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PC5x Digital Phase Angle Controller

Operating Manual & Specifications – Rev. 1.01

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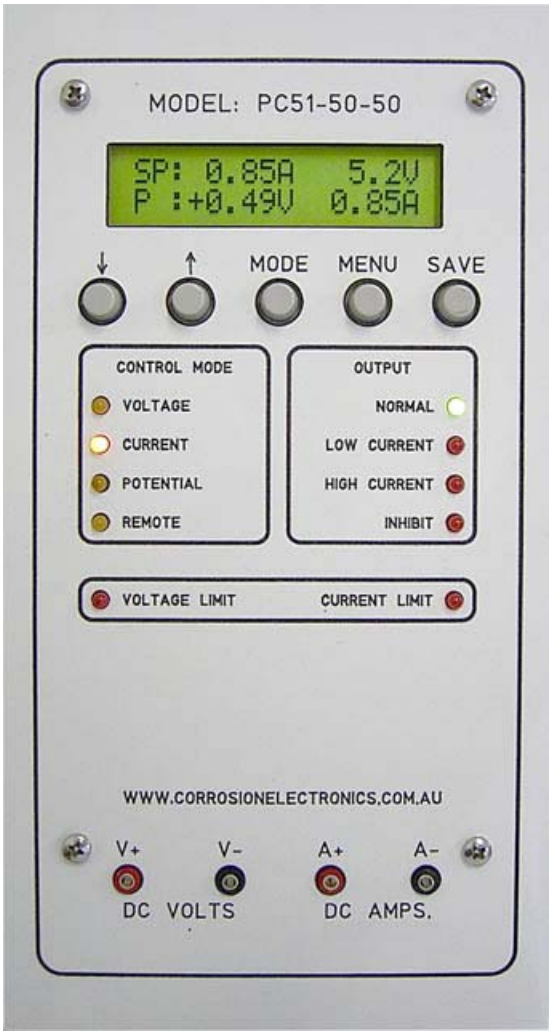
Section 1: PC5x Controller – An Overview



Introducing the PC5x digital phase angle controller from Corrosion Electronics. Packed with features yet simple to operate this controller makes an ideal choice for Cathodic Protection applications where phase angle control is employed.

What's New ?

- An Integrated LCD display to display DC volts and DC amps, Structure to reference volts, and set-point volts/amps plus a variety of other menu options.
- Multiple LED indicators to indicate mode of control, limit conditions, high or low current conditions and inhibit status.
- All controller adjustments performed by use of reliable press-switches instead of using a potentiometer.
- An integrated set of test-points for measuring volts and amps using external measuring equipment.
- Built-in user adjustable high and low current alarm complete with status indicators and clean relay contacts.
- PID control to ensure most stable operation under a variety of operating conditions.
- Scalable control and metering resolution depending on output range.
- 0-10V remote control input which can be enabled within the menu to operate in volts / current / potential (auto) modes.

Main differences between the PC51 and PC52 controllers ...

The PC5x digital phase angle controller is available in two forms. One is the PC51 Controller and the other is the PC52 controller. Both controllers are identical in their operation, however the PC51 has a second rear mounted PCB allowing all inputs/outputs to be connected to the controller itself. The PC52 however, incorporates a front panel mounted board as pictured above that interfaces to a rear panel mounted module known as the DCR3PD module which consists a chassis containing a PCB, transformer, choke, rectifier components, and a blocking diode. Using the DCR3PD module provides a modular approach to the T/R design and allows easier servicing of the T/R in the rare case of output failure – making it an ideal choice for multiple output T/R systems.
The PC52 controller is suitable for DC output requirements up to 20V 6A whereas the PC51 controller can be used for any output size.

