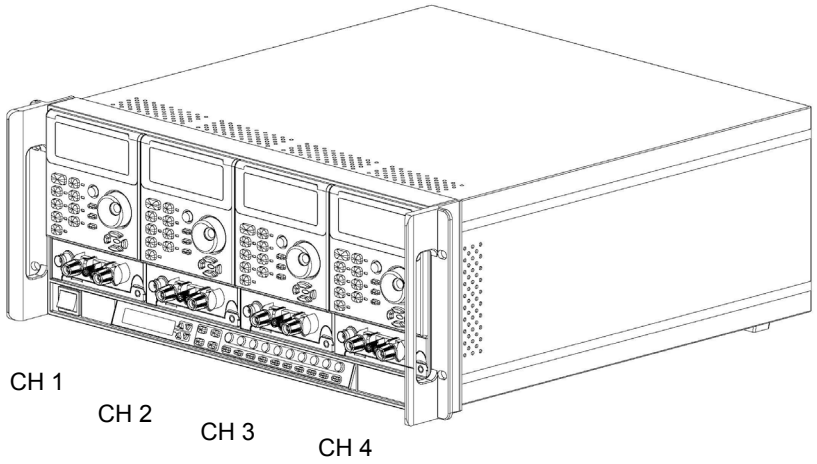
The Electronic Load has an analog programming input on the rear panel of the mainframe. The analogue programming input enables the load module to track and load according to an external 0-10V (ac or ac + dc) signal.

The analog programming input is configured as a BNC socket on the mainframe's rear panel. For the multi slot 3300F & 3305F mainframes the BNC socket is labeled with the respective channel number to correspond with the electronic load module fitted in that position.

The numbering convention is left to right. So channel 1 relates to the load module located on the left hand side and channel 4 is the load module on the right hand side

The analogue programming input operates in CC or CP modes only. The 3310F series Load
Module will attempt to load proportionally according to the signal and the load module's maximum current or power range. For example: 3311F: Imax = 60A and Pmax = 300W

So in CC mode if analogue programming input is 5V = 30A load setting
Or in CP mode if analogue programming input is 1V = 30W load setting



The analog programming signal can act alone or it can be summed with the programmed value set via the front panel or the optional computer interface (GPIB, RS-232, USB, or LAN) or the front panel.

Example:

Fig 3-6 shows the result of an analog programming signal at 4 Vac, 500Hz when it is summed with a 24A programmed setting in CC mode of 3311F Load module.

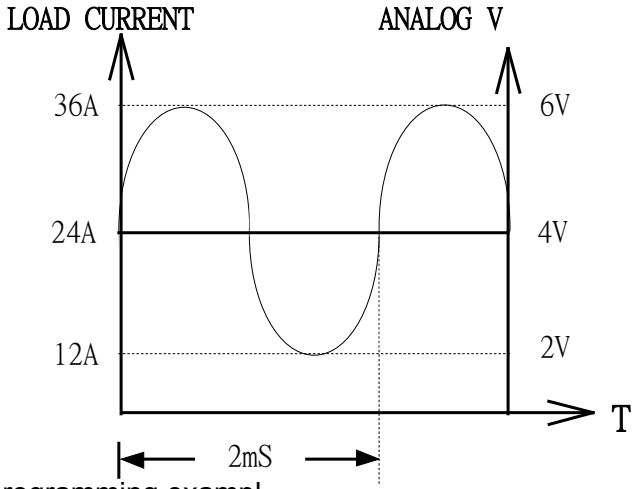


Fig 3-6 Analog programming exampl

3-3 Initial setting of 3310F series load module

The following tables detail the initial settings of the 3310F series of Load Modules when Shipped from the factory.

Item		Initial value	Item		Initial value
CC L+Preset		0.0000 A	LIMIT	V_Hi	60.000 V
CC H+Preset		0.0000 A		V_Lo	0.000 V
CR H+Preset		120000 Ω		I_Hi	30.000 A
CR L+Preset		120000 Ω		I_Lo	0.000 A
CV H+Preset		60.000 V		W_Hi	150.00 W
CV L+Preset		60.000 V		W_Lo	0.000 W
CP L+Preset		0.000W	CONFIG	SENSE	Auto
CP H+Preset		0.000W		LD-ON	1.0 V
DYN	T HI	0.050 mS		LD-OFF	0.500 V
	T L0	0.050 mS		POLAR+LOAD	
	RISE	125.0mA/uS		MPPT	2000ms
	FALL	125.0mA/uS		AVG	1
			SHORT		Disable
			OPP		Disable
			OCP		Disable

Table 3-1 3310F initialize

Item		Initial value	Item		Initial value
CC L+Preset		0.0000 A	LIMIT	V_Hi	60.000 V
CC H+Preset		0.0000 A		V_Lo	0.000 V
CR H+Preset		60000 Ω		I_Hi	60.000 A
CR L+Preset		60000Ω		I_Lo	0.000 A
CV H+Preset		60.000 V		W_Hi	300.00 W
CV L+Preset		60.000 V		W_Lo	0.00 W
CP L+Preset		0.000W	CONFIG	SENSE	Auto
CP H+Preset		0.000W		LD-ON	1.0 V
DYN	T HI	0.050ms		LD-OFF	0.500 V
	T L0	0.050ms		POLAR+LOAD	
	RISE	250mA/us		MPPT	2000ms
	FALL	250mA/us		AVG	1
			SHORT		Disable
			OPP		Disable
			OCP		Disable

Table 3-2 3311F initialize

Item		Initial value	Item		Initial value
CC L+Preset		0.0000 A	LIMIT	V_Hi	250.00 V
CC H+Preset		0.0000 A		V_Lo	0.00 V
CR H+Preset		1500 KΩ		I_Hi	12.0000 A
CR L+Preset		1500 KΩ		I_Lo	0.0000A
CV H+Preset		250.00V		W_Hi	300.00 W
CV L+Preset		250.00 V		W_Lo	0.00 W
CP L+Preset		0.000W	CONFIG	SENSE	Auto
CP H+Preset		0.000W		LD-ON	2.0 V
DYN	T HI	0.050ms		LD-OFF	0.50 V
	T L0	0.050ms		POLAR+LOAD	
	RISE	50.0mA/us		MPPT	2000ms
	FALL	50.0mA/us		AVG	1
			SHORT		Disable
			OPP		Disable
			OCP		Disable

Table 3-3 3312F initialize

Item		Initial value	Item		Initial value
CC L+Preset		0.0000 A	LIMIT	V_Hi	500.00 V
CC H+Preset		0.0000 A		V_Lo	0.00 V
CR H+Preset		3000 KΩ		I_Hi	12.0000 A
CR L+Preset		3000 KΩ		I_Lo	0.0000A
CV H+Preset		500.00V		W_Hi	300.00 W
CV L+Preset		500.00V		W_Lo	0.00 W
CP L+Preset		0.000W	CONFIG	SENSE	Auto
CP H+Preset		0.000W		LD-ON	4.0 V
DYN	T HI	0.050ms		LD-OFF	0.50 V
	T L0	0.050ms		POLAR+LOAD	
	RISE	50.0mA/us		MPPT	2000ms
	FALL	50.0mA/us		AVG	1
			SHORT		Disable
			OPP		Disable
			OCP		Disable

Table 3-4 3314F initialize

Item		Initial value	Item		Initial value
CC L+Preset		0.00000 A	LIMIT	V_Hi	60.000 V
CC H+Preset		0.00000 A		V_Lo	0.000 V
CR H+Preset		240KΩ		I_Hi	15.0000 A
CR L+Preset		240KΩ		I_Lo	0.0000A
CV H+Preset		60.000V		W_Hi	75.000 W
CV L+Preset		60.000V		W_Lo	0.000 W
CP L+Preset		0.0000W	CONFIG	SENSE	Auto
CP H+Preset		0.0000W		LD-ON	1.0 V
DYN	T HI	0.050ms		LD-OFF	0.500V
	T L0	0.050ms		POLAR+LOAD	
	RISE	62.5mA/us		MPPT	2000ms
	FALL	62.5mA/us		AVG	1
			SHORT		Disable
			OPP		Disable
			OCP		Disable

Table 3-5 3315F initialize

3-4 Input terminal and wire consideration

The Load input terminals are rated at 63A. Please note that the banana plug and spade/hook connectors provided in the accessory pack have a current rating of 20A. Please be sure to use the correct connection method if sinking high currents. There are five ways to connect the Device under Test (DUT) to the Electronic Load as detailed below.

