



OPERATING AND MAINTENANCE MANUAL

Product: ***Primary Current Injection System***

Type: ***PCU1-SP mk3***



DESIGNED AND MANUFACTURED BY:

T & R Test Equipment Limited

15-16 Woodbridge Meadows, Guildford, Surrey, GU1 1BJ, United Kingdom

Telephone: 01483 207428

e-mail: sales@trtest.com

Web: www.trtest.com

GENERAL SAFETY STATEMENT



WARNING

The following safety precautions should be reviewed to avoid injury to the user and damage to the product (and other products connected to it). To avoid potential hazards only use this product as specified.

- **Only suitably qualified personnel should use this equipment. Servicing of this product should only be carried out by suitably qualified service personnel.**

To Avoid Fire Hazards and Personal Injury

- Use the correct power supply lead. Only use a suitably rated and approved power supply lead for the country of use.
- Ensure that systems that the unit is to be connected to are isolated from the supply and earthed.
- Do not connect and disconnect leads whilst outputs are switched on. Breaking the output circuit with current flowing may cause potentially fatal arcing.
- Ensure that the product is grounded. To avoid electric shock it is essential that the grounding conductor is connected to the earth ground. An additional earth terminal is provided on the unit that should be connected to a local earth. Ensure that the unit is properly grounded before making any connections to inputs or outputs.
- Terminal ratings must be observed to prevent fire hazards and risk of injury to the operator. Consult the product manual for ratings information before making connections to any terminal.
- It is ESSENTIAL to consult the product manual for rating information before making any connection to a terminal or terminal group marked with a warning triangle.
- Only use fuses of a type and rating specified for this product.
- Do not operate the unit out of its case or with any covers or panels removed.
- Do not touch exposed connections and components when power is present.
- Do not operate the product if any damage is suspected. Refer the unit to qualified service personnel to be checked.
- Do not operate the unit in wet or damp conditions
- Do not operate the unit in an explosive atmosphere
- The PCU1-SP systems have a very high output current (up to 10kA), and therefore generate large magnetic fields around the output leads and loading transformer. Care must be taken in siting the unit next to items sensitive to magnetic fields (such as computer monitors and other sensitive equipment).
- Warnings from cardiac pacemaker manufacturers state that strong magnetic fields may affect operation. Any high current unit such as the PCU1-SP should therefore not be operated by, or in the vicinity of persons fitted with cardiac pacemakers or any other electronic or electrical medical implants.

If any further queries occur regarding the usage and maintenance of the equipment detailed in this manual, please refer these to the supplier of the equipment in the first case or to the manufacturer, T & R Test Equipment Limited.

SAFETY TERMS AND SYMBOLS

The following safety symbols appear on the equipment:



CAUTION/WARNING – Refer to manual



HOT – Refer to manual



Mains off



Mains on

The following safety symbols appear in this manual:



CAUTION

This action or procedure may be dangerous if not carried out correctly and may cause damage to the equipment or connected equipment.



WARNING

This action or procedure may cause injury or death to the operator or other personnel if not carried out correctly using applicable safety procedures.



HOT

Parts of the unit may become hot during use, particularly when operating at high currents

CONTENTS

1.	DESCRIPTION OF EQUIPMENT	9
1.1	Control Unit Front Panel Layout and Functions	10
1.2	Loading Unit Front Panel Layout	12
1.2.1	NLU2000 & NLU5000	12
1.2.2	NLU200	13
1.3	Electrical Specification	14
1.3.1	Supply Requirements	14
1.3.2	Loading Unit Outputs	15
1.3.3	Secondary Injection Output	16
1.3.4	Metering	16
1.3.5	Timing System	18
1.3.6	Storage of results	18
1.4	Displayed Values and Messages	23
1.4.1	Displayed Values	23
1.4.2	Warning Messages	23
1.5	Primary Current Injection Lead Sets	25
1.5.1	Description	25
1.5.2	Factors Affecting Maximum Output Current	26
1.5.3	Lead Set Voltage Drops	27
1.5.4	Unit Output Voltage Under Load	27
1.6	Overload Protection	28
1.7	Construction	28
1.8	Installation	29
2.	OPERATION	30
2.1	Primary Current Injection with Loading Unit	30
2.1.1	Connections	30
2.1.2	Testing	31
2.1.3	After Testing	31

2.2	Secondary Current Injection	32
2.2.1	Connections	32
2.2.2	Testing	32
2.2.3	After Testing	33
2.3	Timing System	33
2.3.1	Timer Modes	34
2.3.2	General Procedure for Timing Tests	35
3	APPLICATION NOTES – TESTING SPECIFIC DEVICES	37
3.1	Secondary Injection of an Over-Current Relay	37
3.1.1	Timer Mode	37
3.1.2	Connections	37
3.1.3	Test Procedure	37
3.2	Primary Injection of an Over-Current Relay	38
3.2.1	Timer Mode	38
3.2.2	Connections	38
3.2.3	Test Procedure	38
3.2.4	Using Pulse Mode to Set the Current	38
3.3	Timing of Auto-reset/Reclosing Devices	39
3.3.1	Timer Mode	39
3.3.2	Connections	39
3.3.3	Test Procedure	39
3.4	Timing Devices with NO Auxiliary Contacts	40
3.4.1	Timer Mode	40
3.4.2	Connections	40
3.4.3	Test Procedure	40
3.5	Using the Control Unit as a Single Contact Timer	41
3.5.1	Timer Mode	41
3.5.2	Connections	41
3.5.3	Test Procedure	41
3.6	Using the Control Unit as a Dual Contact Timer	41
3.6.1	Timer Mode	41

3.6.2	Connections	41
3.6.3	Test Procedure	41
3.7	CT Polarity	42
3.7.1	Modes & Settings	42
3.7.2	Connections	42
3.7.3	Test Procedure	42
3.8	CT Ratio	43
3.8.1	Modes & Settings	43
3.8.2	Connections	43
3.8.3	Test Procedure	43
4.	MAINTENANCE	45
4.1	Output Control Brushes	45
4.2	Removal of the PCU1-SP from Case	45
4.3	Warranty	45
5.	STANDARD ACCESSORIES	47
5.1	Spare Fuses Supplied:	47
5.2	Standard Accessories Supplied:	47
6.	OVERALL PERFORMANCE SPECIFICATION	49
6.1.	Insulation Resistance at 1000V DC	49
6.2.	Applied Voltage Test	49
6.3.	Accuracy of Instruments	49
6.3.1	Loading Unit Current Output	49
6.3.2	Secondary Injection Current Output	50
6.3.3	Auxiliary Metering Input	50
6.3.4	Timing System	50
7.	REVISION	51

1. DESCRIPTION OF EQUIPMENT

The PCU1-SP series are medium powered primary current injection systems offering output currents up to 5000A. The system consists of a separate control unit containing all metering and control functions and a loading unit that provides the high current output. The PCU1-SP mk3 is ideally suited to primary current injection, stability testing and circuit breaker testing. In addition, the SP version offers direct-reading CT ratio and polarity tests and a 100A secondary injection output.

All references to the PCU1-SP in this manual refer to the PCU1-SP mk3.

Three loading units are available, delivering a maximum output current of 200A, 2000A or 5000A. Each loading unit has two or three output taps to allow for a wide range of load impedances. For example, the NLU5000 may be configured to either give a maximum current of 5000A on the 2.3V range, 2500A on the 4.6V range or 1250A on the 9.2V range.

The control units are rated at 11.5kVA. All metering is digital, and a memory facility is provided to hold the current reading when the output trips or is switched off. The current is thyristor controlled and is automatically switched off when the device under test trips.

The PCU1-SP systems have a high accuracy timing system, allowing timing tests to be carried out to a resolution of 1ms. Selection for normally open or normally closed contacts is automatic, and the status of the contacts is shown on the front panel.

Timing modes are available to test under and over current devices, re-closers, under and over voltage devices, current trips and circuit breakers. A full range of high current output leads are available to complement the system in a range of lengths.



WARNING

The PCU1-SP and associated loading units are designed to be used on 'dead' systems (i.e. no externally supplied voltages are present on the test object). Under no circumstances connect a PCU1-SP to a live system. Always check that the power to the device under test is off and the circuit is isolated and earthed before making any connections.

