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DESCRIPTION AND OPERATING INSTRUCTIONS FOR THE POTENTIO-GALVANO-SCAN MODEL PGS 2001D



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1. Principle and application of the PGS 2000D

The phase angle inside the PGS 2001D does not exceed 90° so that a further 90° margin remains for the electrochemical cell. The low-pass filter inside the potentiostat has a time constant of approx. 10^{-6} sec for full feedback from output to input. The phase angle of the electrochemical cell must never exceed 90°, otherwise the control becomes unstable and the system oscillates. The danger of the cell phase angle exceeding 90° increases when using high impedance reference electrodes in connection with large double layer capacitance's

When the output control limit of the PGS 2001D is reached, i.e. when the voltage demand at the counter electrode exceeds 35V, the overload lamp lights up. When this lamp is bright the potentiostat no longer produces full control either in the potentiostatic or in the Galvanostatic mode.

2. Switching on and Operation

2.1. Mains Supply

The instrument is normally supplied for operation on 220V 50 Hz. a.c. supply unless a different mains supply is specified in the order. The mains supply is marked near the cable entry at the back of the instrument. The primary of the mains transformer has 2 windings tapped 0-100-115-120V each for series and parallel connection. Apart from these values which form the supply voltages with the windings in parallel, the transformer windings can be connected in series for a.c. supply voltages of 200, 215, 220, 230 and 240V 50 to 60 Hz. The circuit diagram shows two values for the primary fuse of the PGS 2000D. The higher fuse rating applies to primary windings in parallel for 100 to 120 V, the lower value to series connection for 200 to 240 V. The 3-core mains cable connects the two poles of the supply as well as the supply ground to the instrument's housing. This ground connection must never be interrupted. When the instrument is connected to other grounded instruments it is possible to avoid a ring ground by removing the link plug below the mains switch on the front panel. This link plug connects the grounded housing to the instrument zero.

Where the grounding to the mains supply is not reliable, as for example in laboratories with obsolete electrical wiring, it is possible to connect an external instrument ground to the uninstalled socket below the mains switch on the front panel

The supply voltage stabilization can deal with mains voltage fluctuations between + 10 % and - 5 % and + 30 % have no effect.

The use of a stabilized supply for the instrument is unnecessary and offers no advantages unless the mains supply is very poor and the fluctuations frequently exceed ± 10 %

2.2. Switching on and zero adjustment

Before switching on the "Operating Selector" is set to "O". In this position the electrochemical cell is disconnected and the control circuit is closed internally on a cell replacement resistor. The instrument is switched on by operating the mains switch on the left of the front panel. The mains lamp lights up and the instrument is ready for operation immediately after switching on.

The electrical zero should be checked annually; occasionally it may also prove necessary to adjust the mechanical zero of the meter. The meter is first zeroed at high sensitivity and the range switch is then moved to a low-sensitivity step (e.g. 1A); any error is corrected using the

instrument trimmer. With very critical investigations when potential errors smaller than 1mV become importantly it may be necessary to check the zero every month. Before making this adjustment the instrument should be operated for about 15 minutes with the "Operating Selector" in position "O".

The zero adjustment starts with the main (common) zero of the instrument. The corresponding trimmer is located between the "Control Input" sockets. After removing a link plug at the "Control Input" a sensitive milivoltmeter (0,1mV sensitivity, input impedance greater than 100 K), is connected from the green to the black (low) socket. A suitable instrument is a digital voltmeter with a sensitivity of $\pm 0,1$ mV. The trimmer is adjusted so that the deviation does not exceed 0,1 mV. After the adjustment the milivoltmeter is removed and the link plug replaced in position.

With the range switch set to maximum sensitivity (0,1v full-scale deflection) and the "Control" switch set to E, the meter is zeroed using the trimmer adjacent to the "Current Output" The operation is then repeated with the "Operating Selector" set to E_S and the "Multiplier" on O, using the trimmer adjacent to "Potential Output". It is essential that the adjustments are made in this sequence. The recorder output terminals for current and potential have now been zeroed, with the potential measured on the red (high) socket against the black (low) socket,

A more accurate zero adjustment can be reached if a digital voltmeter is connected to the current and potential output terminals having a sensitivity of ± 1 mV. Correction is made in "0" position of the "Operating Selector" switch with the adjacent trimmers. The sequence first current and second potential remains essential.