3.4.1 Plug connectors: This is the most popular way to connect the input of electronic load to the device under test. It is recommended that the load current is less than 20A to keep within the current rating of the plug. A maximum wire gauge of AWG14 can be used in this application.

3.4.2 Spade/Hook terminals: The spade terminals provide a good contact to the binding posts. The spade terminals provided in the accessory pack are rated at 20A. The maximum wire gauge of AWG10 can be used for this connection method.

3.4.3 Insert the wire into the input terminal: Unscrewing the binding post will reveal a hole. The wire from the output of the DUT can be pushed into this hole and the binding post tightened to clamp the wire. The Maximum wire gauge is AWG14.

3.4.4 Both plug connectors and spade terminals:
It is recommended to use this method when input current is greater than 20A or if long load wires are used between the DUT and the load module.

3.4.5 Both plug connectors and Insert the wire into the input terminal.
It is recommended to use this method when the input current is greater than 20A or long wires are needed to connect the DUT to the load module.

A major consideration in making the input connection is the wire size. The minimum wire size is required to prevent overheating and to maintain good regulation. It is recommended that the wires should be large enough to limit the voltage drop to less than 0.5V per lead.

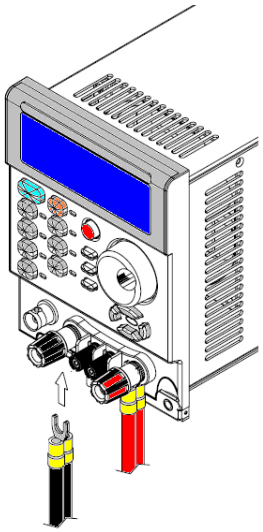


Fig 3-7 Hook Terminal Y type large size terminal connections

3.4.6 Wire/Cable Guide

The following table provides a guide to the current carrying capability (ampacity) of Both Metric and AWG sizes. Metric sizes are expressed as a cross sectional areas (CSA). If in any doubt of a cables ampacity it is recommended that you ask your Cable supplier.

Wire Size AWG	**Ampacity (A)**	**CSA (mm^2)**	**Notes:** Ratings for AWG-sized wires derived from MIL-W-5088B. Ratings for metric-sized wires derived from IEC Publication
22	**5.0**	**-----**	Ampacity of aluminium wire is approximately 84% of that listed for copper wire.
20	**8.33**	**-----**	
---	**10**	**0.75**	When two or more wires are bundled together, ampacity for each wire must be reduced to the following percentages:
18	**15.4**	**-----**	
---	**13.5**	**1**	
16		**------**	
---	**16**	**1.5**	2 conductors 94%
14	**31.2**	**-------**	3 conductors 89%
---	**25**	**2.5**	4 conductors 83%
12	**40**	**-------**	5 conductors 76%
---	**32**	**4**	
10	**55**	**------**	
---	**40**	**6**	4. Maximum temperatures:
8	**75**	**------**	Ambient = 50° C
---	**63**	**10**	Conductor = 105° C
6	**100**	**------**	
4	**135**	**------**	

Table 3-6 Stranded Copper Wire Ampere Capacity

3-5 . Protection features

The protection features of the 3310F series Electronic load modules are as follows:

3.5.1. **Overvoltage protection:** The Electronic Load input will turn OFF if the overvoltage circuit is tripped. The message OVP will be displayed on the LCD. When the OVP fault has been removed the load can be set to sink power again. While the unit will attempt to protect itself given an OVP state it is strongly advised to guard against any potential OVP fault state by using external protection and the correctly rated electronic load.

The Overvoltage protection circuit is set at a predetermined voltage and cannot be adjusted. The OVP level is 105% of the 3310Fs nominal voltage rating.

CAUTION: Never apply an AC voltage to the input of the 3310F series Load. Do not apply a DC voltage that is higher than 3310F Load Module's rating. If this advice is ignored it is likely that damage will be caused to the electronic load module. This damage will not be covered by the warranty.

3.5.2. Over current protection (OCP): The OCP protection will engage if the current being taken by the load reaches 105% of the load module's maximum current. The message OCP will be displayed on the front panel and the unit will switch to its LOAD OFF state. Once the source of the over current has been removed the load can be switched on again.

3.5.3. Over power protection (OPP): The 3310F series Electronic Load monitors the power dissipation level. The input to the load is automatically switched to LOAD OFF if the power dissipation is greater than 105% of the rated power input. If an over power condition occurs the display will show OPP

3.5.4. Over temperature protection (OTP): The load module's internal temperature at the heat sink is monitored. If the temperature reaches approximately 90°C the OTP message will be displayed and the unit will automatically switch to the LOAD OFF state. If an OTP error occurs please check the ambient temperature is between 0 to 40°C. Also ensure that the front and rear air vents of the mainframe are not obstructed. The air flow is taken from the front of the mainframe and exhausted from the rear. Therefore a suitable gap needs to be left at the rear of the mainframe. A minimum of 15cm is recommended. After a suitable cooling period the load can be switched.

3.5.5. Reverse Polarity: The 3310F series load module will tolerate a reverse current up to the maximum current rating of the load module. The '-' symbol will be shown on the voltage and current displays.

Please note that damage will occur if the reverse current is higher than the load module's maximum rating. If a reverse current is noticed turn off and disconnect the dc power source and turn the load off. The connections between the DC Source and the Load Module can now be correctly made.

If a reverse polarity situation occurs the load will sink power even if the LOAD button is OFF. No current will be displayed on the 3310F series load module. Current up to the load's maximum current rating will be tolerated in reverse polarity. However there is no OVP OCP and OPP protection. It is strongly recommended that the load lines be fused if it is likely that the load could be subject to reverse polarity. These fuses should be fast acting and rated at the maximum current of the load module +5%.

Chapter 4 Applications

This chapter details the basic operating modes along with some common applications in which the 3310F series Electronic Load modules are used.

4-1 Local sense connections

Local sensing is used in applications where the lead lengths are relatively short, or where load regulation is not critical. When connected in local sense mode the 5 digit voltage meter of the 3310F series Electronic load measures the voltage at its DC input terminals. The connecting leads between the DUT and the Electronic Load should be bundled or tie wrapped together to minimize inductance.

Fig 4-1 illustrates a typical set up with the electronic load connected to the DC power supply.

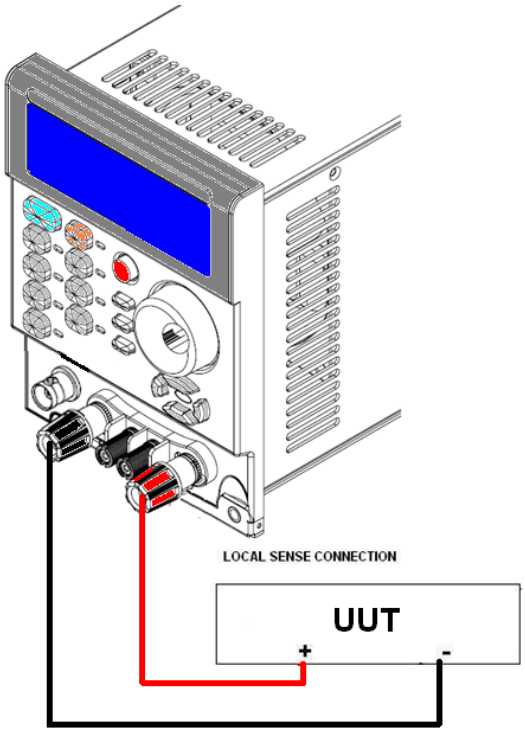


Fig 4-1 Local voltage sense connections

4-2 Remote sense connections

Remote sensing compensates for the voltage drop in applications that require long lead lengths. It is useful under low voltage high current conditions. The remote voltage sense terminals (Vs+) and (Vs-) of the load are connected to (+) and (-) output of the DC Source. Be sure to observe the correct polarity or damage may occur. The power and sense cables should be bundled or tie wrapped together to minimize inductance.