1.1 Control Unit Front Panel Layout and Functions

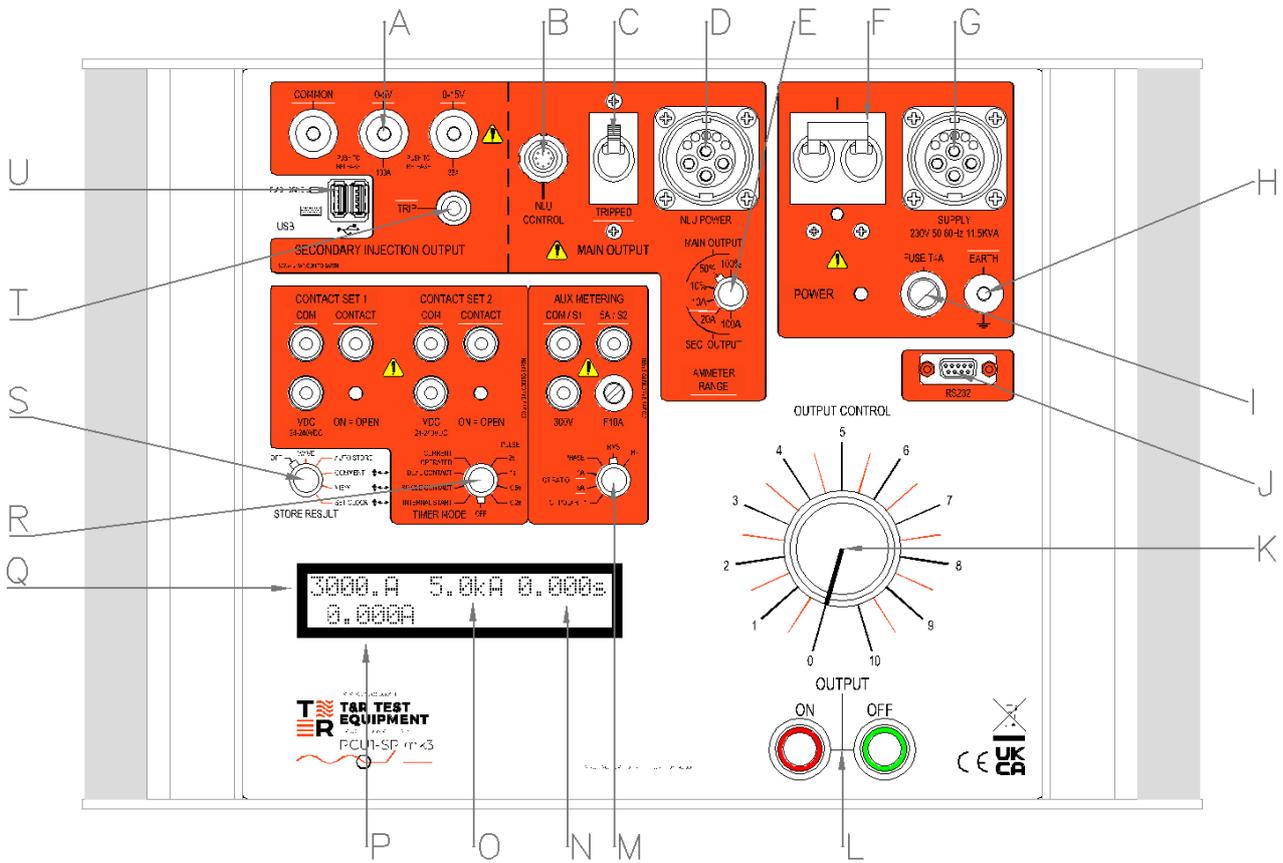


Figure 1.1 PCU1-SP mk3 front panel layout

ITEM	FUNCTION	
A	Secondary Injection Output	0-100A Secondary injection output
B	NLU metering connection	Metering/control connection to loading unit
C	Output circuit breaker	Protection for primary current output
D	Loading unit power connector	Power supply to loading unit
E	Metering range/output selection switch	Selects between outputs on PCU1-SP (primary/secondary injection) and metering range
F	Mains input switch/circuit breaker	Supply isolation switch and protection
G	Mains inlet connector	Mains supply connection
H	Earth terminal	Connect to local earth.
I	Fuse	Fuse for metering and control circuits
J	RS232 connector	Serial connection for calibration purposes

K	Main output control	Sets output current
L	Output on and off pushbuttons	Switch output on and off and indicate output state
M	Auxiliary metering inputs	Voltage and current input for auxiliary metering circuit
N	Timer display	Display of timer value
O	Metering range display	Full scale of current metering range for primary injection
P	Auxiliary metering display	Display of selected auxiliary meter value
Q	Current display	Output current
R	Timer inputs and selector	Timer mode selection switch and contact inputs
S	Storage selector	Clock set and storage mode selection switch for creating comments and storing results
T	Output trip	Secondary current injection circuit breaker
U	USB Sockets	For USB storage device and USB keyboard

1.2 Loading Unit Front Panel Layout

The PCU1-SP system is available with a range of optional loading units and output lead sets.

The loading unit is connected to the control unit using a metering cable and a power cable. Three output taps are provided for connection to the load. The load is connected between the common terminal and one of the output taps.

1.2.1 NLU2000 & NLU5000

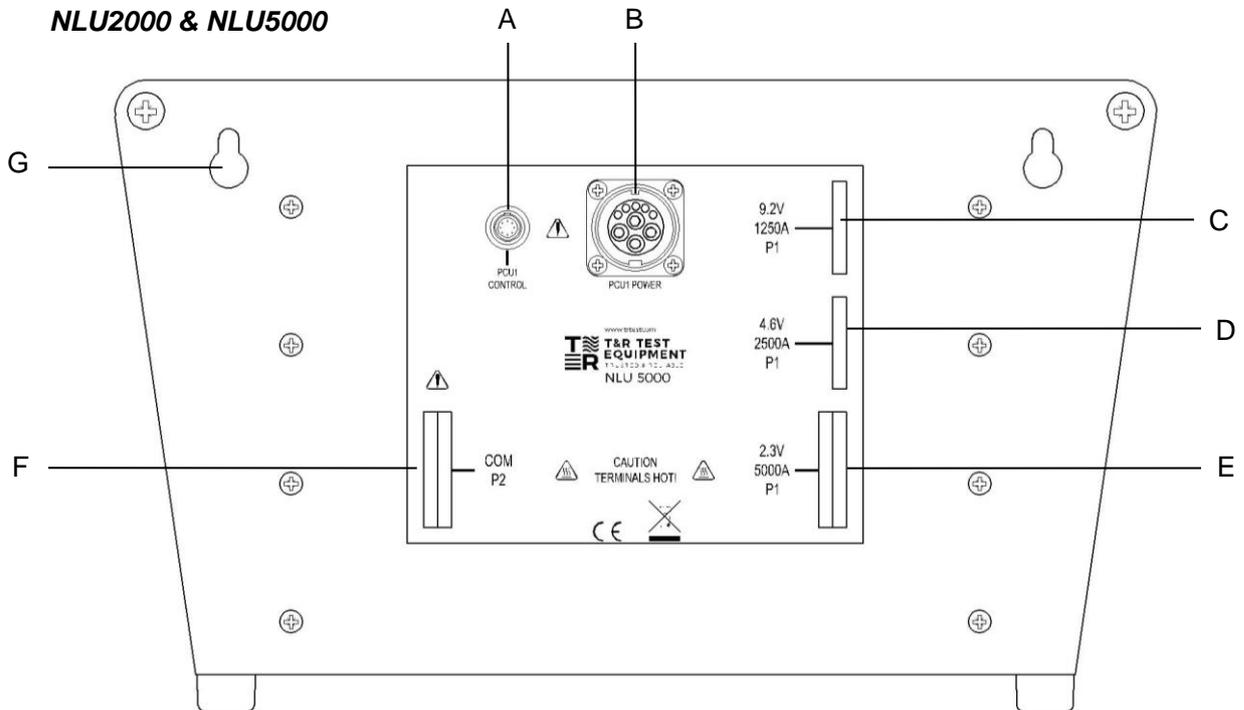
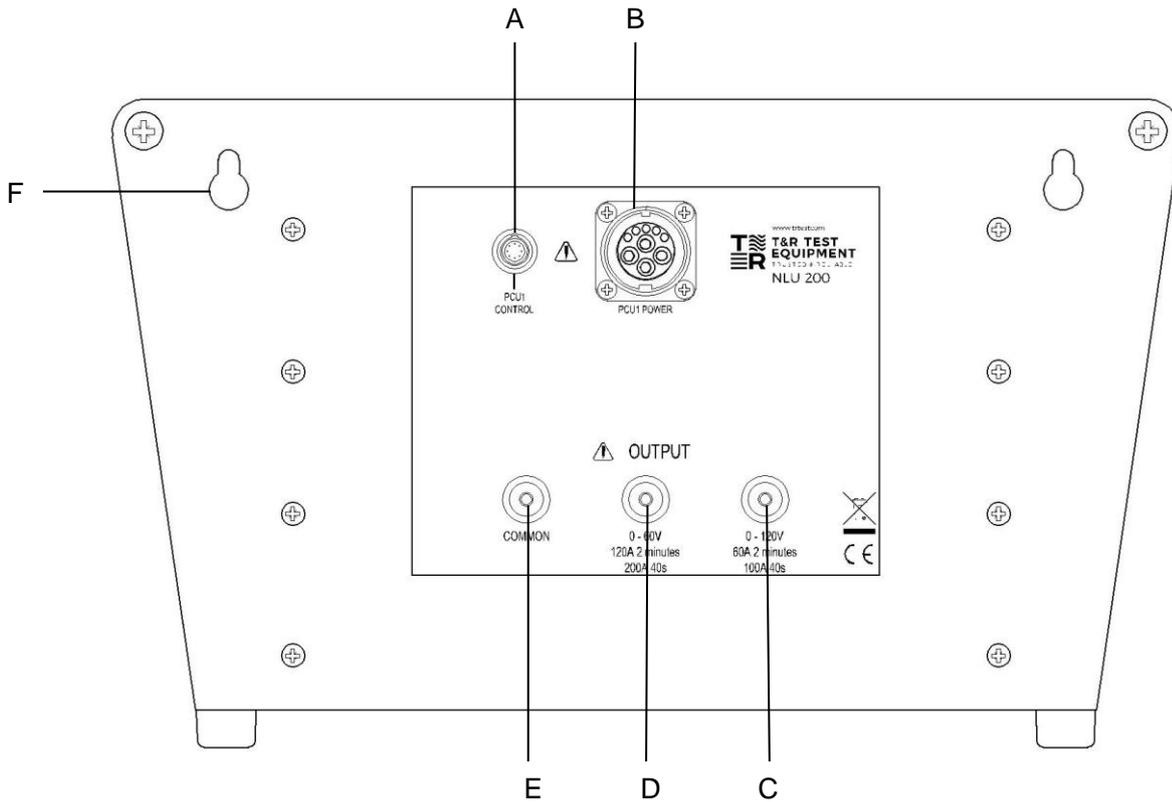


Figure 1.3 Loading unit front panel

	ITEM	FUNCTION
A	PCU1-SP metering connection	Metering/control connection to control unit
B	Power connector	Power supply from control unit
C	Tap 3 output	Highest voltage, lowest current output (1250A 9.2V on NLU5000)
D	Tap 2 output	Highest voltage, lowest current output (2500A 4.6V on NLU5000)
E	Tap 1 output	Highest voltage, lowest current output (5000A 2.3V on NLU5000)
F	Common output	Output common terminal. One of the output leads is always connected to this terminal. For CT polarity testing this is the P2 terminal.
G	Trolley mounting point	Four mounting points are provided on each unit to allow them to be mounted on the optional trolley

1.2.2 NLU200



ITEM	FUNCTION
A	PCU1-SP metering connection Metering/control connection to control unit
B	Power connector Power supply from control unit
C	Common output Output common terminal. One of the output leads is always connected to this terminal.
D	Tap 1 output Highest current, lowest voltage output 200A 60V
E	Tap 2 output Highest voltage, lowest current output 100A 120V
F	Trolley mounting point Four mounting points are provided on each unit to allow them to be mounted on the optional trolley

1.3 Electrical Specification

1.3.1 Supply Requirements

The PCU1-SP systems require a single phase 50/60Hz supply of 230V±10%. The maximum power requirement of the system depends on the level of current to be drawn from the control unit. For maximum output a 50A supply is required, but in most situations a 32A supply will suffice.