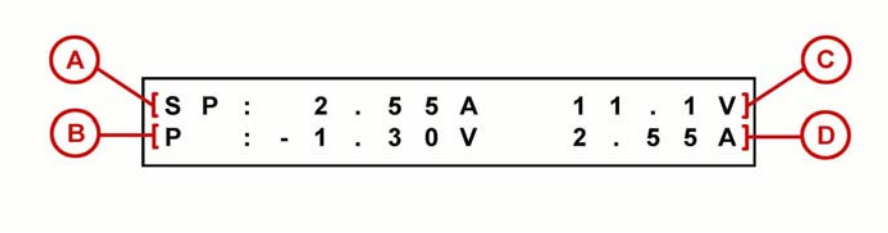
Section 2: The user interface

The user interface of the PC5x controller consists of an LCD type display, a series of 5 push buttons, a variety of LED indicators (10 in total) and voltage/current monitoring posts.

Even though 5 push buttons and 10 LED's might sound confusing to some, the PC5x controller is very intuitive to operate. The reason there are so many LED indicators is so the operator can tell, at a glance, what mode of control is in effect and whether there are any alarm conditions present or limiting conditions imposed on the CP system.

2.1 The Display

The PC5x controller utilises a 16 character / 2 line LCD backlit LCD display to display necessary information. The display – under normal operating conditions is best described below.



A **Set-point Value**

B **Structure to Reference Potential**

C **Output Volts DC**

D **Output Amps DC**

The above display will be shown on the controller at all times unless viewing menu options.

2.2 Adjusting the mode of control

The PC5x controller is designed to operate in 1 of 4 possible modes of control. These modes of control are:

- **Voltage Mode**

  In voltage mode of control the DC output will be controlled to a constant voltage defined by the set-point which is adjustable from zero to the maximum voltage range.

- **Current Mode**

  In current mode of control the DC output will be controlled to a constant amperage defined by the set-point which is adjustable from zero to the maximum amperage range.

- **Potential (auto) Mode**

  In potential mode of control the DC output will be controlled to a achieve a constant structure to reference potential defined by the set-point which is adjustable from +1.00 VDC to -4.00VDC.

- **Remote Mode**

  In remote control mode the controller receives a 0-10V signal in order to vary the set-point. Whilst in remote mode the set-point can not be adjusted locally but will still be displayed as a value interpreted from the 0-10V signal input. There are 2 menu options regarding remote mode, these are remote mode enable/disable and remote 'mode of control' select (voltage/current/potential). Refer to sections 3.8 and 3.9 of this manual for more information on these menu options.
  When remote mode is enabled and selected - 2 control mode LED's will be lit, one will be the remote LED and the other will be the LED associated with the selected mode of control.

To adjust the mode of control ...

With the display in its normal operating mode (not in the menu), Press and hold the MODE button for approx 2 seconds to toggle the mode of control. A LED indicator situated directly under the arrow keys states the presently selected mode of control. The mode of control can not be adjusted whilst the inhibit LED is lit. i.e. when the TR is interrupting the output.

2.3 Adjusting the output

In the top left corner of the display is the set-point value. This value can be adjusted from zero to a maximum range by using the up/down arrow keys.

With the display in its normal operating mode (not in the menu), Use the UP / DOWN arrow keys to increase or decrease the set-point value. You can also hold down the arrow keys for a faster adjustment of the set-point.

Note: The output can not be adjusted whilst the inhibit LED is lit. i.e. when the TR is interrupting the output.

2.4 Accessing the menu

To enter or exit from the menu at any time simply press the MENU button situated under the display. Whilst in the menu, the TR will operate normally even though the normal display mode is no longer visible.
To navigate through the various menu options press the MODE button and to adjust the parameters for any menu option use the UP / DOWN arrow keys.

For example: To adjust the low current alarm set-point you would do the following –

- Press the MENU button.
- Press the MODE button until the display reads ‘Low Curr Alarm’.
- Press the UP or DOWN arrow keys to adjust the low current alarm set-point to the desired value.
- Press the MENU button to exit the menu.