The trimmer for the "Inverting Current Output", blue socket against black socket, is located inside the instrument adjacent to the operational amplifier 741 to the right of center on the circuit board. After the instrument has been operating for a considerable time the inverting current output can be zeroed there on the 10 K trimmer after the non-inverting current output has been set to zero.

2.3 Adjusting the Scanner

The scanner is best adjusted with the "Digital Voltmeter" switch set to E_S . The "Control" switch is set to E, the "Range" switch to a suitable voltage sensitivity, e.g. 0,2, 2 or 20V for larger scans. The electrochemical cell is still separated from the instrument in position E_S so that adjustment and checking of the scan does not affect the cell.

All the scanner controls are located to the left of the meter. The start potential is set on the dial "Potential Initial (A)" and its polarity on the toggle switch below. Position "-" produces cathodic polarization of the working electrode "+" anodic polarization. The range of the dial (1000 divisions) corresponds to 1000 mV with the "Multiplier" switch set to 1, 2000 mV in position 2 and 5000 mV in position 5.. To speed up the check press the key "Fast Run" until the lamp "Run" goes out. The Voltmeter now indicates the start potential; deflection to the left represents a negative absolute potential, deflection to the right a positive potential in potentiostatic operation, or cathodic current (left) anodic current (right) in Galvanostatic operation. In potentiostatic operation the rest potential must, of course, be taken into account in establishing the polarization relative to the reference electrode.

The final potential of the scan is set on the dial "Potential Final (B)", its polarity on the switch above it.. For last changeover from A to B press "Run" and "Fast" together until the "Run" lamp goes out. Read Final Potential on D. Voltmeter.

The meter reading is subject to a tolerance of 1 % through the inherent accuracy of the meter. More accurate results are obtained on the dials whose tolerance is only 0,2%. If necessary, even more accurate measurements of the scan can be made at the output sockets "Scan Out" digital voltmeter (only in position "Es").

After the switch Run "A,B" has been operated the scan runs towards the potential "A" or "B". The slowing speed of the scan is selected on the coarse switch "Scan Rate" and on the dial below it which provides fine adjustment of all scan rates between the coarse steps over the range from 1 000 to 100. Position 1 00 corresponds to a 10-fold reduction in scanning speed; the adjustment should not be moved below 1 00, the next lower coarse step should be selected instead. At the lowest coarse step (0.01 mV/sec) the scanning rate can be slowed down to a dial setting of approx. 300, i.e. down to 0.003 mV/sec corresponding to about 10mV/hour. Below this value the scan loses linearity and the final potential may not be reached so that the "Run" lamp does not go out.

2.4 Connecting up the cell, ground connection

The electrochemical cell should be set up to the right of the PGS 2000D and connected to the instrument by the cell cable supplied, preferably without extending it. The connections for the various cell electrodes are color coded as follows:

Electrode	Color (banana plug)	5-pole plug (cable)
Reference electrode	white	pin 3
Counter electrode	red	pin 2
Working electrode		
potential lead	yellow	pin 5
Ground	black	pin 1
Screen of reference electrode	no connection	pin 4

With the "Operating Selector" set to "ES" or "O" the electrode connections are disconnected internally so that all preparations can now be carried out. It is important that both banana plugs, are connected to the working electrode. The single-core cable (potential lead) should be nearer the actual working electrode than the current lead (multi-core cable). This avoids errors through contact resistance's in the current supply which may have an appreciable effect on potential control at higher current levels.

Metal components near the cell should be grounded to the PGS 2000D unless they are already grounded otherwise. Any metal stand in particular should be grounded to the light gray plug of the cell cable, making a sound electrical connection. It is important to avoid the formation of a ring ground through the use of two separate ground connections. A ring will nearly always cause induced hum.

Metal screening of the cell is only necessary when measuring very low currents or when the reference electrode has a high impedance. It is important to set up the cell away from mains supply panels and mains cables. Electrical equipment with a strong magnetic field, such as magnetic stabilizers or control transformers, should never be placed close to the cell. Iron components near the cell may cause a concentration of magnetic stray fields within the laboratory on to the cell. While it is fairly simple to

screen the cell against electrical fields, the induction of hum through magnetic fields can be avoided in practice only by a suitable positioning of the equipment.