Loading unit	Open Circuit Voltage	Load current	Max time for load current	Supply current
NLU5000	2.3V	3000A	5 minutes	30A
		5000A	40 seconds	50A
	4.6V	1500A	5 minutes	30A
		2500A	40 seconds	50A
	9.2V	750A	5 minutes	30A
		1250A	40 seconds	50A
NLU2000	3.5V	1200A	5 minutes	18A
		2000A	40 seconds	30A
	6.9V	600A	5 minutes	18A
		1000A	40 seconds	30A
	13.8V	300A	5 minutes	18A
		500A	40 seconds	30A
NLU200	60V	80A	5 minutes	21A
		200A	40 seconds	50A
	120V	40A	5 minutes	21A
		100A	40 seconds	50A

Overload ratings are also available when operating in pulse mode. In this mode the output current (and therefore supply current) may be higher for a maximum of two seconds. In every case the maximum achievable output current is defined by the output cable and load impedance.

1.3.2 Loading Unit Outputs

Each loading unit has two or three output taps. The highest currents are available on the lowest voltage taps.

Loading unit	Open Circuit Voltage	Continuous current	Intermittent current		
			5 min on/ 15 min off	1 min on/ 15 min off	40s on/ 15 min off
NLU5000	2.3V	1500A	3000A	4500A	5000A
	4.6V	750A	1500A	2250A	2500A
	9.2V	375A	750A	1125A	1250A
NLU2000	3.5V	600A	1200A	1800A	2000A
	6.9V	300A	600A	900A	1000A
	13.8V	150A	300A	450A	500A
NLU200	60V	40A	80A	160A	200A
	120V	20A	40A	80A	100A

Each output is rated for a continuous current and also for higher intermittent currents. The maximum 'on' time for intermittent currents is enforced by the unit, and the output will be switched off if the rating is exceeded. The display will then show the following message until the green 'off' button is pressed to clear the trip condition:

Output Tripped
Press Green to Reset

NOTE: If the metering cable is not connected between the control unit and the external loading unit, the ammeter will not function and the output will not switch on when the output **ON** push-button is pressed. The metering cable between the control and external loading unit acts as an interlock circuit.

The control unit automatically selects the correct metering ranges and protection for the loading unit connected.

1.3.3 Secondary Injection Output

The PCU1-SP has a two-tap secondary injection output capable of injecting up to 100A without the use of a loading unit. The secondary injection output is selected using the metering range select switch.

Unit	Range	Voltage	Current		
			Continuous	5 min on/ 15 min off	1 min on/15 min off
PCU-SP	33A	15V	10A	20A	33A
	100A	5V	33A	67A	100A

The secondary injection output will only activate if the power lead to the loading unit is disconnected.

1.3.4 Metering

The PCU1-SP systems are fitted with a memory ammeter that holds the output current at the moment that the output circuit is switched off. In timing modes where the contact inputs are used to signify the end of a test, the last valid current before the contacts changed state is held. This also holds true for the current operated timer mode. The ammeter will capture and calculate the rms of a single cycle of output current.

The output metering ranges for the loading unit depend on the loading unit connected. The metering ranges are identified as 10%, 50% and 100% on the control unit. These relate to the maximum current that is available from the loading unit (on an NLU5000 the metering ranges are 500A, 2500A and 5000A).

1.3.4.1 Loading Unit Ammeter Ranges

Loading unit	Metering range	Metering full scale	Accuracy	Trip current
NLU5000	10%	500.0A	0.5%rdg+5d	525A
	50%	2500A	0.5%rdg+5d	2625A
	100%	5000A	0.5%rdg+5d	5250A
NLU2000	10%	200.0A	0.5%rdg+5d	210A
	50%	1000A	0.5%rdg+5d	1050A
	100%	2000A	0.5%rdg+5d	2100A
NLU200	10%	20.00A	0.5%rdg+5d	21A
	50%	100.0A	0.5%rdg+5d	105A
	100%	200.0A	0.5%rdg+5d	210A

1.3.4.2 Secondary Injection Output Ammeter Ranges

Unit	Ammeter range	Accuracy	Trip current
PCU1-SP	10.00A	$\pm 0.5\%rdg \pm 5d$	10.5A
	20.00A	$\pm 0.5\%rdg \pm 5d$	21A
	100.0A	$\pm 0.5\%rdg \pm 5d$	105A

1.3.4.3 Auxiliary Meter Ranges

The PCU1-SP has an auxiliary metering input with 300V/5A inputs. This can additionally measure the phase angle between output current and auxiliary input or the ratio between output current and auxiliary current.

Auxiliary metering range	Full scale	Function
RMS	300.0V/5.000A Accuracy $\pm 0.7\%rdg \pm 5d$	Displays the RMS voltage or current of the signal connected to the input
CT polarity	Fwd/Rev	Indicates the polarity of a CT connected between the current output (primary) and auxiliary current input (secondary)
CT ratio 5A	5000:5A	Displays the ratio of a 5A CT connected between the current output (primary) and auxiliary current input (secondary)
CT ratio 1A	5000:1A	Displays the ratio of a 1A CT connected between the current output (primary) and auxiliary current input (secondary)
Phase	-179.9° to +180.0°	Displays the phase angle between the output current and the voltage or current connected to the auxiliary input. Only active if the output current is <10% of the selected metering range and the auxiliary input is >0.5A or 20V.
Hz	45.00-99.99Hz	Displays the frequency of the voltage or current of the signal connected to the input. Only active if the auxiliary input is >0.5A or 20V.

1.3.5 Timing System

The PCU1-SP systems are fitted with an integrated timing system linked to the output and the two sets of contact inputs. The system is highly flexible and allows for the timing of all common protection devices and trips. The timer may also be used to time external events not linked to the output of the set. The timer is auto-ranging.

Full details of operating the timer are given in section 2.

Timer mode	Range	Resolution	Accuracy
Pulse 2s	0-2.000s	1ms	±0.01% rdg ±2d
Pulse 1s	0-1.000s	1ms	±0.01% rdg ±2d
Pulse 0.5s	0-0.500s	1ms	±0.01% rdg ±2d
Pulse 0.2s	0-0.200s	1ms	±0.01% rdg ±2d
Off	-	-	-
Internal start	0-999.999s/ 0-9999.99s/ 0-99999.9s	1ms/ 10ms/ 100ms	±0.01% rdg ±2d
Single contact			±0.01% rdg ±2d
Dual contact			±0.01% rdg ±2d
Current operated			±0.01% rdg ±4d

In current operated mode timing results obtained with test currents below 20% of the selected ammeter range are of doubtful accuracy and should be ignored.

The PCU1-SP systems have two contact inputs which are used to start and stop the timer depending on the mode selected. Each input has a connection for volt-free contacts and for triggering by a DC voltage. In each case, the input auto-selects for normally open or normally closed contacts. The contact state is shown by an LED (off when the contact is closed, on when the contact is open).

The maximum open circuit voltage across the contact input is 24V, and the short circuit current through the contacts is limited to 20mA.

The contact inputs are fully isolated.

1.3.6 Storage of results

The PCU1-SP can store all displayed values to a CSV spreadsheet file whenever the timer stops or the output is switched off. This is useful for recording all results, plotting relay curves and plotting transformer magnetisation curves.

Files are stored on the USB key in the folder \TRTEST. A folder is then created in this using the day's date, and results files are named with the time of the test.

A comment can be entered to be stored with the results using a USB keyboard.

The following values are stored:

- Time

- Date
- Main output current
- Timer result
- Comment

1.3.6.1 USB key

A standard USB flash memory key is used to store the results files. The unit has been tested with keys up to 16Gb in size.

Insert the USB key into the upper USB socket on the unit before starting to test. Most USB memory devices have an LED that indicates when the device is accessed. This will flash when a result is written.



Do not unplug the USB key whilst data is being written – data loss will result.

1.3.6.2 Setting the clock

The output of the unit must be switched off to set the clock. Use an external USB keyboard to set the clock.

- Set the STORE RESULT switch to SET CLOCK.

```
hh:mm:ss dd-mm-yy
10:13:24 15-12-08
```

- Use the ← and → keys to select which digit to change.
- Use the ↑ and ↓ arrows to change the selected digit.
- Use the ENTER button to save the changes to the clock.
- Use the green OFF button to cancel setting the clock.
- Set the STORE RESULT switch to OFF.

1.3.6.3 Entering a comment

Each result is tagged with a comment when it is stored. The comment is entered by setting the store result control to “comment” and typing the comment using the optional USB keyboard.

The same comment is tagged to each result until the comment is updated, and the comment is erased when the unit is switched off.

Any USB keyboard can be used with the PCU1-SP.

The comment can be typed on the USB keyboard using the letters a-z, numbers 0-9 and punctuation marks. A maximum of 39 characters may be entered for the comment.

The following keys are also used:

- Shift + a-z Enter capital letter.
- ←→ Move cursor left/right.

Ins	Switch between overwrite and insert mode. By default the unit will overwrite the character to the right of the cursor when a new character is typed. Switching to insert mode will shift characters of the right of the cursor right when a new character is typed.
Enter	Accept the current comment.
Esc	Lose the changes made to the comment since entering comment mode and revert to the last comment entered.
⇐ (backspace)	Delete the character to the left of the cursor.
Del	Delete the character under the cursor.
→ (cursor right)	Move cursor one character to the right.
← (cursor left)	Move cursor one character to the left.
Shift+→	Move cursor to end of comment .
Shift+←	Move cursor to start of comment.
End	Move cursor to end of comment .
Home	Move cursor to start of comment.

The following keys have no effect: caps lock, shift lock, alt, Windows key, tab, ↑, ↓, page up/down, F1-F12.

1.3.6.4 Auto-store

Set the STORE RESULTS switch to AUTO-STORE.

Set TIMER MODE to internal start, 1 contact, 2 contacts or current operated.

A result record is added to the current result file whenever the timer stops (this includes when the output is switched off in internal start mode).

If results are to be stored not dependant on the timer, set the timer mode to internal start, and press the OFF button for the main output when a result is to be stored.

Results are not stored when the timer is set to OFF. This allows the output current to be set without storing any results to the output file.

Pressing the ON while the output is already ON, will cause a snapshot to be written to the .csv file. An 'S01' will appear on the LCD screen and will increment each time the ON button is subsequently pushed until 'S99' or the OFF button is pushed.