2.5 The SAVE button

After making any adjustment to the PC5x controller whether it be adjusting the output level or an adjustment to the mode of control or even a menu option, you must press the SAVE button in order to make these changes permanent. Failure to do this can result in different settings being applied to the controller during start-up in the event of a power loss to the controller.

The SAVE button can be pressed at anytime including during menu adjustments and will ensure that the current settings for the controller will exist on next start-up. When pressing the save button – the display will momentarily display ‘Saving Settings’ just so that you know that a save has occurred.

TIP: Try to press the save button after every adjustment you make to the controller – you can never save too often.

Section 3: The menu

The PC5x controller has a built-in menu which is used for adjusting various setup options such as output limits, alarm conditions, PID control parameters and remote control features. Please refer to the following sections for detailed descriptions on each of these options.

Note: When values within the menu are altered, the changes are instantly applied to the controller. However, to ensure the changes remain permanent – don't forget to press the SAVE button afterward.

For information on how to use the menu, refer to section 2.4 – Accessing the menu.

3.1 Voltage limit adjustment

This menu setting allows the operator to specify a maximum allowable output voltage. This value can be adjusted anywhere from 1V (minimum) up to the maximum output voltage in 1V increments. If the output voltage tries to go beyond this value the voltage limit LED will become lit to indicate that the voltage limit has been reached.

The factory default value for the voltage limit is equal to the maximum output voltage (Vmax).

3.2 Current limit adjustment

This menu setting allows the operator to specify a maximum allowable output current. This value can be adjusted anywhere from 100mA (minimum) up to the maximum output current in 100mA increments. If the output current tries to go beyond this value the current limit LED will become lit to indicate that the current limit has been reached.

The factory default value for the current limit is equal to the maximum output current (Imax).

3.3 Low current alarm adjustment

The low current alarm set-point found in the menu can be adjusted anywhere from zero amps up to the maximum output current in increments of 50mA.

The factory default value for the low current alarm is 15% of the maximum output current.

Refer to section 4 – Built-in alarms for more information.

3.4 High current alarm adjustment

The high current alarm set-point found in the menu can be adjusted anywhere from zero amps up to the maximum output current in increments of 50mA.

The factory default value for the high current alarm is 100% of the maximum output current.

Refer to section 4 – Built-in alarms for more information.

3.5 PID Control

The proportional gain, integral gain and derivative gain all form the PID control loop. The PID control loop is used to determine the amount of correction the controller must apply in order to reduce the error between the controller set-point and the measured feedback. Needless to say, inappropriate settings for the proportional/integral/derivative gains can adversely affect the output stability.

Differing load conditions found in the varying CP systems may require different PID control parameters in order to provide stability across all conditions.

Sections 3.5.1 to 3.5.3 discuss each of the gain factor adjustments in turn, don't worry if it all sounds a bit too confusing – **it is very likely that these settings will never need to be changed from the factory presets.**

3.5.1 Proportional gain adjustment

The most common adjustment to make is the proportional gain adjustment, reducing the amount of proportional gain will help to remove any DC output oscillations that can occur, on the other hand, increasing the amount of proportional gain will provide a faster rise in the output for tasks such as DCVG testing. An important thing to remember is that too much proportional gain can easily give rise to future instability.

Within the menu there is a proportional gain adjustment which can vary from 1 (Slow response) to 10 (Fast response).

The factory default value for proportional gain is 4. This should suit the vast majority of CP applications.

3.5.2 Integral gain adjustment

The integral gain adjustment can be used to compensate for instabilities relating to a high proportional gain. To help explain this concept lets take a look at the case of fast switching of the DC output.

If a TR output needs to cater for both a fast switching output as well as a good oscillation free continuously on state, proportional gain on its own may not be able to achieve this. A higher proportional gain will surely quicken the rise time of the DC output during fast switching but oscillations might still occur when the DC output is at a steady state. By increasing the integral gain, the fast switching performance can be improved together with steady state stability. Be careful though, too much integral can lead to excessive overshoot and instability occurring on the DC output.