Fig 4-2 illustrates a typical set up with the electronic load connected for remote sense operation.

Please note that if V-sense is set to AUTO and the sense leads are connected to the DUT the losses need to be approx. 500mV (3310F, 3311F & 3315F) or 2.5V (3312F & 3314F) before the display compensates for the voltage loss. If V-sense is set to 'ON' and the sense terminals are connected to the DUT the load will check and compensate for all voltage drops. The maximum voltage sense compensation is the same as the rating of the 3310F. For example Vmax of 3310F is 60Vdc so maximum Vsense is also 60Vdc.

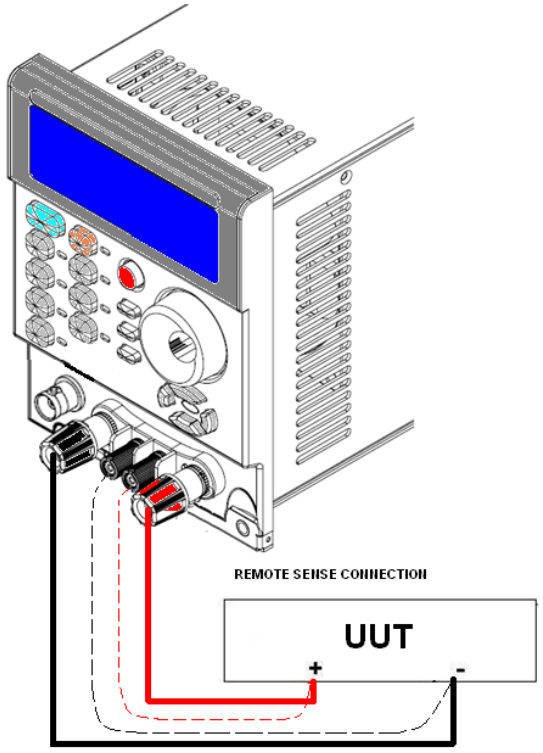


Fig 4-2 Remote voltage sense connections

4-3 Constant Current mode application

The Constant Current (CC) mode is ideal for testing the Load Regulation, Cross Regulation, Output Voltage and Dynamic Regulation of the power supply under test. The CC mode can also be used to test the Discharge Characteristics and the Life Cycle of cells and battery packs. In CC operation the 3310F can operate as a static load with switchable high and low current levels. It is also possible to operate the load dynamically enabling the user to adjust sink current with time.

4.3.1 Static mode: (Fig 4-3)

Major application areas include:

- Voltage source testing
- Power supply load regulation testing
- Battery discharge testing

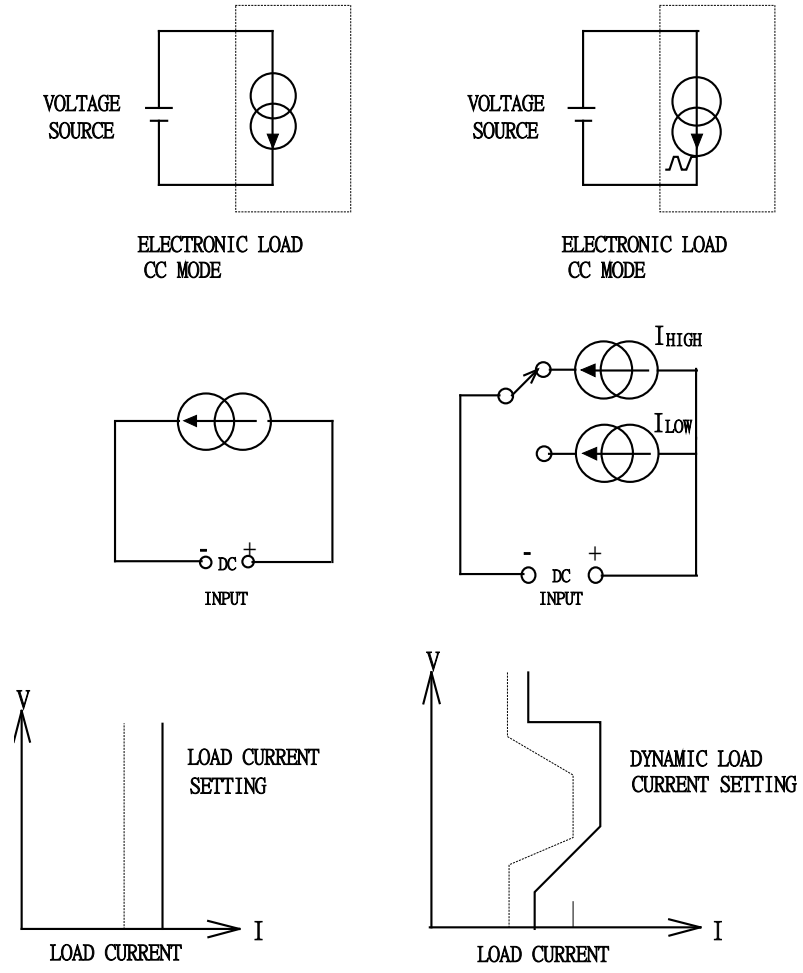


Fig 4-3 constant CURRENT mode application

4.3.2 Dynamic mode:

The built-in pulse generators allow the user to recreate real world loads that vary With time

Major application areas for dynamic operation in CC mode include:

- Power supply load transient response testing
- Power recovery time testing
- Battery Pulse load simulation
- Power component testing
- Two levels of current can be set and the rate of change between the 2 current levels can be adjusted in relation to time. The current rise (slew) rate and the current fall (slew) rate can be adjusted independently from each other and are further defined below

- Rise slew rate = | Ilow - Ihigh | / Ta (A/us)
- Fall slew rate = (Ihigh - Ilow) / Tb (A/us)
- Rise time (Ta) = (Ilow - Ihigh) / Rise slew rate
- Fall time (Tb) = (Ihigh - Ilow) / Fall slew rate

- Please see Fig 1-11 for more information on slew rates.

- The time the waveform is high (Thigh) and the time the waveform is low (Tlow) can Also be adjusted. The diagram below shows the 6 adjustable parameters that Define the dynamic waveform.

4.3.3 Analogue programming input

The analogue programming input can also be used in CC mode. The analogue programming input allows a complex dynamic waveform to be set up on an external oscillator. The 3310F series load module will track and load according to the external signal as long as it is within its dynamic capability. The input signal can be the range of 0-10V(dc+ac). The 10V is proportional to the full current capability of the load module.

More information on the analogue programming input can be seen in section 3.2.