When using high-impedance reference electrodes (appreciably higher than 10kOhm) the cell should be screened. An aluminum sheet formed into an angle so that the front remains open is usually quite sufficient. The sheet together with a stand is grounded through the gray plug of the cell cable.

2.5 Measuring the rest potential, "Control" switch on E

The rest potential of the cell can be measured in position '-ER' and with the "Range" set to 0.2 to 20V fsd of the meter. The rest potential of the current-free cell can also be measured at the "Potential Output" terminals. Any digital voltmeter used for precise measurement should have an input impedance greater than 1 MOhm since the output impedance of the potential output is 1 K.

In position '-ER' the internal meter as well as a digital voltmeter connected to the potential output indicates the potential of the reference electrode relative to the working electrode. With a meter deflection to the right, or a positive reading on the digital voltmeter, the working electrode is cathodic relative to the reference electrode, and vice versa. To call special attention to this fact the position is marked "-E R".

When the rest potential of the cell corresponds to the starting potential of the scanner, the 'Operating Selector' can be switched directly to position "I" for potential control of the cell. The cell current remains zero since the cell is controlled at the rest potential.

Scanner start potential and cell rest potential are equal when the deflections in positions 'ES' and "-ER" of the "Operating Selector" are equal but of opposite polarity; as mentioned before, the position "-ER" shows the potential of the reference electrode relative to the working electrode.

2.6. Potential control of an electrochemical cell, "Control" switch on E

When the "Operating Selector" is moved from "-ER" to "I" the cell electrodes are connected to the potentiostat control circuit. The potential between the working and reference electrodes is controlled at the start potential, assuming that no additional external control signal is applied to one of the inputs. This start potential can be recorded at the "Potential Output". If the start potential differs from the rest potential, the corresponding cell current is indicated on the meter. A suitable value for the current sensitivity of the meter is selected on the "Range" switch. The figures at the "Range" switch correspond to full-scale deflection of the meter in mA. Deflection to the right corresponds to anodic current of the working electrode and vice versa.

Current density/potential curves can be recorded either on an XY recorder or with an oscilloscope. Virtually all modern instruments of this type are suitable for recording. The input impedance should be at least 10 M. Ohm. The recorder does not have to have a floating input; it is preferable, however, to work with a floating input since this avoids difficulties from ring grounds. If the recorder input is grounded, as in many storage oscilloscopes, it is convenient to interrupt the ground connection of the potentiostat by pulling out the link plug below the mains switch. The system is then grounded through the ground connection of the oscilloscope which should be connected to the black sockets of the recorder outputs. On most potentiometric recorders the input can be operated either grounded or floating; a floating input should then be selected. When using a floating inputs always be connected with the black socket on the potentiostat recorder output. With true differential inputs the polarity is immaterial.

The choice of recorder sensitivity for the potential or X-axis can readily be determined from the scan selected. It can be checked with the operating selector set to 'ES'. With a scan starting from - 1000 mV and going to + 1000 mV, the entire scan covers 2000mV. The X-sensitivity on the recorder can be

set to 50mV/cm, giving a scan of 40cm in the X-direction. When connected with standard polarity the recorder moves from right to left since the potential output produces the voltage of the reference electrode against the working electrode. Normal polarity is: recorder input X, positive connected to red socket and negative to black socket of the potential output. This form of recording does not cause any difficulty since current recording is also reversed relative to the electrochemical notation; simply rotating the chart produces the characteristic in the form usually presented in electrochemistry, cathodic left and bottom, anodic right and top. In observing the formation of the curve the record has to be viewed from the back of the recorder in order to obtain the standard form of presentation.

The recorder sensitivity in the current or Y-axis should be selected to suit the full-scale deflection of the meter. The output voltage at the "Current Output" sockets is 1 V for full-scale deflection. For example, if a current range from -150mA to +300mA (anodic) is expected, the total current span is 450mA, or 1.50V at the "Current Output" sockets when the "Range" switch is set to 300mA. With a recorder sensitivity of 50V/cm this current span corresponds to a movement of 30cm. The zero should be set at 20cm since anodic currents are recorded downwards when the Y-channel of the recorder is connected with its positive input to the red socket and with its negative input to the black socket of the "Current Output".