Within the menu there is a integral gain adjustment which can vary from 1 (decelerated response) to 10 (accelerated response).

The factory default value for integral gain is 4. This should suit the vast majority of CP applications.

3.5.3 Derivative gain adjustment

The derivative gain is used to reduce the amount of overshoot produced by having too much integral gain operating in an effort to improve overall controller stability. Too much derivative gain can lead to steady state instability and also a reduction in the controllers' ability to reach a given set-point – particularly on power up or interruption.

Within the menu there is a derivative gain adjustment which can vary from 1 (less derivative effect) to 10 (more derivative effect).

The factory default value for derivative gain is 3. This should suit the vast majority of CP applications.

3.6 Remote 'Mode of Control' Select

If remote mode is enabled you might want to set what the isolated 0-10V remote input is equal to.

If 'Voltage' mode is selected then 0-10V equates to 0 - Maximum Volts as a set-point and voltage control is in effect.

If 'Current' mode is selected then 0-10V equates to 0 - Maximum Amps as a set-point and current control is in effect.

If 'Potential' mode is selected then 0-10V equates to +1 to -4 Volts as a set-point and potential control is in effect.

By pressing to MODE button, toggle through the menu options until you see 'Remote Control Mode =' and use the ARROW keys to adjust between the 'Voltage', 'Current' or 'Potential' selections.

The factory default value for this option is 'Remote Control Mode = Current'.

3.7 Remote Control Enable / Disable Option

The remote mode of control feature can be enabled or disabled in the menu. If not being used, it is a good idea to keep the remote control feature disabled. If disabled, the remote control mode will not be included when changing between the various modes of control (see section 2.2 – adjusting the mode of control).

By pressing to MODE button, toggle through the menu options until you see 'Remote Control =' and use the ARROW keys to adjust between the 'Enabled' or 'Disabled' selections.

The factory default value for this option is 'Remote Control = Disabled'.

Section 4: Built-in Alarms

The PC5x controller has built-in high and low current alarms with the following features:

- Adjustable high and low current alarms
- Built-in relay for external triggering
- 3% dead-band to eliminate sporadic triggering of the alarm
- 15 second delay on relay operation following alarm condition
- LED indicators to notify operator of an alarm condition

4.1 Low current alarm adjustment

By adjusting the low current alarm setting found in the menu, the operator can specify a low current threshold which can trigger an alarm using in in-built relay. As the output current moves below the low current alarm set-point, the low current LED becomes lit. A 3% dead-band ensures that the low current alarm condition remains until the output current rises to the low current alarm set-point + 3% of the output current range. After approximately 15 seconds of the low current alarm condition being met, an onboard relay will de-energise to trigger an external alarm of some kind. (e.g. a beacon or scada inputs etc)

The low current alarm set-point found in the menu can be adjusted anywhere from zero amps up to the maximum output current in increments of 50mA.

The factory default value for the low current alarm is 15% of the maximum output current.

4.2 High current alarm adjustment

By adjusting the high current alarm setting found in the menu, the operator can specify a high current threshold which can trigger an alarm using in in-built relay. As the output current moves above the high current alarm set-point, the high current LED becomes lit. A 3% dead-band ensures that the high current alarm condition remains until the output current falls to the high current alarm set-point - 3% of the output current range. After approximately 15 seconds of the high current alarm condition being met, an onboard relay will de-energise to trigger an external alarm of some kind. (e.g. a beacon or scada inputs etc)

The high current alarm set-point found in the menu can be adjusted anywhere from zero amps up to the maximum output current in increments of 50mA.

The factory default value for the high current alarm is 100% of the maximum output current.