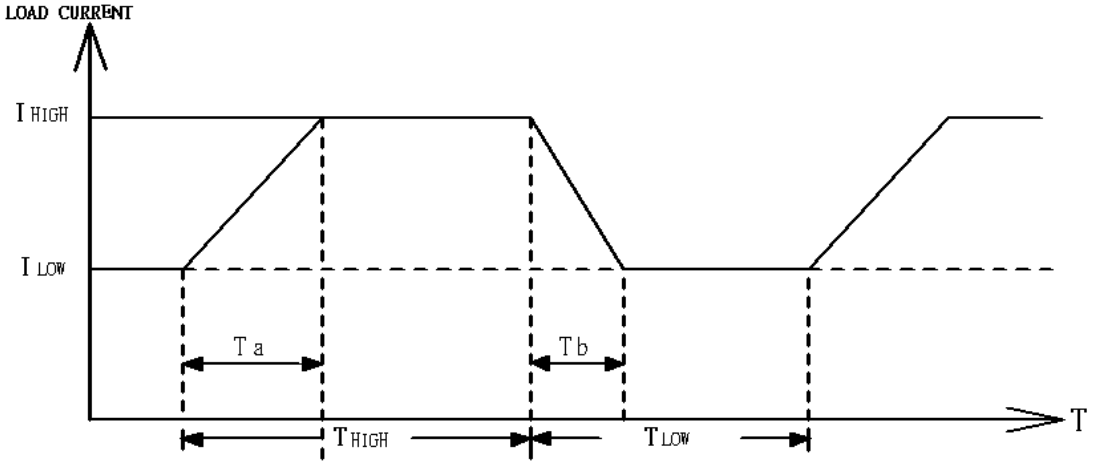
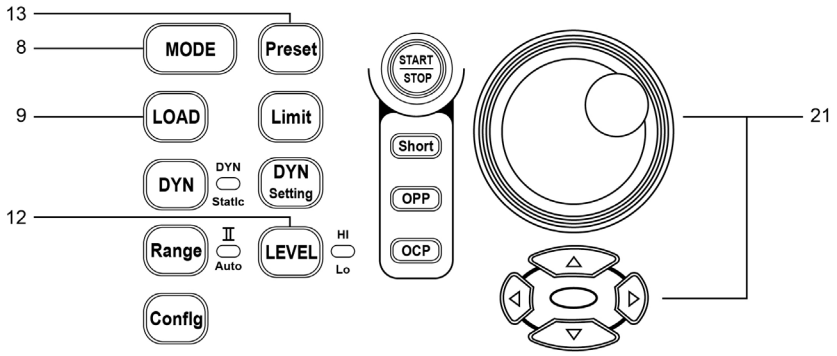


Fig 4-4 Dynamic load current with independent programmed Rise/Fall slew rate

4.3.4 CC Mode Operating Instructions



Example: PSU 5 V / 3 A, CC mode, Level HI 3.000A, Level 1.500A

4.3.4.1 . These can be selected in turn by pressing the "MODE" key (8), LCD will illuminate According to the operating mode is selected CC.

4.3.4.2 . Pressing the "Preset" Key (13) once will cause the Button to illuminate.

4.3.4.2.1. Pressing the LEVEL key (12) LED once will illuminate, Select LEVEL Hi, adjusted By The rotary knob and arrow key (21) can be read from the lower display during Setting 3.0000 A.

4.3.4.2.2. Pressing the LEVEL key (12) LED once will off, Select LEVEL Lo, adjusted by the Rotary knob and arrow key (21) can be read from the lower display during setting 1.5000A.

4.3.4.3 . Pressing the "Preset" Key (13) LED once will cause the button to off, Leave setting mode.

4.3.4.4..Pressing the “LOAD “ Key(9) LOAD button lit(Load on), Pressing the "LEVEL" key(12), LED Once will illuminate, Select is “LEVEL Hi”

4.3.4.5..Pressing the "LEVEL" key(12), LED Once will off, Select is “LEVEL Lo”

4-4 Constant Voltage mode application

In Constant Voltage (CV) operation the load will attempt to sink as much current as required in order to reach the set voltage value. CV operation is useful in checking the load regulation of dc current sources. The CV mode is also ideal for characterizing the current limit of dc power supplies. These application areas are explained a little more below.

4.4.1 Current source testing.

A common application for a dc current source is as a battery charger. Most battery chargers are designed to automatically adjust their charging current according to the battery voltage. In CV mode the electronic load will sink the current that is needed to reach the desired voltage. The CV mode is therefore ideal for checking the charge current at a particular voltage level.

If the battery charger is tested at a number of different voltage levels in CV mode a current curve can be recorded. Thus the battery charger’s load regulation can be checked during development, production and batch testing.

4.4.2 Power supply current limit characterization

The current limit is a necessary function for power supplies. The fold back current limit curve is very common for fixed output switching power supplies. The constant current limit curve is more popular for adjustable laboratory power supplies.

It is very difficult or impossible to find the current limit curve by CC or CR mode. However it becomes simple by using CV mode. The user sets the CV voltage and Records the output current. Plotting the current measurements against the voltage Settings result in the output current limit curve of a power supply (Figure 4-5).

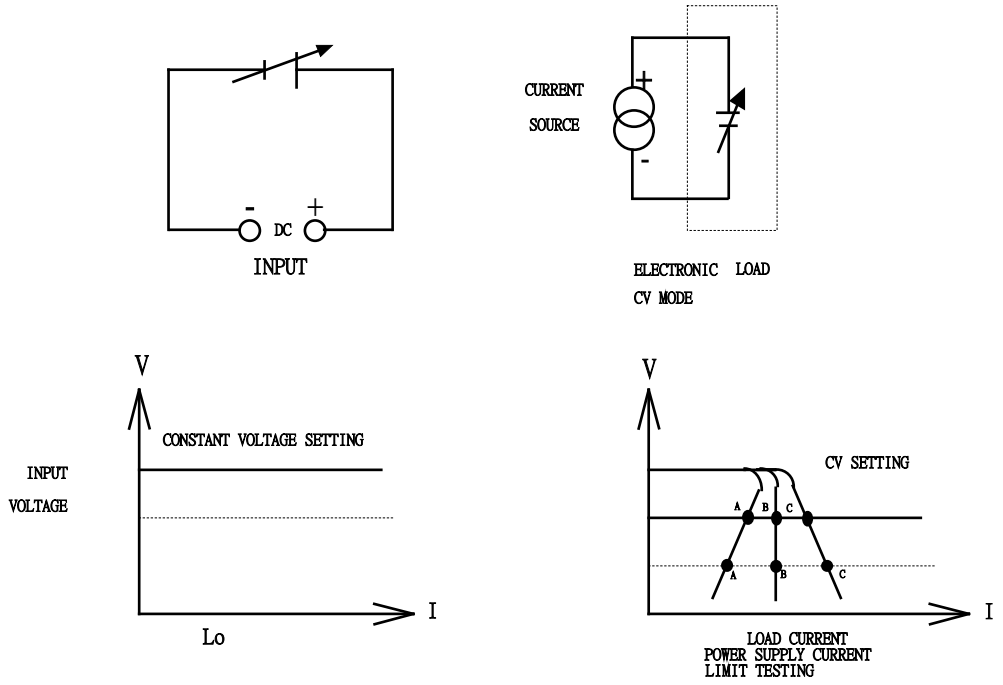
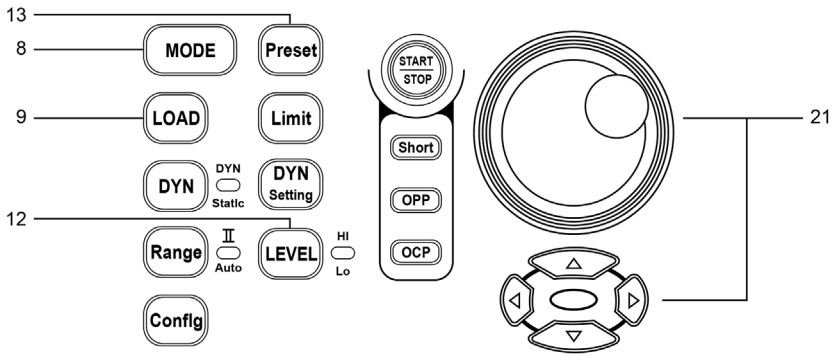


Fig 4-5 Constant Voltage mode application

4.4.3 CV Mode Operating Instructions



Example: PSU 5 V / 1A, CV mode, Level HI 4.000V, Level 3.000V

4.4.3.1. These can be selected in turn by pressing the "MODE" key (8), LCD will illuminate According to the operating mode is selected CV.

4.4.3.2. Pressing the "Preset" Key (13) once will cause the button to illuminate.

4.4.3.2.1. Pressing the LEVEL key (12) LED once will illuminate, Select LEVEL Lo, Adjusted by the rotary knob and arrow key (21) can be read from the lower Display during Setting 3.0000V.

4.4.3.2.2. Pressing the LEVEL key (12) LED once will illuminate, Select LEVEL Hi, Adjusted by the rotary knob and arrow key (21) can be read from the lower Display during Setting 4.0000V.