Deflection beyond full scale on the meter does not endanger the instrument since it is protected against overloads. Up to a factor of 2, corresponding to 2V at the "Current Output", there is no appreciable limitation in the accuracy of potential control; when the factor exceeds 3 there is a loss of accuracy. Beyond a factor of 5 the loading limit is exceeded. Factor 3 should not be exceeded; in addition to the loss of accuracy the range resistors on the "Range" switch for the settings 30mA to 300mA become overloaded. Over control is not possible within the ± 1 A range since the current clipper stops a further rise at about ± 1.2 A.

After the recorder has been adjusted as explained above the potential scan can be started. The switch "A, B" on the scanner is moved to "B" and the scan runs at the selected speed from potential A to potential B. The "Run" lamp goes out to indicate that potential B has been reached. Recording can now be stopped, or the test can be run back to the start potential by switching back to "A".

External control voltages (sinusoidal, square-wave pulses) can be superimposed on the scan through the "Control Inputs". A positive control voltage at the "Control Input" produces additional anodic polarization of the working electrode relative to the reference electrode, and vice versa. Any inputs not in use must be kept shorted with the link plugs.

2.7 Current control of an electrochemical cell 'Control' switch set to CELL

The connection of the electrochemical cell to the PGS 2000D through the cell cable remains the same as described in Section 2.4 for potentiostatic control.

Galvanostic control of the electrochemical cell by the PGS 2000D with the "Operating Selector" switch in position Cell should normally begin in the zero-current condition. With the current scan set and ready to run, this is achieved by simply setting the "Multiplier" switch to 0. Assuming that no external voltages are applied at the 'Control Inputs', the system is then set to control the cell at zero current.

The current scan program is set on potentials in the range, ± 1000 mV ('Multiplier' setting 1) since 1000mV correspond to full -scale deflection current on the meter. The current range is selected on the 'Range' switch where current ranges from ± 10 μ A to ± 1 A are available in steps of 1: 3: 10.

Example: The cell current should be scanned over the range from -150mA (cathodic current of the working electrode) to +300mA (anodic current). The "Range" switch is set to 300mA. Potential A is set to 500 and '-', the potential B to 1000 and '+'. The switch "A, B" is set to "A". The scan rate is converted so that full-scale deflection of the meter as selected on the "Range" switch (here 300mA) corresponds to 1000 mV. Thus, if 300 mA is to be scanned in 1000 sec., the coarse 'Scanning Rate' is set to 1 mV/sec (fine dial on 1000). When the "Run" lamp has gone out, the scanner is on the start potential required to produce -150mA. By moving the "Multiplier" switch from 0 to 1 this current value is now under control within the cell. Moving the control from the start to the final value ("A, B" moved from 'A' to 'B') causes the cell current to change linearly from -150mA to + 300 mA in 25 min.

The potential difference between reference electrode and working electrode caused by the current density at the working electrode boundary layer can be taken from the "Potential Output" sockets and recorder. The "Current Output" sockets reproduce the current scan.

It is possible to check the current scan before the actual experimental run. The 'Control' switch is set to I and the selector to position ES; the actual current scan can now be produced. The "Range" switch must only be set to positions up to 10mA; for higher values the voltage limit of the equipment is exceeded, taking into account the cell replacement resistance of 1 K ohm, and the overload lamp lights up. In the ranges 0.1 mA to 10mA the meter reading is independent of the "Range" switch setting. Cathodic current is to the left, anodic current to the -right on the meter scale.

The rest potential can also be measured during galvanostatic operation ("Control" switch on I) by moving the "Voltmeter Selector" to "Ers". The meter reading always corresponds to 1V full-scale deflection, irrespective of the "Range" switch setting.

2.8 IR potential drop, error compensation

For purely mechanical reasons the reference electrode capillary cannot be advanced as far as the plane of the double layer on the working electrode. Due to this unavoidable condition there is a potential drop between the plane of the capillary tip and the boundary layer of the working electrode whose potential has to be controlled. This potential drop is proportional to the current density and inversely proportional to the electrolyte conductivity. It only becomes important where the current density is high or the conductivity of the electrolyte is very low.