The example below shows data stored when testing a relay.

```
PCU1-SP,V1.3.12,C00,P1,A1,
Time,Date,Main_A,Timer,Phase,Freq Hz,Aux Range,Comment
02:09:58,27/02/24,0.340,3.276,0.000,0.000,100A,Comment - up to 39 characters,
```

1.3.6.5 *Waveform storage*

Waveform storage mode allows the main output current and auxiliary input waveform to the USB memory key as a CSV file.

Set the STORE RESULTS switch to WAVEFORM.

Set TIMER MODE to internal start, 1 contact, 2 contacts or current operated.

The waveform is stored to the memory key whenever the timer stops or the output is switched off. It takes a number of seconds to write the waveform data to the memory key. Please be patient while the unit finishes writing the data.

A spreadsheet program (e.g Microsoft Excel or OpenOffice Calc) can be used to show the waveform graphically.

1.3.6.6 *File formats*

Results file format

The results file is in CSV (comma separated value) format. The first line of the file details unit type, software version and configuration information. The second line specifies column headings for the data, and the third line onwards is data.

```
PCU1-SP,V1.3.12,C00,P1,A1,  
Time,Date,Main_A,Timer,Phase,Freq Hz,Aux Range,Comment  
02:09:58,27/02/24,0.340,3.276,0.000,0.000,100A,Comment - up to 39 characters,
```

Double-clicking on a results file in MS Windows on a PC with a spreadsheet installed will open the file.

Waveform file format

The waveform file is in CSV (comma separated value) format.

The first line lists the time, date, and time between samples in ms (0.15=150us). The second line specifies column headings, and subsequent lines list one sample value for main output current in A. 1024 samples are stored.

```
02:14:41,27/02/24,Comment - up to 39 characters,Sample Time (ms),0.1562,  
Main,  
0.844,  
0.230,  
0.165,  
0.509,  
-0.114,  
0.165,
```

Double-clicking on a results file in MS Windows on a PC with a spreadsheet installed will open the file.

1.3.6.7 *Viewing results*

The VIEW RESULTS setting allows the results from the current day to be displayed.

Ensure the main output is off. Set the STORE RESULTS switch to VIEW. The files to view can be scrolled through using AUX AC ADJ and the file to view opened using →. The results in the file can then be stepped through using AUX AC ADJ.

Press OFF to delete the current result. Changes are not saved after deleting a result until the → key is pressed.

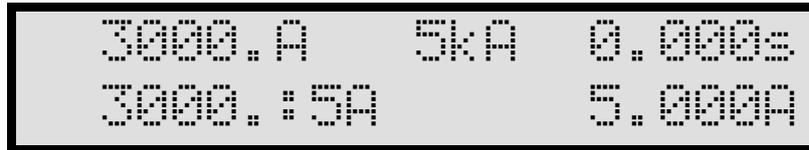
Navigate folders with the ↑, ↓, ← and → arrows on the external USB keyboard. ESC will exit the current folder/file.

1.4 Displayed Values and Messages

1.4.1 Displayed Values

The PCU1-SP display simultaneously shows the injected test current, the loading unit metering range full scale, the timer result, the selected auxiliary input value and quantity (SP models only), and the state of the output on a liquid crystal display. It also displays warning and error messages, detailed in the following section.

PCU1-SP Output current FS of loading unit range Timer



Auxiliary metering

Figure 1.4 Normal values displayed on screen

1.4.2 Warning Messages

In addition to the normal display screens, the PCU1-SP systems can display a range of warning messages if the unit trips on over-current or duty cycle or is too hot internally. If an over current or duty cycle trip occurs, the green 'off' pushbutton must be pressed to clear the trip condition. If the unit trips on over temperature, the unit will automatically reset when the temperature falls to an acceptable level. If the unit is over temperature, switching the unit off and back on will not clear the message – the unit must be allowed to cool.



Figure 1.5 Over-current trip warning message



Figure 1.6 Duty cycle trip warning message



Figure 1.7 Unit over temperature warning message



Remove Loading Unit
Green to continue

Figure 1.8 Secondary injection selected with loading unit power lead plugged in to PCU1-SP



Connect Loading Unit
Green to continue

Figure 1.9 Primary injection selected with loading unit not connected



Press Green to
continue

Figure 1.10 Loading unit fault cleared, waiting for user



LU Over Temperature
Output Disabled

Figure 1.11 Loading unit over temperature

1.5 Primary Current Injection Lead Sets

1.5.1 Description

Optional output lead sets are available to complement the PCU1-SP system. These lead sets are optimised to minimise impedance.

Lead set	Cross-sectional area	No. of leads
200NAL	25mm ²	2
2000NAL	280mm ²	2
3000NAL	420mm ²	4
4000NAL	560mm ²	4

The 2000NAL lead set consists of one pair of leads that are connected between the NLU and the load as shown in figure 1.11.

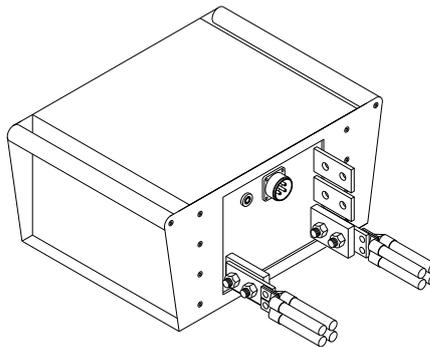


Figure 1.11 2000NAL connected to NLU

The 5000NAL lead set consists of two pairs of leads that are connected between the NLU and the load as shown in figure 1.12. The leads are also connected together in the same way at the load.

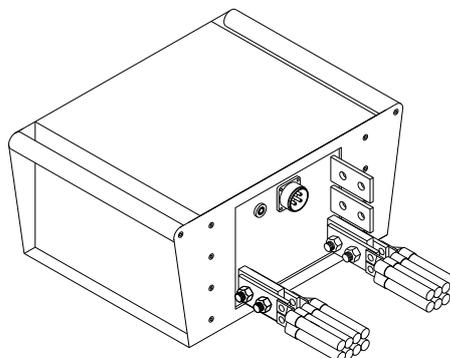


Figure 1.12 5000NAL connected to NLU

1.5.2 Factors Affecting Maximum Output Current

The maximum output current obtainable from each tap of the loading unit output depends on the following factors:

- Lead impedance
- Lead length
- Load impedance

The lead impedance is often dominant in defining the maximum current that may be injected into the load. The cross-sectional area of the leads and the lead layout have a large effect on impedance.

Figure 1.10 shows the effect of lead layout on the maximum current obtainable from a PCU1-SP and NLU5000 with a 3m 5000NAL output lead set.

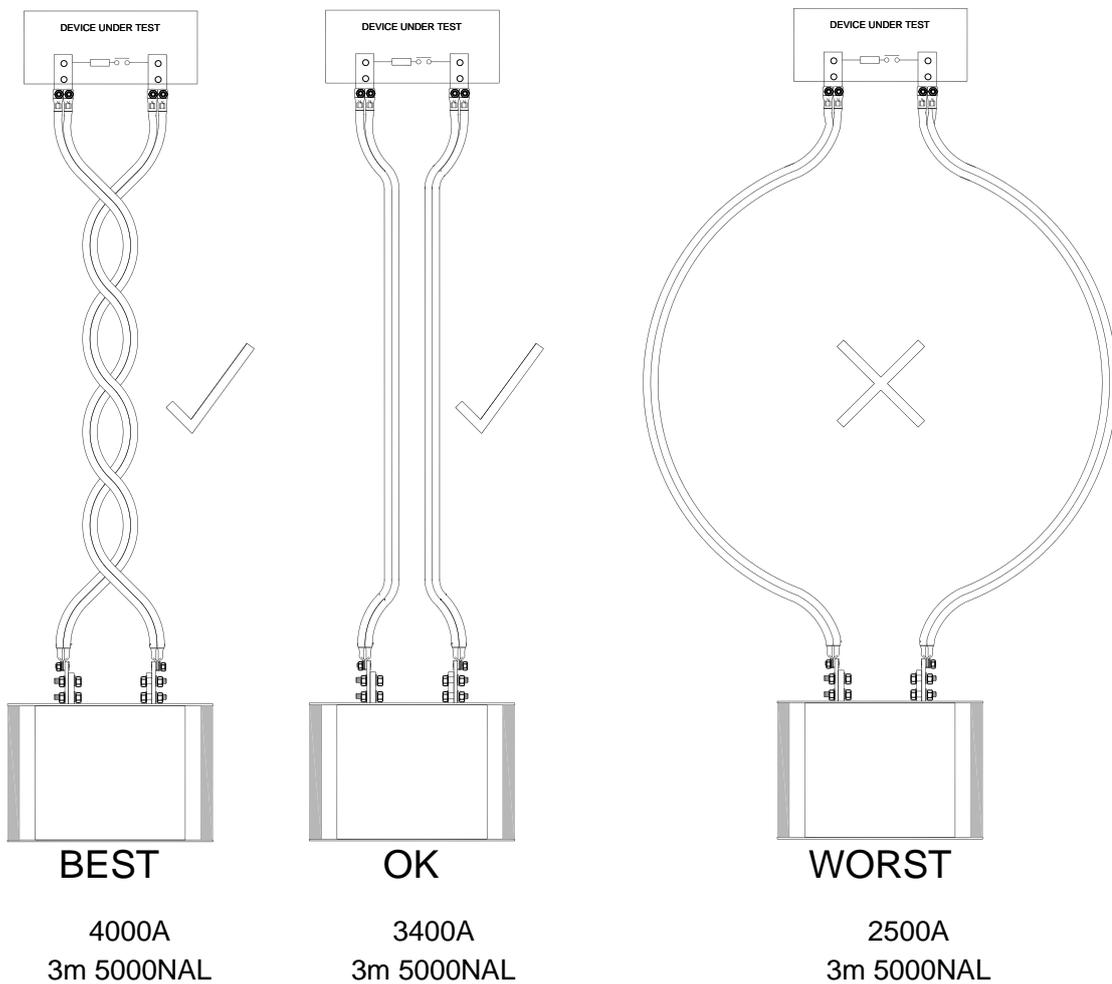


Figure 1.13 Effect of lead routing on maximum output current

1.5.3 Lead Set Voltage Drops

Approximate voltage drops for the lead sets are shown below. Please note that the arrangement of the output leads has a very large effect on the output voltages available.