4.4.3.3. Pressing the "Preset" Key (13) LED once will cause the button to off, Leave setting Mode.

4.4.3.4. Pressing the “LOAD “Key (9) LOAD button lit (Load on), Pressing the "LEVEL" Key (12), LED Once will illuminate, Select is “LEVEL Hi”

4.4.3.5. Pressing the "LEVEL" key (12), LED Once will off, Select is “LEVEL Lo”

4-5 Constant Resistance mode application

Operating in Constant Resistance mode is useful for testing both voltage and current Sources. The CR mode is particularly suited for the ‘soft start’ of power supplies. This is explained in more detail below.

4.5.1 Power supply power up sequence

In constant current mode the demand at initial ‘Load ON’ of the preset current value is almost instantaneous. This might cause the Device Under Test (DUT) problems meeting the relatively high current demand at initial switch on. .

For example: A 5V/50A output power supply may not be able to deliver 50A over its entire start-up range of 0-5 volts. In many cases the power supply’s short circuit or over current protection circuit cause the power supply to shut down. This is because the power supply is trying to deliver the 50A at a voltage level that is too low.

The answer to this problem is not to use CC mode but to use CR mode instead. This is because in CR mode the current and voltage ramp up together providing a ‘soft start’ when compared to standard CC mode.

However please note that with the 3310F series of Electronic Loads allow an adjustable current ramp can be set. This feature is found within the dynamic settings as RISE slew rate. Even in static mode the 3310F load will regulate its current demand at ‘Load ON’ in line with the adjusted RISE slew rate. The FALL slew rate also in the dynamic settings allows the current ramp down to be controlled at ‘Load OFF’.

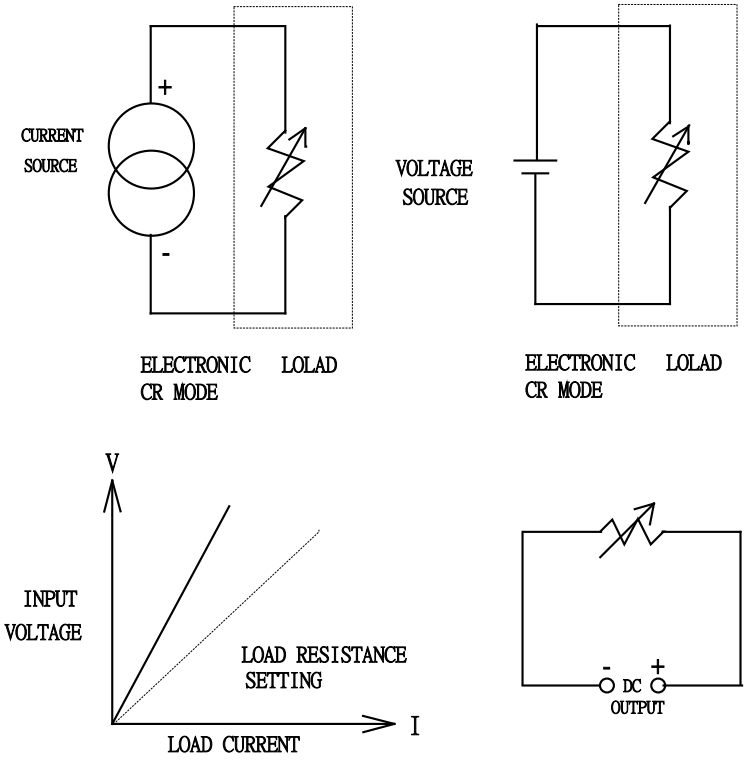
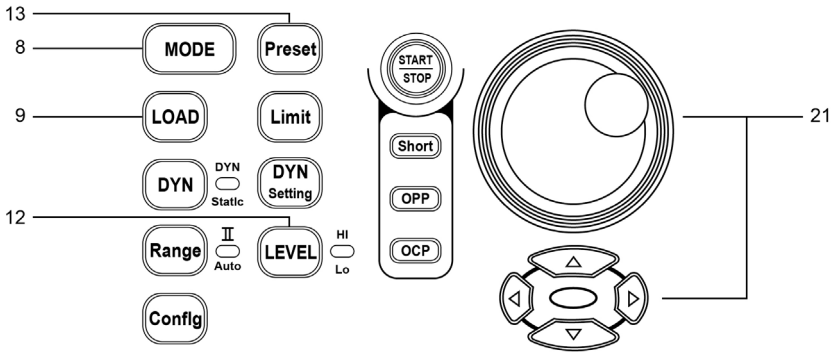


Fig 4-6 Constant Resistance mode Application

4.5.2 CR Mode Operating Instructions



Example: PSU 5 V / 3 A, CR mode, Level HI 2.0 Ohm, Level Lo 4.0 Ohm

4.5.2.1. These can be selected in turn by pressing the "MODE" key (8), LCD will illuminate According to the operating mode is selected CR

4.5.2.2. Pressing the "**Preset**" Key (13) once will cause the button to illuminate.

4.5.2.2.1. Pressing the LEVEL key (12) LED once will illuminate, Select LEVEL Hi, Adjusted by the rotary knob and arrow key (21) can be read from the lower Display during Setting 2.0000Ω.

4.5.2.2.2. Pressing the LEVEL key (12) LED once will illuminate, Select LEVEL Lo, Adjusted by the rotary knob and arrow key (21) can be read from the lower Display during Setting 4.0000Ω.

4.5.2.3. Pressing the "Preset" Key (13) LED once will cause the button to off, Leave setting Mode.

4.5.2.4. Pressing the “LOAD “Key (9) LOAD button lit (Load on), Pressing the "LEVEL" Key (12), LED Once will illuminate, Select is “LEVEL Hi”

4.5.2.5. Pressing the "LEVEL" key(12), LED Once will off, Select is “LEVEL Lo”

4-6 Constant Power mode application

4.6.1. Battery Evaluation

Primary or secondary batteries are the power source for a wide range of portable electronics products, such as notebook computers, video cameras and mobile phones. To ensure long usage times and customer satisfaction the battery pack should be able to provide a constant power for the longest time possible.

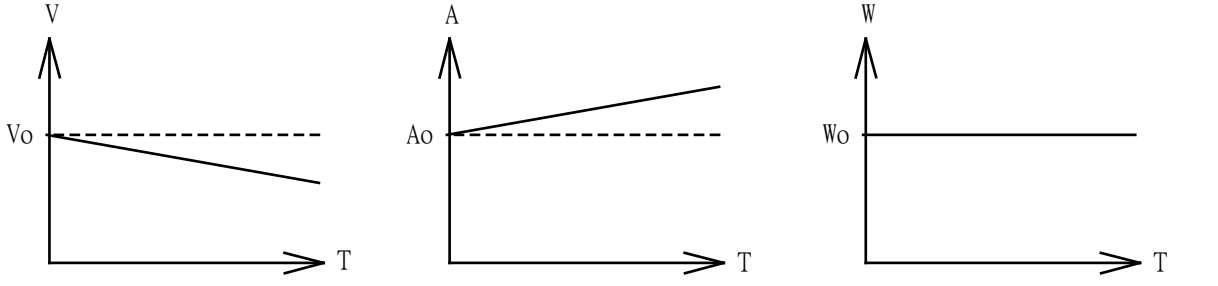
It can be measured that the output voltage of a battery will drop over time (Fig 4-7a). The rate of voltage decay depends on a number of factors including duty cycle, chemistry type, battery age and ambient temperature.

So to keep the device powered for the longest possible time the battery must be able to provide a stable power output regardless of output voltage (Fig 4-7c). In order to maintain a constant power the output current will need to increase over time to compensate for the reducing voltage (Fig 4-7b).