In certain applications of potential control within a cell it is possible to replace this potential drop by a reasonably constant electrolyte resistance R multiplied by the cell current I . A constant electrolytic resistance in series before the boundary layer of the working electrode can obviously be compensated by feeding back into the input a voltage drop which is proportional to the current. Accurate determination of the value of this resistance does, however, raise considerable experimental difficulties. In most cases it is also by no means certain that this measured electrolyte resistance remains constant with changes in potential, with changes in current, when chemical reactions take place in the boundary layer, during temperature fluctuations, and especially with movement of the capillary tip relative to the working electrode boundary layer. Methods for evaluating this electrolytic series resistance have been described for special applications but their discussion goes beyond the scope of these Notes.

The PGS 2000D has provision for applying IR drop compensation provided the assumptions for the use of the method, an approximately constant electrolytic series resistance, are valid. A voltage drop relative to ground, proportional to the cell current, is available at the "Inverting Current Output" terminals (blue,

black). Part of this voltage (using an external potentiometer voltage divider) can be fed back into one of the superposition "Control Inputs". Positive feedback proportional to the current increases the control voltage by an amount which is proportional to the resistance selected on the "Range" switch and to the cell current. With an external potentiometer voltage divider the corresponding part of the resistance produces the positive current feedback.

The resistance's inserted in the various "Range" settings are as follows:

Setting	Resistance		
0.1	10	K	} 0.1 %
0.3	3.33	K	
1	1	K	
3	333	Ohm	
300	3.33	Ohm	} 0.5 %
1 A	1	Ohm	

The resistance's are generally too high for positive current feedback for I R drop compensation. It is advisable, therefore, to insert a resistance before the external feedback potentiometer (for which a suitable value is 10-turn 10K). A voltage division in the ratio 10:1 is approximately right and produces appropriate values for the electrolytic series resistance to be compensated within the range of the external potentiometer.

Example: 90 K series resistance between the blue "Current Output" socket and the upper connection of the 1 OK potentiometer, lower potentiometer connection on the black socket, slider to one of the green "Control Input" sockets.

A rough approximation to I R drop compensation can be obtained from the response to a step input as seen on an oscilloscope, without having previously determined the electrolytic series resistance. A 1 kHz square-wave pulse of approx. 10mV amplitude is applied to one of the "Control Inputs" and thereby added to the scan. The amount of positive feedback is gradually increased from zero using an external 10 K.Ohm potentiometer until the step response on the oscilloscope connected to the potential output indicates appreciable overshoot. Under these conditions at least the major part of the electrolytic series resistance has been compensated. This assumes, of course, that there is a double layer capacitor in the boundary layer of the working electrode, a condition which is present in most applications.

The problems of I R drop compensation can only mentioned briefly within the scope of these Operating Instructions. It should be pointed out, however, that the I R drop may be over-compensated up to a factor of 2 without causing instability of the control circuit; this statement contrasts with opinions often found in publications on this subject. Loss of system stability occurs only when-the total resistance of the control loop has been compensated; this condition drives the potentiostat towards maximum output, resulting in rapid destruction of the carefully prepared specimen. Experiments incorporating I R drop compensation should only be performed by persons with extensive experience and in full knowledge and appreciation of the processes involved.

It is always advisable to check in each individual case whiter the I R drop can be kept sufficiently small by a suitable cell design so that it can be neglected in determining the characteristics.

2.9 Switching off. Maintenance

Before the instrument is switched off, the "Operating Selector" should be set to 'O' to ensure that the cell cannot receive uncontrolled currents from the energy stored in the instrument.

If the potentiostat is out of use for a longer period it should be covered with a sheet of plastics. It should be removed from any areas where chemical vapours are likely to be present. After a prolonged period of non-use all switches should be operated several times so that the self-cleaning action of the knife blades can restore reliable contact during operation. Following several years' use it may be found that sound contact cannot be obtained despite repeated operation of the switches; a good-quality contact spray should then be applied to the contacts of the rotary switches while they are being operated.