Lead set	CSA (mm ²)	Length	Voltage drop Leads twisted	Voltage drop Leads in large loop	Test current
2000NAL	280	3m	1.5V	2.4V	2000A
2000NAL	280	5m	2.5V	4V	2000A
5000NAL	560	1.25m	1V	2.4V	5000A
5000NAL	560	3m	2.2V	5.9V	5000A
5000NAL	560	5m	3.7V	9.8V	5000A

From this table it can be seen that the maximum output current is not available with all combinations of lead sets and lengths. In particular, 5000A output current is only achievable using very short, low impedance leads.

1.5.4 Unit Output Voltage Under Load

When current is injected from the output of the loading unit, the voltage available at the output drops due to the internal impedance of the unit. The under load voltages for the loading units are shown below.

Loading unit	Output	Load current	Terminal voltage
NLU5000	2.3V	No load	2.3V
		2500A	2.0V
		5000A	1.5V
	4.6V	No load	4.6V
		1250A	4.0V
		2500A	3.4V
	9.2V	No load	9.2V
		625A	8.3V
		1250A	7.5V

Loading unit	Output	Load current	Terminal voltage
NLU2000	3.5V	No load	3.5V
		1000A	2.9V
		2000A	2.4V
	6.9V	No load	6.9V
		500A	6.4V
		1000A	5.9V
	13.8V	No load	13.8V
		250A	13.0V
		500A	12.3V

1.6 Overload Protection

The PCU1-SP is fitted with a range of over protection devices:

Location	Protection
Mains supply	Circuit breaker
Main output	Circuit breaker Electronic over-current trip Electronic duty cycle trip Thermal protection
Contact circuits	Auto-resetting semiconductor fuses
Auxiliary metering current input	F6.3A fuse

1.7 Construction

The PCU1-SP series units are housed in robust aluminium cases fitted with lifting handles.

1.8 Installation

The PCU1-SP and associated loading units are designed for use in an indoor environment.

The unit must be connected to an installation category II supply (wall socket). Before installation, a suitable mains connector must be connected to the 3-core mains input cable provided. The connector and supply must be rated for 32A for output currents up to 3000A and 50A for output currents up to 5000A. It is also essential to ensure that the unit is adequately earthed.



WARNING

Ensure that the unit is adequately earthed. If necessary, an extra earth connection may be made between the earth terminal on the front panel of the control unit and a suitable low impedance local earth.



WARNING

Ensure that the unit is connected to an appropriate supply by a suitably rated connector.



WARNING

The PCU1-SP series control units and NLU series loading units are heavy. Avoid lifting where possible. Ensure that two people are used to lift the units and that appropriate manual handling techniques are used.

2. OPERATION

This chapter describes how to use the PCU1-SP systems in a variety of applications. Specific examples are given in the applications section.

2.1 Primary Current Injection with Loading Unit

The loading unit output from the PCU1-SP control unit is ONLY for connection to a T&R Test Equipment NLU series loading unit. The loading unit provides isolation from the mains.

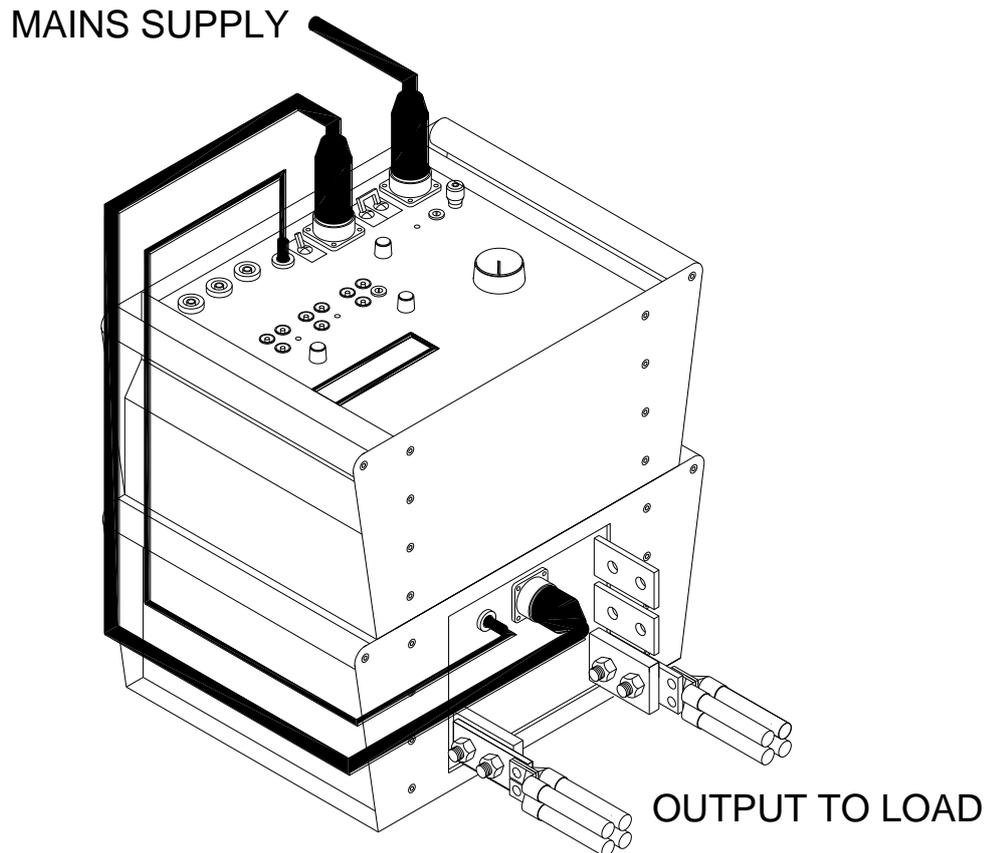


Figure 2.1 Connection between control unit and loading unit
(PCU1-SP and NLU5000 shown)

The main output is switched on and off using the on and off push-buttons. The current level is controlled by the main output control and protected by the output circuit breaker.



WARNING

Never break the high current output circuit when the output is switched on – this may cause arcing.

2.1.1 Connections

Ensure that the unit is switched off and the test object is isolated and grounded before making any connections.

Connect the loading unit to the control unit as shown in figure 2.1. When switched on, the control unit will automatically detect the loading unit type.

Set the metering range switch to 10%, 50% or 100%. These ranges refer to % of maximum rated current of the connected loading unit, so for an NLU5000 100% is 5000A and for an NLU2000 100% is 2000A.

Select the desired output on the loading unit. One output lead always connects to the common terminal, and the other connects to one of the three output taps. Use the correct tap for the voltage and current that you require. The output leads should always be attached using fully tightened stainless steel nuts, bolts and washers. Connect the output cables to the test object.



HOT

After testing, the output terminals and leads may be hot. Allow to cool before touching connections.

Connect the supply lead to the mains and switch the supply circuit breaker on. The supply on lamp should now illuminate.

2.1.2 **Testing**

Always start the first test with the output control knob at zero to ensure that the test object is not subjected to an unintentional over-current.

Switch the output on using the “on” pushbutton and then increase the output current to the desired test current. If you cannot achieve the desired test current, one of the following will be limiting the current:-

- Output leads too long. Use shorter output leads.
- Output leads in a large loop – minimising the area in the loop of the output leads will maximise the current available.
- Output leads of insufficient cross-sectional area. Either use thicker output leads or use two output leads per connection.

2.1.3 **After Testing**

On completion of the test, switch off the output using the “off” pushbutton. Return the output control to zero and switch off the supply. Before disconnecting the test object ensure the mains supply switch is in the OFF position.

2.2 Secondary Current Injection

The secondary current injection output of the PCU1-SP allows currents of up to 100A to be injected for testing relays and trips.



To use the secondary injection output the loading unit power lead must be disconnected and one of the secondary injection metering ranges selected.

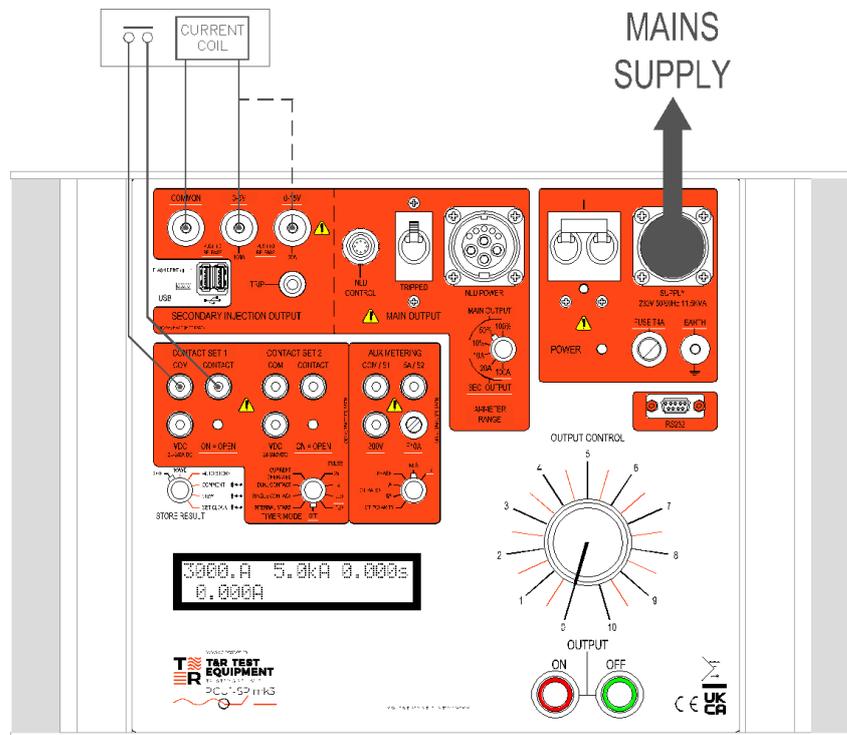


Figure 2.2 Secondary Injection Connections

2.2.1 Connections

Ensure that the unit is switched off and the test object is isolated and grounded before making any connections.

Connect the test object as shown in figure 2.2. The contact/timer connections will vary depending on the device type.

Set the ammeter range switch to “sec output” 10A, 20A or 100A.

Connect the supply lead to the mains and switch the supply circuit breaker on.

2.2.2 Testing

Always start the first test with the output control knob at zero to ensure that the test object is not subjected to an unintentional over-current.

Switch the output on using the “on” pushbutton and then increase the output current to the desired test current.