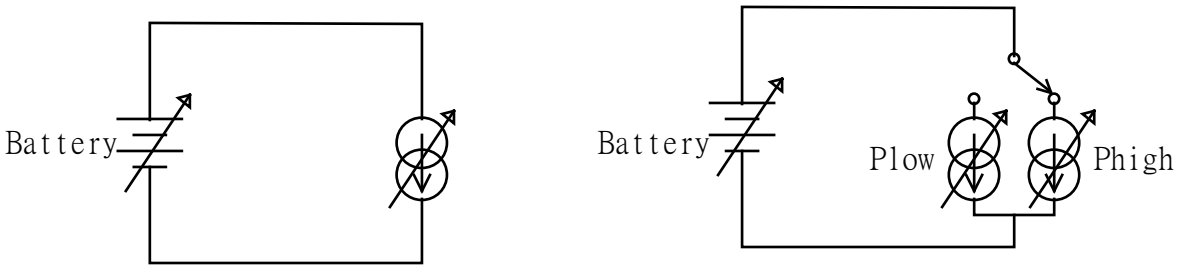
Operating the 3310F series electronic load in CP mode is ideal for testing the characteristics of a battery. This is because as the battery voltage drops the load current will automatically increase in order to keep the CP setting. By logging sink values against time the test engineer can also measure the battery's energy capacity at various discharge rates.

The 3310F also features an adjustable Load OFF setting. This allows a voltage level to be set so that the electronic load automatically stops sinking power upon reaching this preset voltage. This can be used to ensure the battery is not subjected to a damaging deep discharge.

Along with static operation the load can also be operated dynamically in CP mode. The dynamic functions allow the ramp, fall and plateau times to be adjusted between 2 levels of power. This capability means that 'real world' loads can be more accurately simulated. For example the dynamic mode could be used to test the performance of a battery that is required to provide power pulses to transmit data from a radio frequency terminal.



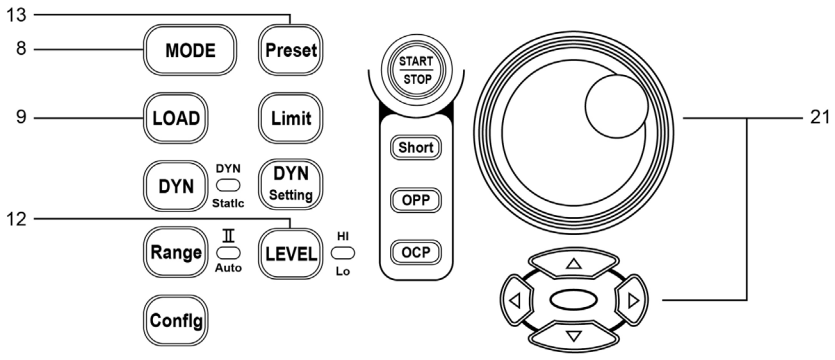
(a) The output voltage of battery (b) The output current of battery (c) The output power of battery



(d) Constant Power Mode (STATIC) (e) Constant Power Mode (DYNAMIC)

Fig 4-7 CONSTANT POWER MODE APPLICATION

4.6.2. CP Mode Operating Instructions



Example: PSU 5 V / 3 A, CC mode, Level HI 10.00W, Level 5.000W

4.6.2.1. These can be selected in turn by pressing the "MODE" key (8), LCD will illuminate According to the operating mode is selected CP.

4.6.2.2. Pressing the "Preset" Key (13) once will cause the button to illuminate.

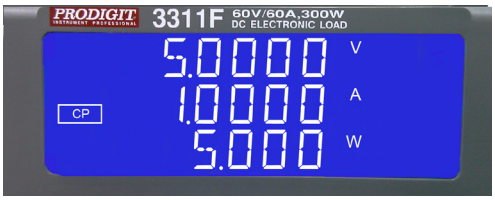
4.6.2.2.1. Pressing the LEVEL key (12) LED once will illuminate, Select LEVEL Hi, Adjusted by the rotary knob and arrow key (21) can be read from the lower Display during Setting 10.000W.

4.6.2.2.2. Pressing the LEVEL key (12) LED once will illuminate, Select LEVEL Hi, Adjusted by the rotary knob and arrow key (21) can be read from the lower Display during Setting 5.000W.

4.6.2.3. Pressing the "Preset" Key (13) LED once will cause the button to off, Leave setting Mode.

4.6.2.4. Pressing the “LOAD “Key (9) LOAD button lit (Load on), Pressing the "LEVEL" Key (12), LED Once will illuminate, Select is “LEVEL Hi”.

4.6.2.5. Pressing the "LEVEL" key (12), LED Once will off, Select is “LEVEL Lo”.



4-7 The connection of a multiple output power supply

The following is a rule for a multiple output power supply connects to the 3310F series Electronic Loads.

Rule: The potential of positive input (Red binding post) must be higher than the potential of negative input (Black binding post) of 3310F series Electronic load.

Here is an example of +5V, -5V, +12V and -12V four outputs power supply connected to a 3310F series electronic load

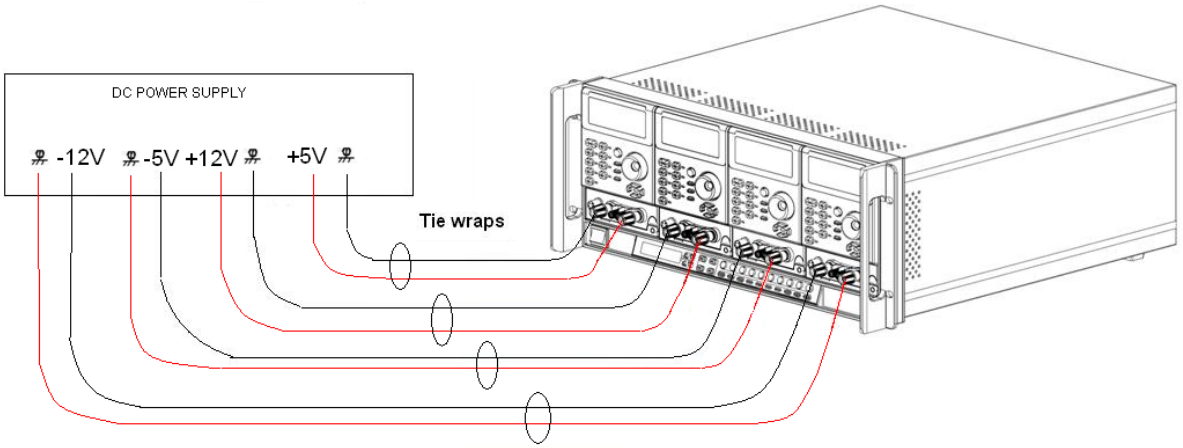


Fig 4-8 Connection between 3310F series plug-in load and multiple output power supply

4-8 Parallel operation

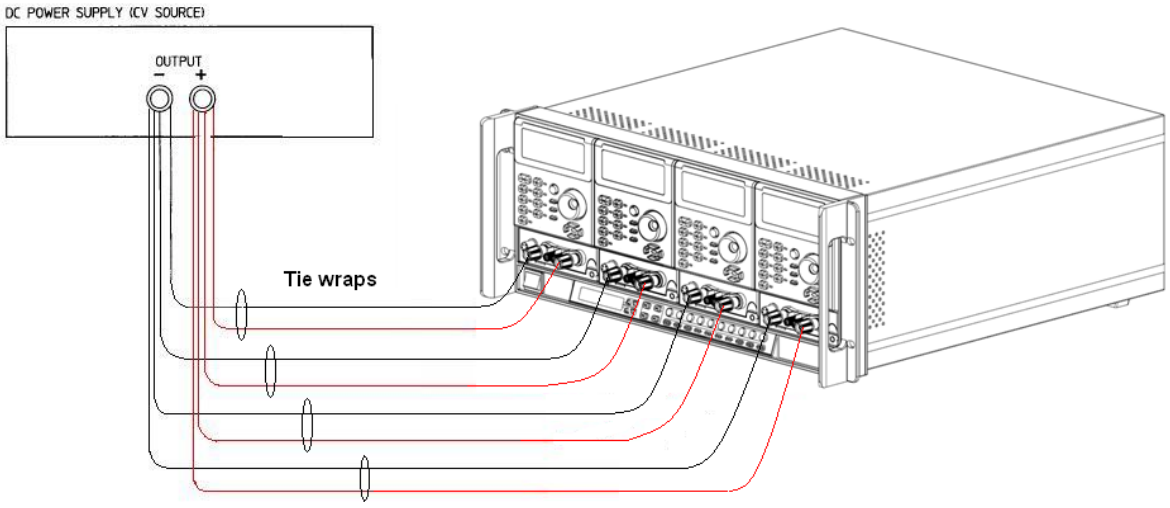
It is possible to operate load modules in parallel if the power and/or current capability of a single 3310F series load module is not sufficient.