Apart from these points the PGS 2000D is essentially maintenance-free except for the adjustments described in these Instructions. With heavy dust deposits it is advisable to clean the instrument with compressed dry air. Any dirt not removed by this means can normally be cleaned off with a clean, soft brush. Methylated spirits is usually satisfactory for removing deposits from the printed circuit board; it is applied lightly with a clean brush and removed with a clean absorbent cloth.

3. Circuit description

3.1 Power supply and stabilization

The rectified a.c. voltage of the transformer charges the capacitors 2.200 p F to about + and - 36 V. The zener diodes ZD 22 stabilize a voltage of + and - 22 V (tolerance ± 1 V). The operational amplifiers 10 and 11, supplied with 22 V each control the general supply voltage to + and - 16 V (± 0.5 V tolerance), measured across the capacitors 47 p F. This general supply voltage for all the operational amplifiers 1-9, except the power amplifier 5, is highly stabilized. It is controlled according to the reference diodes 1 N 4576. A feedthrough of either ambient temperature changes or line voltage variations on the general supply voltages can be neglected.

The power output amplifier 5 has its own stabilization and is therefore supplied with the unstabilized voltage of + and - 36 V.

The load current of the stabilized ± 16 V supply is about 20 mA. This current can be measured across both the 100 Ohm resistors at the collectors of the BC 182 and BC 212 transistors, producing a 2 V voltage drop there.

The complete supply voltage stabilization is situated on the left side of the printed board.

3.2 Potential/current converter

The operational amplifier 1 and 2 (Type of RCA) are MOSFET types providing high input impedance, gain and bandwidth. Their noninverting input terminal is connected to the potential of the reference (1) or the working electrode (2). Op-amp 1 provides the potential difference between both electrodes. The output voltage of Op-amp 2 is proportional to the current of the working electrode and to the ranging resistor.

The operating mode of the high gain amplifier 4 and 5 is selected by the toggle switch "Control" E/I to either potential (E) or current (I) control.

Both the Op-amps 1 and 2 provide a twofold gain, that is reduced to unity at the output terminals by precision voltage dividers (2 K 0.1 %). The output resistance of the "Potential" and "Current Output" terminals is exactly 1 K. This output resistance should be taken into consideration, when external meters

or recorders are connected to the outputs, or when noise reduction is needed by insertion of a low pass filter. The low pass filter time constant is formed by this internal 1 K resistor and by an external capacitor bridging the output terminals.

When the "Operating Selector" switch is switched to 0 position both the Op-amp 1 and 2 have zero input. If zero adjustment of 2 and 1 (succession is important, see chapter 2.2 zero adjustment) is possible, it can be supposed that the buffers operate correctly.

Operational amplifier 1 is situated on the printed board slightly left below the "Operating Selector" switch, operational amplifier 2 slightly on the right from the switch.

Operational amplifier 3 only inverts the output voltage of 2. Its internal zero trimmer should only be operated, if the zero output is adjusted at operational amplifier 2 in advance. Op-amp 3 together with its zero trimmer is placed behind 2 on the printed board.

3.3 Operational amplifier of the potentiostat

Operational amplifier 4 is the high gain voltage amplifier of the feedback circuit. Its inverting input is biased to zero, the noninverting input is feedback-controlled to virtual zero. That means, the sum of all currents flowing to this input is practically kept at zero. Since the total gain of the potentiostat is about 1 mil I ion, deviations from virtual zero remain considerably below 0.1 mV. So it is convenient to adjust the zero to less than ± 0.1 mV deviation.

Operational amplifier 4 is placed in the back part on the right hand side of the printed board. Its zero trimmer can be reached between the control input terminals. If adjustment to virtual zero, as described before in chapter 2.2, is possible, it can be supposed that op-amp 4 operates correctly.

3.4 Output power stage

Operational amplifier 5, the power amplifier LS 81, is supplied with unstabilized voltage. Only the current across the input transistors is stabilized by the Zener diodes ZD 22 and ZF 15. This stabilized current determines the rest current of the complementary Power-Mos-Stage, that should have a magnitude of 50 to 100 mA. The rest current in the power stage is adjusted by both trimmer potentiometers 2.5 K, so that the voltage drop across the 2.2 Ohm (5 W) source resistors is in the range from 100 to 200 mV.