2.2.3 After Testing

On completion of the test, switch off the output using the “off” pushbutton. Return the output control to zero and switch off the supply. Before disconnecting the test object ensure the mains supply switch is in the OFF position.

2.3 Timing System

The PCU1-SP timing system is closely integrated with the main output and is very flexible. A summary of the start and stop events for the timer is shown in the table below.

Timer Mode	Timer Start Condition	Timer Stop Condition	Automatic output off	Example application
Off	-	-	-	Set current
Internal Start	Main output on	Contact set 1 change	When timer stops	IDMT relay
Single Contact using Contact 1	C1 1st change	C1 2nd change	C1 1st change (timer start)	Auto-recloser
Single Contact using Contact 2	C2 1st change	C2 2nd change	C2 2nd change (timer stop)	Drop-off timing
Dual Contact 1st change C1	C1 change	C2 change	C2 change (timer stop)	
Dual Contact 1st change C2	C2 change	C1 change	C2 change (timer start)	Auto-reclose relay
Current Operated	Current >20% of selected metering range	Current < 10% of selected metering range	Current <10% Timer stop	Miniature circuit breakers
Pulse 0.2s	Main output on	Time = 0.2s	200ms	Set current for thermal devices
Pulse 0.5s	Main output on	Time = 0.5s	500ms	
Pulse 1s	Main output on	Time = 1s	1s	
Pulse 2s	Main output on	Time = 2s	2s	

The timer resets automatically when the output “on” pushbutton is pressed. In each mode that the timer is active, the output of the unit must be switched on to arm the timer.

Each contact channel has a contact input for volt-free contacts and a Vdc input for dc voltages. The Vdc input may be used to trigger the timer from a dc voltage, and will trigger from either the voltage switching from zero to 24-240Vdc or 24-240Vdc to zero. The voltage must be connected with positive to the red “Vdc” terminal and negative to the blue “com” terminal.

2.3.1 Timer Modes

2.3.1.1 Timer Mode: Off

In the 'off' mode, the timer has no effect on the operation of the set, and the timer does not run. This mode is used to set the required current through the test object before a timing test.

2.3.1.2 Timer Mode: Internal Start

The internal start mode starts the timer when the main output is switched on, and stops the timer on the first change of contact set 1. When the timer is stopped, the output of the unit is automatically switched off.

2.3.1.3 Timer Mode: Single Contact

In single contact mode, the timer starts on the first change of state of contact set 1 after the output is switched on, and stops on the second change on contact set 1. The output is automatically switched off when the timer is started. The timer is reset when the output is switched on. This timer mode is ideally suited to timing auto-reclose relays.

If a single contact mode is required where the output remains on until the second change of contact, this may be achieved by using single contact mode with contact set 2.

2.3.1.4 Timer Mode: Dual Contact

Dual contact mode uses both contact set 1 and contact set 2. The time between C1 and C2 changing is always measured whether C1 or C2 changes first. If C1 changes first, the output switches off when the timer stops. If C2 changes first, the output switches off when the timer starts. In dual contact mode the timer will initially start when the output is switched on, but will restart on the first contact change.

2.3.1.5 Timer Mode: Current Operated

Current operated mode is used to time devices that have contacts in series with the current sense element. This includes miniature circuit breakers and MCBs.

The timer is started when the output current exceeds 20% of full scale of the selected metering range and stops when the current falls below 10%. The timer is reset once the ON button is pushed. If the OFF button is pushed before current reaches the 20% threshold, the timer will display the previous time.

Loading unit	Metering range	Range full scale	Approximate timer start current
None Secondary Injection	10A	10A	2A
	20A	20A	4A
	100A	100A	20A
NLU5000	10%	500A	100A
	50%	2500A	500A
	100%	5000A	1000A
NLU2000	10%	200A	40A
	50%	1000A	200A
	100%	2000A	400A
NLU200	10%	20A	4A
	50%	100A	20A
	100%	200A	40A

2.3.1.6 Pulse Mode

Pulse mode may be used to generate high current pulses into the test object. The electronic trips are disabled in pulse mode, and the output current is only limited by the circuit impedance. This is useful for setting the current when testing thermal devices and testing instantaneous trips.

2.3.2 General Procedure for Timing Tests

The procedure for timing is the same whether an external loading unit is connected or the secondary current injection output from the PCU1-SP is used.

2.4.2.1 Connections

Ensure that the unit is switched off and the test object is isolated and grounded before making any connections.

Connect the loading unit to the control unit as shown in figure 2.1. In the case of the secondary injection output, make the connections shown in figure 2.2.

Set the ammeter range switch to one of the main output ranges (10%, 50% or 100%). Connect the output cables to the desired output on the loading unit and to the test object.

Connect the supply lead to the mains and switch the main supply switch on. The display will come on, showing the unit type and loading unit type whilst starting up.

2.4.2.2 *Testing*

It is advisable to make a preliminary test on the test object, starting at zero voltage, in order to test the load impedance, before performing the test with output control set at higher values. Therefore, ensure the output control knob is fully anti-clockwise before switching on.

Ensure the timer mode switch is in the off position, and depress the on push-button. Increase the current by rotating the output control knob in a clockwise direction until the desired current is indicated on the ammeter. Press the output off push-button.

Connect the test object contacts to the contact terminals on the test set, select the internal start timer mode. If the test object has no auxiliary contacts (e.g. thermal breakers), it will be necessary to use the current operated timer mode.

When the output "on" pushbutton is pressed, the following will occur:

- a. The timer will start and current will flow through the test object.
- b. When the test object's contacts change state the timer will stop and the test current will be automatically switched off.

2.4.2.3 *After Testing*

On completion of the test, return the output control to zero and switch off the supply. Before disconnecting the test object ensure the mains supply switch is in the OFF position.

3 APPLICATION NOTES – TESTING SPECIFIC DEVICES

3.1 Secondary Injection of an Over-Current Relay

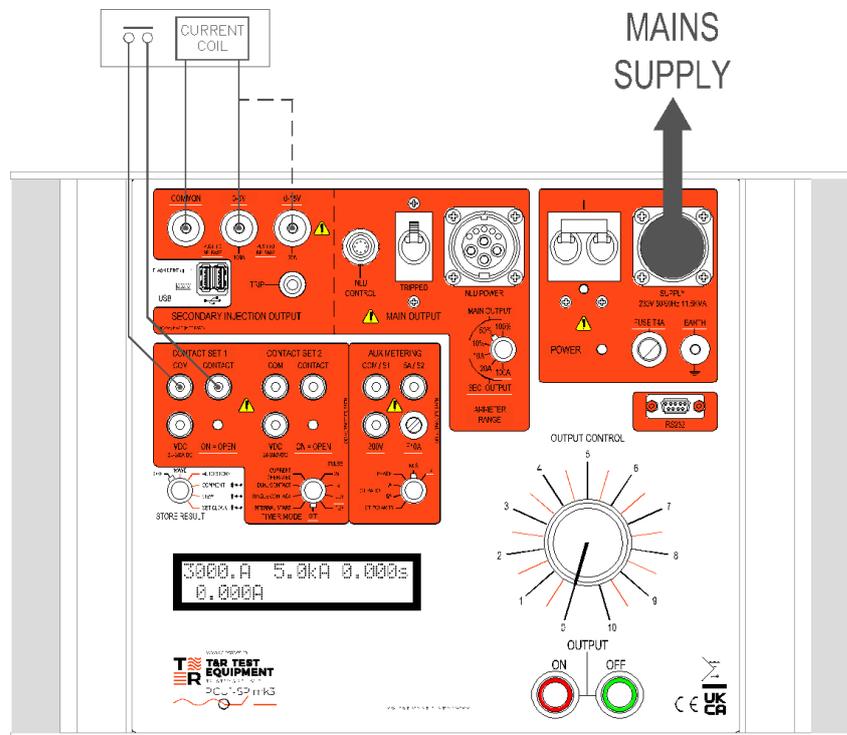


Figure 3.1 Secondary injection of over-current relay

3.1.1 Timer Mode

Internal start

3.1.2 Connections

Connect the relay current coil to the most appropriate output on the PCU1-SP (5V 100A or 15V 33A).

Connect the trip contacts on relay under test to contact set 1 on the PCU1-SP.

3.1.3 Test Procedure

Switch on the main supply switch.

Set the metering range switch to the most appropriate secondary injection range (10A, 20A or 100A). Set the timer mode switch to the off position.

Ensure that the output control is in the zero position.

Press the output on push-button and increase the output current to the desired level.

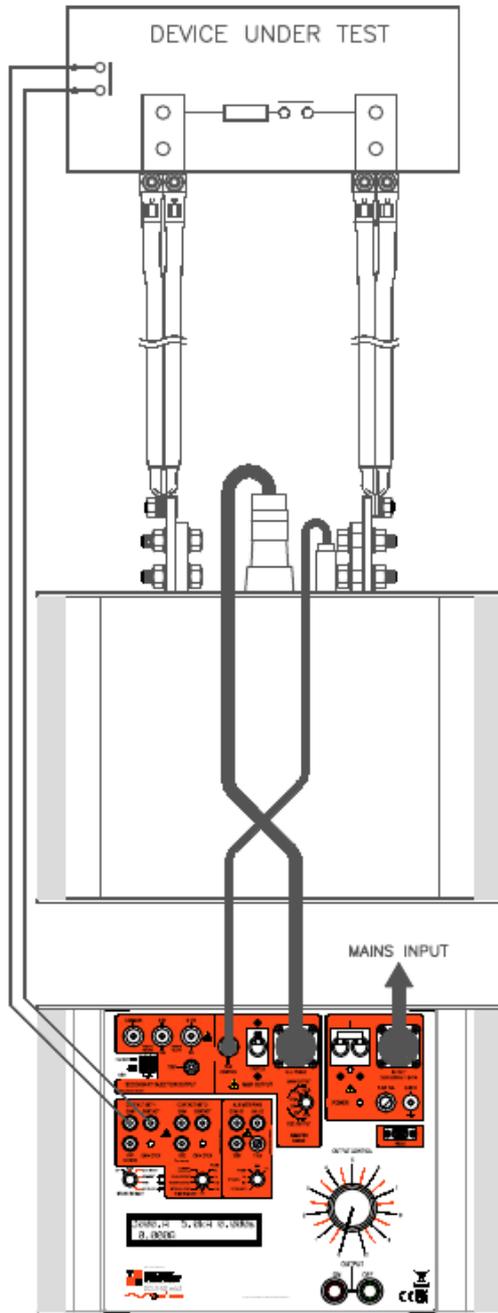
Press output off push-button.