The positive and negative outputs of the power supply are connected individually to each load module as shown in the Fig 4-9 below. The setting is made at each individual load module. The total load current is the sum of the load currents being taken by each module.

It is permitted to operate 'F' series load modules with different voltage, current and power ratings to sink in parallel. For example the 4 loads modules shown in Fig 4-9 could be a mixture of 3311F, 3314F, 3332F and 3340F.

While in static mode the load modules can be set to operate in CC, CR or CP. When using multiple loads to sink power from a single DC Source it is not permissible to operate in dynamic mode.

Note: 1. the electronic load only may carry on the parallel operation under the fixed electric current pattern.
2. The electronic load do not use under series connection.



I=I1+I2+I3+I4

Fig 4-9 3310F series plug-in module parallel operation

4-9 Zero-Volt loading application

As shown in Fig 4-10, the Electronic load can be connected in series with a DC voltage source which output voltage greater than 0.6V (3310F,3311F), 1V (3312F), 6V(3314F) or 0.3V(3315F) so that the device under test that are connected to the Electronic load can be operated down to a Zero- Volt condition, the DC voltage source provides the minimum 0.6V (3310F,3311F), 1V (3312F), 6V(3314F) or 0.3V(3315F) operating voltage required by the Electronic load. This application is suitable for low voltage Battery cell with high discharge current testing.

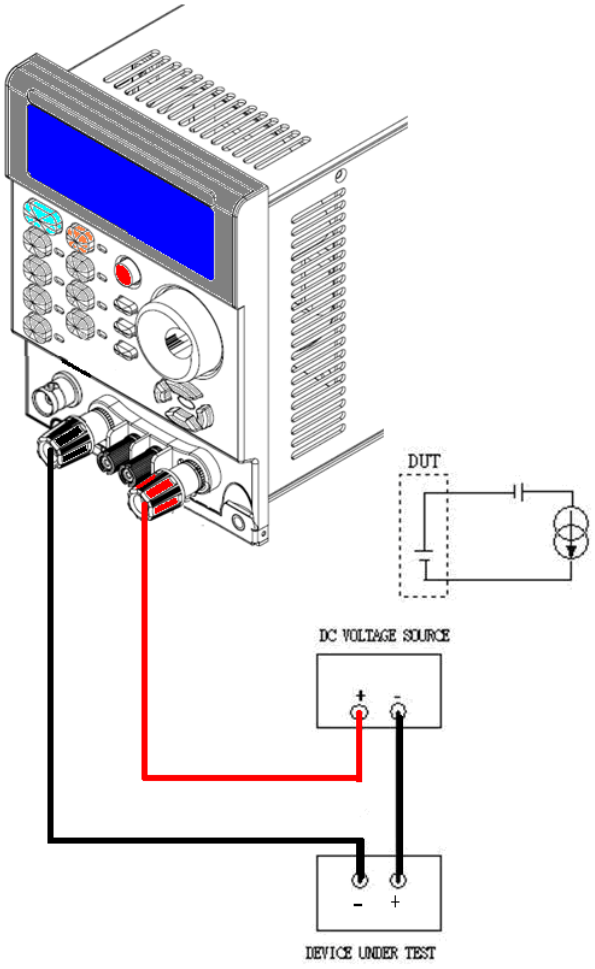


Fig 4-10 Zero-Volt loading connection

4-10 3310F series electronic load OCP, OPP, SHORT operation flow Chart

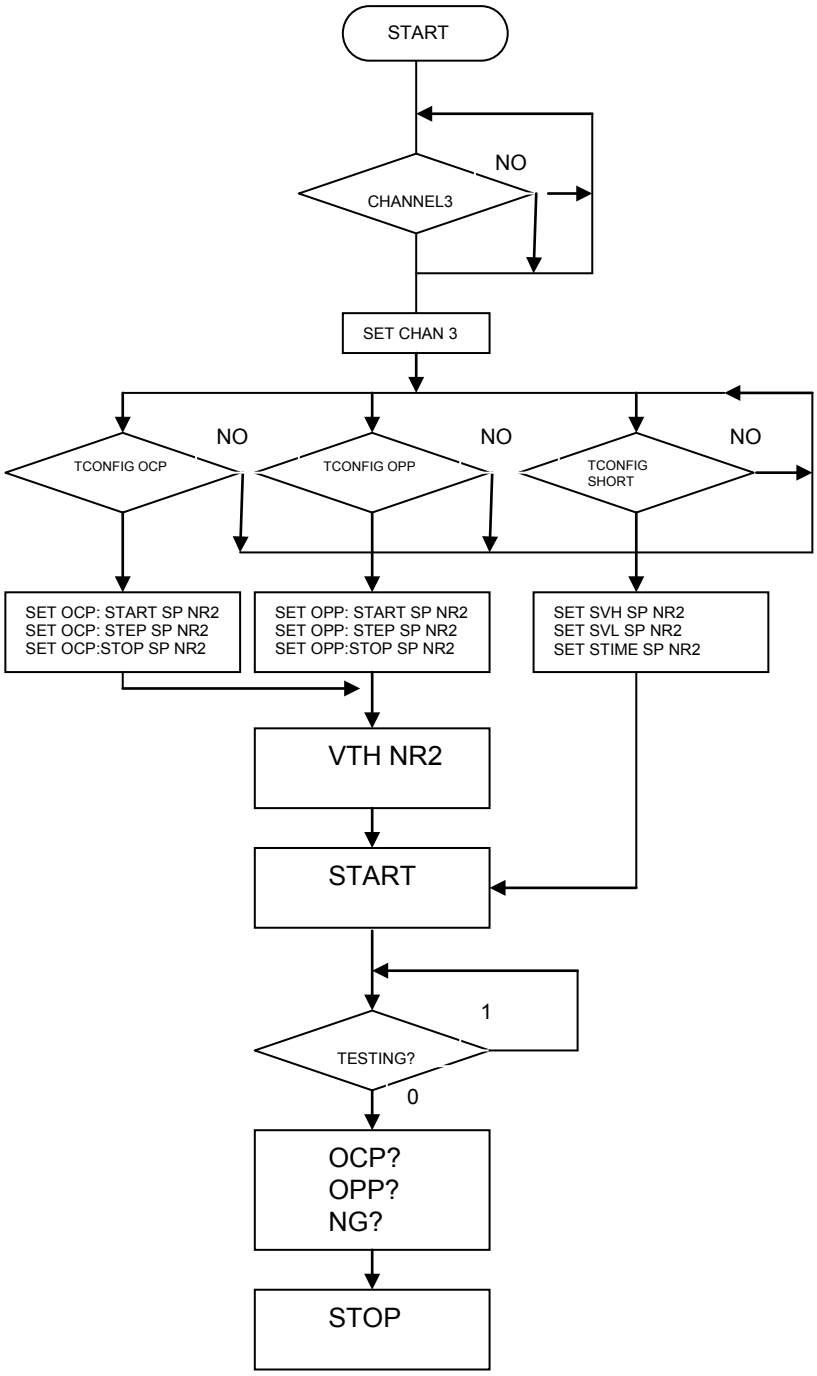


Fig 4-11 3310F series electronic load OCP, OPP, SHORT operation flow chart

4-11 Power Supply OCP testing

4.11.1 OCP Manual control

Example:

4.11.1.1. First, press Limit Key function to setting I_Hi 6A.

4.11.1.2. Press Limit Key function to setting I_Lo 0A.

4.11.1.3. Setting OCP test, press OCP key to the next step.

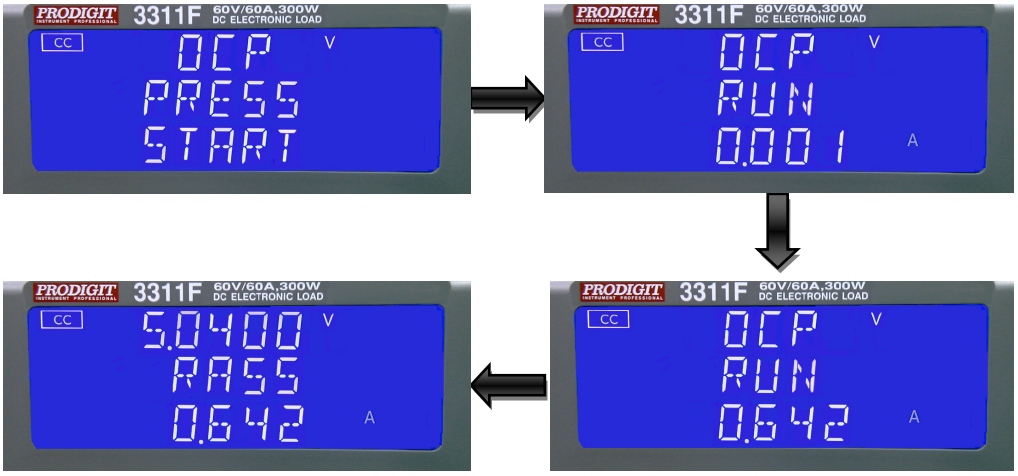
4.11.1.4. Setting start load current 0A, press OCP key to the next step.

4.11.1.5. Setting step load current 0.001A, press OCP key to the next step.

4.11.1.6. Setting stop load current 0.65A, press OCP key to the next step.

4.11.1.7. Setting OCP VTH 0.600V, press OCP key to the next step.

4.11.1.8. Press START/STOP test key.



4.11.1.9. the UUT's output voltage drop-out lower than the threshold voltage(V-th setting), and the OCP trip point is between I_Hi and I_Lo limitation, then middle 5 digits LCD display will shows "PASS", otherwise shows "FAIL".

4.11.2 Remote control OCP

EX :

REMOTE	(Set Remote)
TCONFIG OCP	(Set OCP test)
OCP:START 0.1	(Set start load current 0.1A)
OCP:STEP 0.01	(Set step load current 0.01A)
OCP:STOP 2	(Set stop load current 2A)
VTH 3.0	(Set OCP VTH 3.0V)
IL 0	(Set current low limit 0A)
IH 2	(Set current high limit 2A)
NGENABLE ON	(Set NG Enable ON)
START	(Start OCP testing)
TESTING?	(Ask Testing? 1：Testing，0：Testing End)
NG?	(Ask PASS/FAIL?，0：PASS，1：FAIL)
OCP?	(Ask OCP current value)
STOP	(Stop OCP testing)

4-12 Power Supply OPP testing

4.12.1 OPP Manual control

Example:

4.12.1.1. First, press Limit Key function to setting W_Hi 30.00W..

4.12.1.2. press Limit Key function to setting W_Lo 0W..

4.12.1.3. Setting OPP test, press OPP key to the next step.

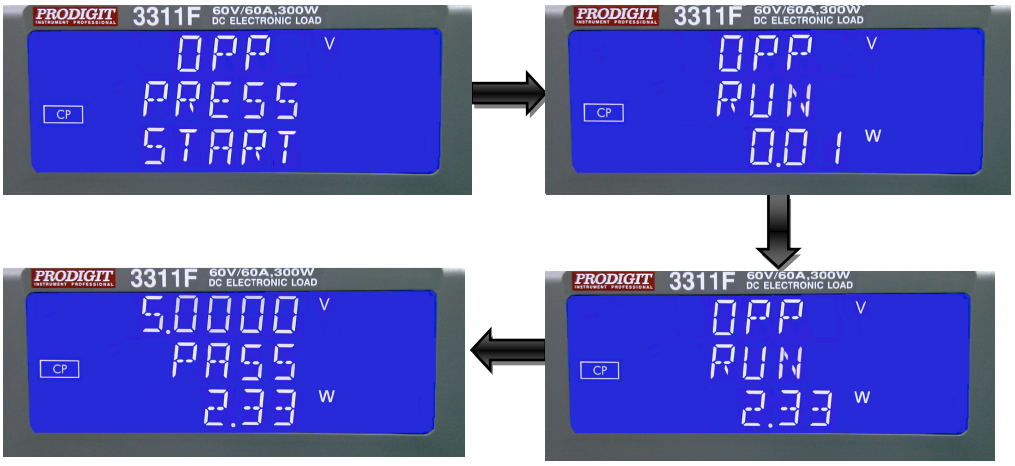
4.12.1.4. Setting start load watt 0W, press OPP key to the next step.

4.12.1.5. Press up key, set step load watt 0.01W, press OPP key to the next step.

4.12.1.6. Press up key, set stop load watt 3.25W, press OPP key to the next step.

4.12.1.7. Setting OPP VTH 0.600V，press OPP key to the next step.

4.12.1.8. Press START/STOP Test key.



4.12.1.9. the UUT's output voltage drop-out lower than the threshold voltage (V-th setting), and the OPP trip point is between W_Hi and W_Lo limitation, then lower 5 digits LCD display will shows "PASS", otherwise shows "FAIL".

4.12.2 Remote control OPP

EX ：

REMOTE	（Set Remote）
TCONFIG OPP	（Set OCP test）
OPP:START 3	（Set start load watt 3W）
OPP:STEP 1	（Set step load watt 1W）
OPP:STOP 5	（Set stop load watt 5W）
VTH 3.0	（Set OPP VTH 3.0V）
WL 0	（Set watt low limit 0W）
WH 5	（Set watt high limit 5W）
NGENABLE ON	（Set NG Enable ON）
START	（Start OPP testing）
TESTING?	（Ask Testing? 1：Testing，0：Testing End）
NG?	（Ask PASS/FAIL?，0：PASS，1：FAIL）
OPP?	（Ask OPP watt value）
STOP	（Stop OPP testing）

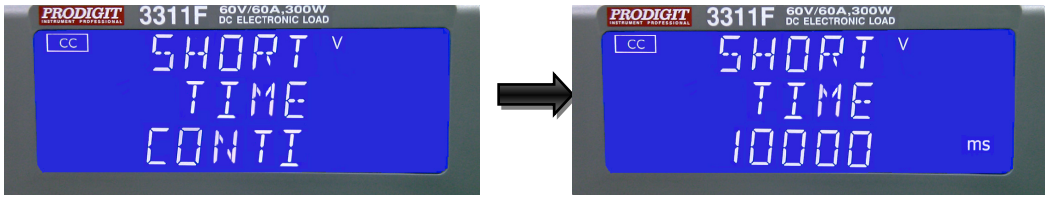
4-13 SHORT testing

4.13.1. SHORT Manual control

Example:

4.13.1.1. Setting SHORT test, press Short key to the next step.

4.13.1.2. Press UP key, setting Short time to 10000ms, press Short key to the next Step.



4.13.1.3. Press down key, setting V-Hi voltage to 1.000V, press Short key to the next Step.

4.13.1.4. Press down key, setting V-Lo voltage to 0V, press Short key to the next Step.

4.13.1.5. Press START/STOP test key.

4.13.1.6. Short test finish, the UUT's drop voltage is between V_Hi and V_Lo limitation, then middle 5 digits LCD display will shows "PASS"

4.13.1.7. The UUT's not drop voltage is between V_Hi and V_Lo limitation, LCD display will shows FAIL.

4.13.2. Remote control SHORT

EX :

REMOTE	(Set Remote)
TCONFIG SHORT	(Set SHORT test)
STIME 1	(Set short time 1ms)
START	(Start SHORT testing)
TESTING?	(Ask Testing? 1：Testing，0：Testing End)
STOP	(Stop SHORT testing)