The trimmers are adjusted iteratively to receive both: The rest current within its correct range and the common input control point near to zero. This common input point is the contact of both emitter resistors 1 K together with the input resistor 2 K and the feedback resistor 20 K. Deviations at this point should remain below ± 0.1 V. Please pay attention, when measuring or readjusting, that the instrument, used to measure the deviations from zero at the common input point must not have a capacitance load in the input. If the meter has an input capacitance, a preresistor of at least 10 K must be used, otherwise oscillations may appear leading to wrong adjustment results.

Op-amp 5 - LS 81 - is separately wired on the printed board set up to the heatsink at the backside of the instrument.

3.5 Scanner

The scanner mainly consist of an analog integrator controlled by the operational amplifier 6 in cooperation with a comparator op-amp 7. The input of the comparator is fed with a highly precise and stabilized voltage, provided by two 10-turn potentiometers A and B alternatively. If the output voltage of the integrator (6) reaches the preset potentiometer voltage, the output of (7) decreases to zero. The integrator is then comprised in a feedback circuit operating to keep the output voltage of (6) exactly at the preset potentiometer level. A differential input of only 1 mV between the preset level and the integrator output results in full output and maximum feedback of the comparator, clipped to ± 5 V at the "Scan Rate" (fine) potentiometer within the feedback circuit.

The output voltage of the integrator (op-amp 6) within the range of ± 5 V then is divided by the 'multiplier' voltage divider to ranges of ± 1 V, ± 2 V or ± 5 V alternatively, to form the actual scan.

If the comparator has a difference input beyond ± 1 mV the signal lamp "Run' lights indicating that the scan did not yet reach its final magnitude.

The precision voltage of + and - 5 V is provided by the operational amplifier 8 and 9 and stabilized by a reference zener diode. Adjustment to the correct magnitude can be made by the internal trimmer 1 K.

The operational amplifiers 6, 7, 8 and 9 are placed in the middle part of the printed board from front to backside.

PGS 2000D k with reversing scan

Changes in operating procedure

Potentiostatic operation (selector switch on E) Potential A is always the start potential.

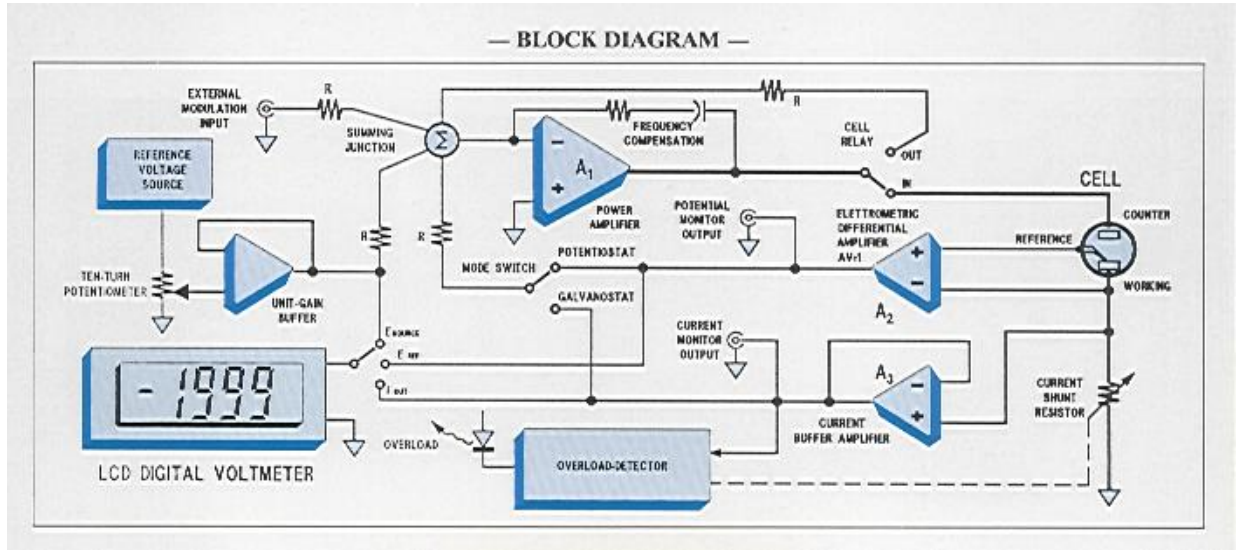
With the toggle switch set on P (potential) the scan runs from potential A to potential B, then reverses and runs back to the potential A.