Select the internal start position on the timer mode switch

Press the output on push-button

When the device under test trips the timer will stop and the output will be switched off automatically.

3.2 Primary Injection of an Over-Current Relay



3.2.1 **Timer Mode**

Internal start

3.2.2 **Connections**

Connect current output from loading unit to desired input on device under test.

Connect trip contact on the relay under test to contact set 1 on the control unit.

3.2.3 **Test Procedure**

Switch on the main supply switch.

Set the ammeter range switch to a primary injection range (10%, 50% or 100%). Set the timer mode switch to the off position.

Ensure that the output control is in the zero position.

Check that connections are made as above.

Press the output on push-button and increase the current to the desired level.

Press the output off push-button.

Select the internal start position on the timer mode switch.

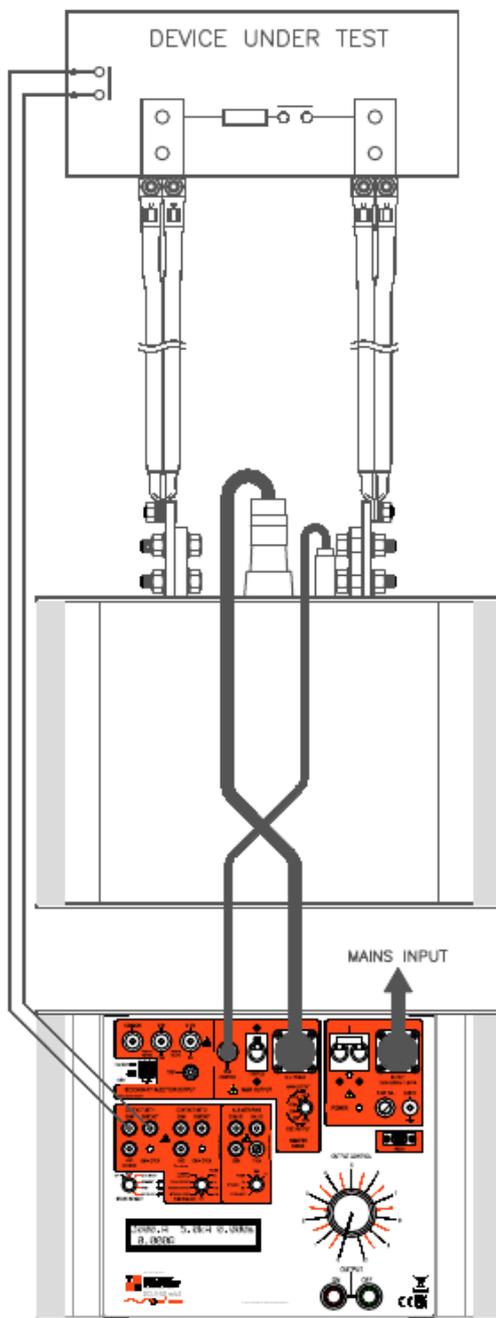
Press the output on push-button. When the device under test trips the timer will stop and the output will be switched off automatically.

Figure 3.2 PCU1-SP with over current device

3.2.4 **Using Pulse Mode to Set the Current**

When setting the current into the load pulse mode may be used to avoid injecting current for long periods of time. Set the timer mode to pulse 0.2s and inject a series of pulses, adjusting the output current until the desired current is set. Set the timer mode to internal start and then press the on pushbutton.

3.3 Timing of Auto-reset/Reclosing Devices



3.3.1 **Timer Mode**

Single contact

3.3.2 **Connections**

Connect current output from loading unit to desired input on device under test.

Connect the trip contact on the relay under test to contact set 1 on the control unit.

3.3.3 **Test Procedure**

Switch on the main supply switch.

Set timer mode switch to the off position.

Ensure that the output control is in the zero position.

Check that connections are made as above.

Press output on push-button and increase the output current to the desired level.

Press output off push-button.

Select the single contact position on the timer mode switch.

Press the output on push-button

Figure 3.3 PCU1-SP with auto-reclose device

When the device under test trips the timer will start and the output will be switched off automatically.

When the device auto-resets the timer will stop.

3.4 Timing Devices with NO Auxiliary Contacts

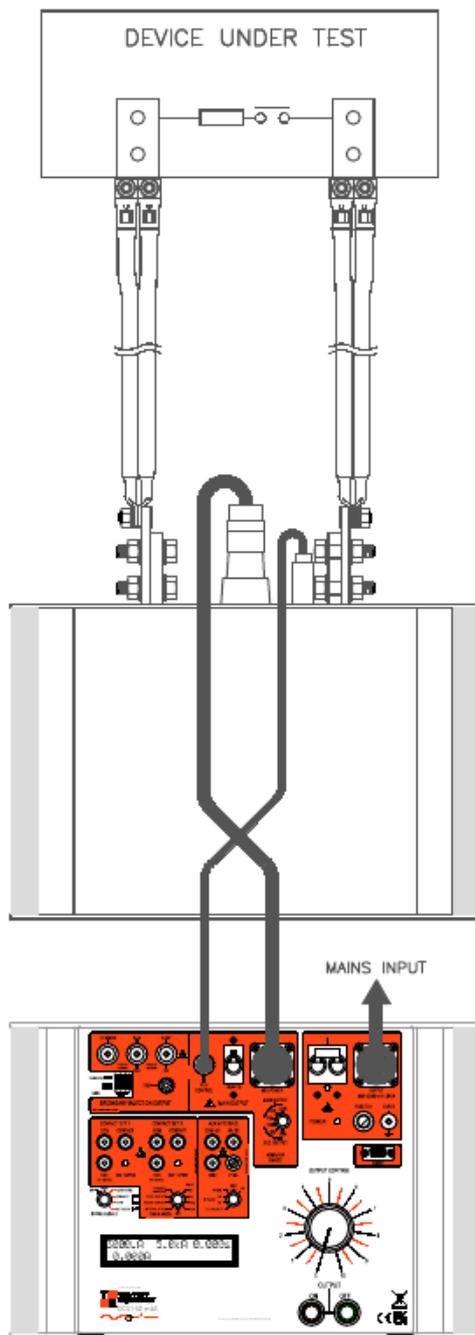


Figure 3.4 CIT with miniature circuit breaker

3.4.1 **Timer Mode**

Current Operated

3.4.2 **Connections**

Connect current output from loading unit to desired input on device under test.

3.4.3 **Test Procedure**

Switch on the main supply switch.

Set timer mode switch to the off position.

Ensure that the output control is in the zero position.

Check that connections are made as above.

Press output on push-button and adjust output control until the desired output level is indicated.

Press output off push-button.

Select the current operated position on the timer mode switch.

Press the output on push-button

When the device under test trips the timer will stop and the output will be switched off automatically.

3.5 Using the Control Unit as a Single Contact Timer

3.5.1 *Timer Mode*

Single contact

3.5.2 *Connections*

Connect contact to be timed to contact set 1.

3.5.3 *Test Procedure*

Switch on the main supply switch.

Set timer mode switch to the single contact position.

Ensure that the output control is in the zero position.

Press output on push-button. The timer system is now armed, and will start when contact set 1 changes state (i.e open to closed or vice-versa).

The timer will stop when the contacts return to their original state.

3.6 Using the Control Unit as a Dual Contact Timer

3.6.1 *Timer Mode*

Dual contact

3.6.2 *Connections*

Connect contact to start timer to contact set 1.

Connect contact to stop timer to contact set 2.

3.6.3 *Test Procedure*

Switch on the main supply switch.

Set timer mode switch to the dual contact position.

Ensure that the output control is in the zero position.

Press output on push-button. The timer runs, and will restart when contact set 1 changes state (i.e open to closed or vice-versa).

The timer will stop when contact set 2 changes state.

3.7 CT Polarity

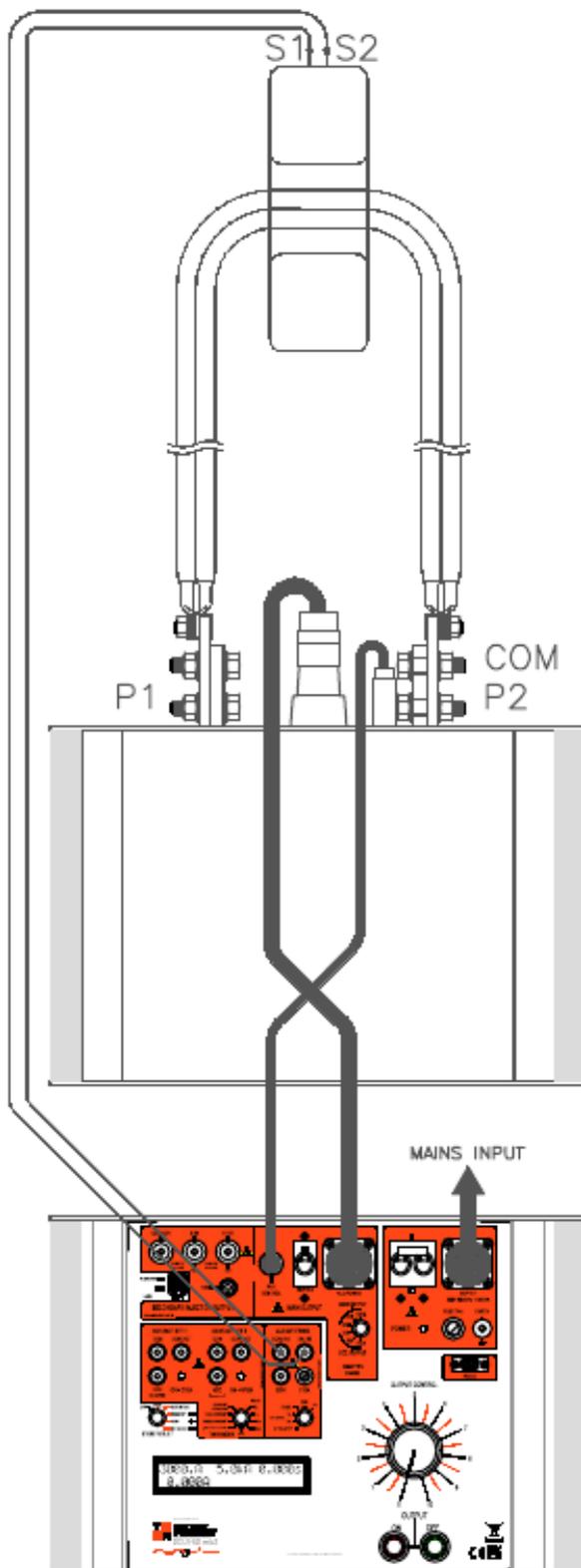


Figure 3.5 PCU1-SP CT ratio/polarity

3.7.1 Modes & Settings

Timer mode: Off

Auxiliary metering: CT polarity

3.7.2 Connections

Connect current output from loading unit to busbar through CT primary (or loop lead through the CT). Ensure that CT P2 connects to COM terminal on loading unit.