Section 5: Output Inhibit Feature

The PC5x controller has an output inhibit feature which operates from a 24VDC voltage being applied to the inhibit input terminals of the controller. When the inhibit voltage is present, the controller output is shut off preventing the controller from outputting to the SCR devices (silicon controlled rectifiers). During inhibit, an LED indicator on the front panel will turn on to indicate that the TR is not outputting. As the inhibit voltage is removed, the TR will commence outputting incorporating a slow start.

Section 6: Technical Specifications

Input Voltage:	220-265 VAC 50Hz single phase
Control Type:	Digital Phase Angle Control
Control Modes:	Constant Voltage Constant Current Constant Potential (Reference Control) Remote Control (0-10V)
Max. Ambient Temperature:	70 degrees C
Control Accuracy:	Better than 2 % of control range (10% - 100% of full load)
Analog to Digital Conversion:	10 bit accuracy

Voltage Mode

Input Impedance:	100 k-Ohm
Max. Input / Output Range:	5 – 99.9 VDC (Factory pre-configured)
Input Protection:	Passive clamping arrangement
Set-point Resolution:	0.1 V increments

Current Mode

Input Impedance:	Greater than 1 G-Ohm
Max. Input Range:	20mV – 100mV (Shunt Voltage) (Factory pre-configured)
Set-point Resolution:	1mA increments for outputs of 1A or less 10mA increments for 1A < max. output current <10A 100mA increments for 10A < max. output current <100A 1A increments for 100A < max. output current <1000A

Potential Mode

Input Impedance:	Greater than 1 G-Ohm
Input Range:	+2 to -5 VDC
Input Protection:	Passive clamping arrangement
Control Range:	+1 to -4 VDC
Set-point Resolution:	10mV increments

Remote Mode

Input Range:	0-10 VDC isolated supply (0-5V available on request)
0-10V Input Impedance:	100 k-Ohm
Control Range:	See control range for required control mode (above)
Set-point resolution:	See set-point resolution for required control mode (above)

Metering

Meter type:	16 character 2 line backlit LCD display With wide operating temperature range
Voltmeter range:	Zero to 125% of maximum TR output voltage
Voltmeter resolution:	0.1 VDC
Voltmeter accuracy:	1% of range (10VDC as maximum output voltage) 0.2% of range (50VDC as maximum output voltage) 0.1% of range (100VDC as maximum output voltage)

Technical Specifications (cont'd)

Ammeter range:	Zero to 125% of maximum TR output current
Ammeter resolution:	1mA for max. output current of 1A or less 10mA for 1A < max. output current <10A 100mA for 10A < max. output current <100A 1A for 100A < max. output current <1000A
Ammeter accuracy:	$= \frac{\text{(ammeter resolution (A) x Max. output current (A))}}{100}$ %
Reference meter range:	+2 to -5 VDC
Reference meter resolution:	10mV
Reference meter accuracy:	0.2 % of range or better

Alarms

Alarm type:	High and low current alarm
Low current alarm range:	Settable from zero to max. current range
High current alarm range:	Settable from zero to max. current range
Alarm set-point resolution:	Adjustable in 50mA increments (Lower increments are available on request)
Alarm indication:	1 red LED for low current alarm condition 1 red LED for high current alarm condition
Alarm dead-band:	3 % of maximum current
Alarm relay trigger:	High or low current alarm present for 15 seconds
Alarm relay contacts:	Normally open clean contacts
Alarm relay ratings:	1A / 24VDC MAX or 0.5A / 125VAC MAX

Inputs / Outputs

Inputs:	Power input - Active Power input - Neutral Inhibit - +24V Inhibit - 0V Voltage sense - V+ Current sense - SH+ Current sense - SH- Reference Input - REF Structure Input - STR Remote input - 10V Remote input - 0V
Outputs:	Alarm contact - C1 Alarm contact - C2 Gate drive 1 - G1 Gate drive 1 - K1 Gate drive 2 - G2 Gate drive 2 - K2