With the toggle switch set on C the scan starts from potential A and runs to a current selected through the range switch (both polarities are possible) and then reverses back to potential A. With the potentiometer dial B set to 1000 divisions the scan reverses at the current corresponding to full-scale deflection of the meter. Within the selected current range the value of the reversal current decreases linearly down to zero with the setting of potentiometer B.

The scan is started with the "RUN" key. During the scan the lamp in the "Fast" key is alight,

Galvanostatic operation (selector switch on I)

With controlled cell current the scan always runs from the starting current selected on the potential A dial to the final current selected on the potential B dial and then return to the starting current, irrespective of the position of the C/P toggle switch.



TEKNİK ÖZELLİKLER

Giriş empedansı	: 10 M.OHM dan büyük
Giriş limitleri	: ± 10 V.
Band genişliği	: 2 MHz. Potansiyel Mod'da
Çıkış tepkisi	: 75 V/ μ san.
Ref Elektrot girişi	: 10 E 12 OHM.
Potansiyostat	:
Kontrol giriş empedansı	: 10 M. OHM. Bağımsız İki Giriş Terminali.
Kontrol giriş voltajı	: ± 10 . (Toplam 20V.)
Operasyon limitleri	: ± 35 V. 1.2 A.
Maksimum Çıkış Gücü	: 40 W.
Gösterge Analog	: Analog, sıfırı ortada, Anodik ve Kadodik akımların izlenmesinde uygun geniş skala.
Gösterge Digital	: Cihaz ön panelinde seçildiğinde voltaj tarayıcı veya Rest Potansiyel Voltajı Digital göstergede okunabilir. Tarayıcı Başlangıç, tarayıcıbitiş voltajları okunabilir. Tarama süresince tarayıcının bulunduğu voltaj sürekli sayısal olarak izlenebilir. 3,5 DİĞİT 0.2, 2, 20 V. Ful Skala seçilebilir. Çalışma limitleri dışına çıktığında OVERLOAD ikazı.
Akım Aralığı	: Ful Skala 0.1 mA. 0.3, 1,3... 300. 1000 mA.(1A)'e kadar Dokuz kademeli seçilebilir.
Doğruluk	: Cihazın Ful Skala doğruluğu her kademedede en az $\pm \% 0.1$
Akım/Gerilim Çevirici	: Akım seçici komitatörün her konumunda X - Y Yazıcıya Full skala 1V. Akım/Gerilim Dönüştürücü.
Çıkış Terminalleri	: Yazıcı Y eskisi için CURRENT (Full Skala 1 V.)
X Eksenini için Voltaj tarayıcı Çıkışı.	Galvano Modunda Sabit ya da Taramalı Akıma karşılık Potansiyel Çıkış terminali (Yazıcı Y eksenini için).
Voltaj Tarayıcı	: ± 5 V. Sınırları içinde, Ayarlanan Başlangıç ve bitiş Potansiyeli setlenen tarama hızında başlangıçtan bitiş potansiyeline gider. Buradan da başlangıç potansiyeline geri döner. Tarayıcı voltajı ve tarayıcı hızı full skala 1,2 ve 5 ile çarpılarak ince ayar yapılabilir.
Tarama hızları	: 6 adımda 0.001, 0.1, 1, 10, 100, 1000mV/san. seçilebilir. Ara değerler için 10 Tur'lu skalalı Dial ile ayarlanabilir. 1,2 ve 5 ile çarpılarak 5000mV/san. tarama hızı seçilebilir.
Sinyal-Gürültü oranı	: >80 dB.
Koruma	: Her konumda Çıkış Terminalleri Kısa Devre Korunmalı
Aksesuarlar	: Hücre Bağlantı Kabloları, Harici Giriş Terminal Bağlantı Kabloları.220V Şebeke kablosu.
Çalışma gerilimi	: 220 Volt/50Hz. ± 15
Garanti	: Sistem, 1 (Bir) Yıl Ücretsiz parçalı Firma Garantisindedir.