Connect S1 & S2 on CT secondary to PCU1-SP auxiliary metering input S1 & S2. Check that CT S1 connects to COM input.

3.7.3 Test Procedure

Switch on the main supply switch.

Set timer mode switch to the off position.

Ensure that the output control is in the zero position.

Check that connections are made as above.

Choose a suitable test current. The test current must be greater than 10% of the metering range in use (e.g. 500A on 100% range with NLU5000). The CT secondary current must not exceed 5A.

Press the output on push-button and increase the output current to the desired test current. The display will show either "OK" for correct polarity or "REV" for reversed polarity.

Press output off push-button.

3.8 CT Ratio

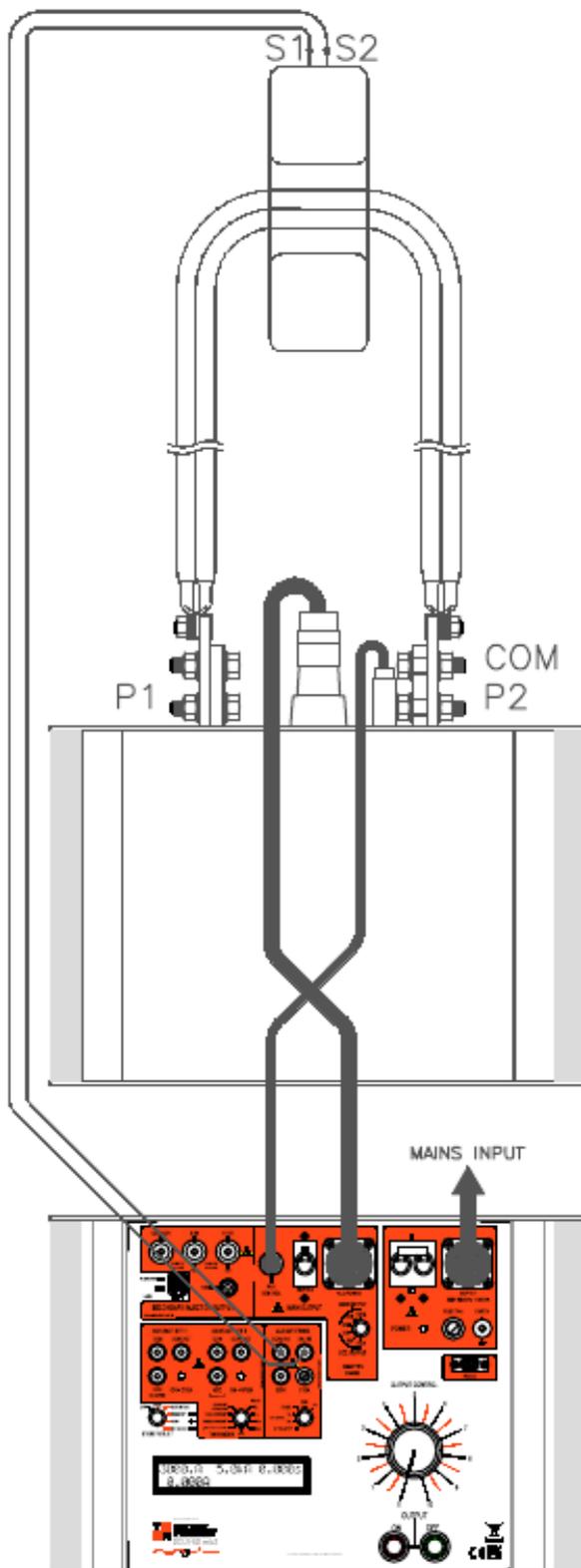


Figure 3.6 PCU1-SP CT ratio/polarity

3.8.1 Modes & Settings

Timer mode: Off

Auxiliary metering: CT ratio 1A or CT ratio 5A as appropriate to CT secondary.

3.8.2 Connections

Connect current output from loading unit to busbar through CT primary (or loop lead through the CT).

Connect S1 & S2 on CT secondary to PCU1-SP auxiliary metering input S1 & S2.

3.8.3 Test Procedure

Switch on the main supply switch.

Set timer mode switch to the off position.

Ensure that the output control is in the zero position.

Check that connections are made as above.

Press the output on push-button and increase the output current to the rated CT primary current. Read off the CT ratio from the display.

Note: If the CT secondary is >5A a lower test current must be used such that no more than 5A flows into the metering input.

Press output off push-button.

4. MAINTENANCE



WARNING

The following actions should only be taken by suitably qualified and competent service personnel. Before removing the unit from its case, ensure that the unit is disconnected from the mains. Under no circumstances connect the unit to the mains whilst it is removed from its case.

4.1 Output Control Brushes

The output control brushes should be examined and replaced if necessary. The interval between inspection and renewal of the brushes will depend upon the amount of usage (particularly at very high currents). However, it should be remembered that damage to the output control can result if the brushes are allowed to wear away to such an extent that a loss of brush pressure occurs.

4.2 Removal of the PCU1-SP from Case

To remove the instrument from its case, the following procedure should be used:-

- a. Remove the 14 socket head screws securing each of the side panels to the unit (each side has 4 screws to the rear, 4 screws to the front and 6 to each side).
- b. Loosen the handles using socket head screws on front of unit.
- c. Remove the side panels, being careful to disconnect the in-line plug and socket to the cooling fan.
- d. Lift the unit out of the U section case.

4.3 Warranty

The warranty for electrical test equipment is designed to provide assurance of the product's quality and reliability. However, it's important to note that this warranty becomes void if the warranty labels on the equipment are removed or tampered with. This is because the labels are a critical part of the manufacturer's quality control process; their removal or alteration can indicate unauthorized attempts to repair or modify the equipment, which could potentially compromise its safety and functionality. Therefore, to maintain the validity of the warranty, it is strongly advised not to remove or tamper with the warranty labels on your electrical test equipment. Always seek professional assistance for any issues related to the equipment's operation or maintenance.

5. STANDARD ACCESSORIES

5.1 Spare Fuses Supplied:

- a. 1 off 20mm F6.3A
- b. 1 off 32mm T4A

5.2 Standard Accessories Supplied:

- a. 5 metre long supply cable terminated at one end to suit the PCU1-SP control unit mains input.
- b. 5 metre long interconnecting lead terminated at both ends to supply power from the control unit to the loading unit.
- c. 5 metre long metering lead to connect loading unit to control unit.
- d. Cable wallet to hold above leads.
- e. User manual.

6. OVERALL PERFORMANCE SPECIFICATION

6.1. Insulation Resistance at 1000V DC

The insulation resistance will not be less than 10 megohms between mains input to frame and all isolated outputs, and all combinations of isolated output to isolated output.

6.2. Applied Voltage Test

Mains input to frame and all isolated outputs 2kV RMS for 1 minute.

All isolated inputs/outputs 1.5kV RMS for 1 minute.

6.3. Accuracy of Instruments

6.3.1 Loading Unit Current Output

Loading unit	Metering range	Metering full scale	Accuracy	Trip current
NLU5000	10%	500.0A	0.5%rdg+5d	525A
	50%	2500A	0.5%rdg+5d	2625A
	100%	5000A	0.5%rdg+5d	5250A
NLU2000	10%	200.0A	0.5%rdg+5d	210A
	50%	1000A	0.5%rdg+5d	1050A
	100%	2000A	0.5%rdg+5d	2100A
NLU200	10%	20.00A	0.5%rdg+5d	21A
	50%	100.0A	0.5%rdg+5d	105A
	100%	200.0A	0.5%rdg+5d	210A

6.3.2 Secondary Injection Current Output

Unit	Ammeter range	Accuracy	Trip current
PCU1-SP	10.00A	$\pm 0.5\% \text{rdg} \pm 5\text{d}$	10.5A
	20.00A	$\pm 0.5\% \text{rdg} \pm 5\text{d}$	21A
	100.0A	$\pm 0.5\% \text{rdg} \pm 5\text{d}$	105A

6.3.3 Auxiliary Metering Input

Auxiliary metering range	Full scale	Accuracy
300.0V RMS	300.0V	$\pm 0.7\% \text{rdg} \pm 5\text{d}$
5.000A RMS	5.000A	$\pm 0.7\% \text{rdg} \pm 5\text{d}$

6.3.4 Timing System

Timer mode	Range	Resolution	Accuracy
Internal start	0-999.999s/ 9999.99s/ 99999.9s	1ms/ 10ms/ 100ms	$\pm 0.01\% \text{rdg} \pm 2\text{d}$
Single contact	0-999.999s/ 9999.99s/ 99999.9s	1ms/ 10ms/ 100ms	$\pm 0.01\% \text{rdg} \pm 2\text{d}$
Dual contact	0-999.999s/ 9999.99s/ 99999.9s	1ms/ 10ms/ 100ms	$\pm 0.01\% \text{rdg} \pm 2\text{d}$
Current operated	0-999.999s/ 9999.99s/ 99999.9s	1ms/ 10ms/ 100ms	$\pm 0.01\% \text{rdg} \pm 4\text{d}$
Pulse	0-999.999s/ 9999.99s/ 99999.9s	1ms/ 10ms/ 100ms	$\pm 0.01\% \text{rdg} \pm 2\text{d}$

7. REVISION

Product / Type: Primary Current Injection – PCU-SP mk3 & NLU Loading Units
File: OM0047-1.docx
Author: M. Clancy 25.03.2024

Issue / Date: 2 / 13/05/2024.
Modified By: E Makonnen CCN1771

Checked By: M Clancy	Date: 14/05/2024
----------------------	------------------

Drawings Required

A3/002276 latest issue (PCU1-SP mk3)