HYDROGEOLOGICAL REPORT 82/4

A REAUTIVITY RECEIVER FOR

HYDROGEOLOGICAL INVESTIGATIONS

GROUP 3

PONZI

FONNES"
Contents:

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3. Calibration
4. Operation

Appendix A: Electronic Parts List

Appendix B: P17 351/280 mV Operating Instructions
The function and operation of the present instrument are basically the same as those of a prototype instrument, described in a previous document. However, the techniques employed here have, however, substantially changed from those of the prototype instrument. In fact, all improvements suggested in the earlier document have been incorporated into the present receiver.

The receiver in its description was designed to read voltages in three ranges of 2000, 200, and 20 millivolts full scale. It provides for automatic compensation of d.c. noise voltage of up to ±300 mV, and in addition, the manual offset of noise voltage of up to ±300 mV on all ranges.

Received signals after compensation for d.c. voltage can read directly from a 3½ digit 2.5-P.M. In addition to a centre zero, a 10-turn 1-milliampere potentiometer is provided to adjust the total input signal (i.e., d.c. voltage plus signal) in the range ±150 millivolts.
The system can be logically divided into the following functional blocks:

1. 2.5 kHz Oscillator
2. Input Buffer
3. Variable Gain Amplifier
4. Track and Hold Circuit
5. Digital Panel Unit
6. Analogue Voltmeter
7. Power Supply

Manual control of the incoming signal in the range ±300 millivolts is provided by a 10-turn potentiometer R1 in combination with diode D1 and resistors R2 and R3.

The incoming signal is then applied to the high impedance buffer comprising IC1 and OI in a voltage follower configuration.

The total incoming signal is displayed on an analogue millivoltmeter,

Component W1 in combination with IC2 and R4, resistor R26 protects the 1 milliamp meter movement by limiting the current to ±1.8 milliamps. Resistor R5 provides a 50% scale shift to the meter by supplying a constant 0.5 milliamps from the regulated 5 volt supply. This effectively converts W1 into a linear zero movement.
After calibrating, the selected voltage is
applied to a variable gain inverting amplifier
built around IC3. Range switch SW2
selects gain of -0.1, -1.0 and -10 and
so provides a full scale output of -200
millivolts of this stage on all voltage
ranges.

A means of inversion of the selected voltage is
provided by the unity gain inverting amplifier
incorporating IC4. The signal is then applied to the 3½ digit panel meter M2.

Besides providing inversion, IC4 also
comprises a differential amplifier stage
by means of which the S.P. voltage tracked
and held by IC5, IC6 combination
is automatically offset. The operation of
this circuit is as follows:

On closing switch SW3 a negative
feedback loop is established from the output
of IC4 via an integrator (IC5) and a
sample and hold amplifier (IC6) to the non-inverting
input of IC4. The required negative feedback
is achieved by the inverter produced by
the inverting amplifier.

An output at pin 6 of IC4 causes
the integrator to ramp up and charge
the sample and hold capacitor C7 via
resistor R18. The capacitor voltage rises
until its value is sustained by IC6 and
attenuated at the R19, R20 combination equals
One half the output voltage of the preceding stage. Since the gain of R14 for n-mosfet at
the non-inverting input is 2, the output of IC1
in the absence of any voltage offset on
the IC's will now be 5V (offset can be taken
care of by the R21 - R23 combination).
On opening switch SW3 the voltage on
pin 3 of IC4 necessary to zero the output
is maintained by the sample and hold
amplifier (IC6 in combination with IC7).

This allows technique allows the automatic
effort of the minor voltages of up to ±300
millivolts at the output of IC3. Allowing for
resampling of the signal by IC3
this corresponds to ±300, ±700 and ±300
millivolts on the 1000, 200 and 20 millivolt
ranges respectively i.e. ±150 % of all voltage
ranging.

Power to the instrument is supplied by a
regulated 5 volt supply necessary to power
IC9 as well as to offset R14 is provided
by voltage regulator IC7.

The 18 volt supply is supplied by
the R25, R26 combination and displayed
in volts on meter Ms.
Calibration

Prior to calibration the instrument should be first compensated for offsets as described in the next section. The calibrating operation then proceeds as follows:

1. With range switch SW2 in the 200 millivolt position and switch SW1 closely fast and the display key momentarily depressed.

2. Quickly open switch SW1 and apply a known voltage of approximately 200 millivolts to the inputs.

3. Adjust trim pot at the rear of the instrument until the display shows the correct voltage.

4. Repeat steps 1 and 2 with the range switch in the 5000 millivolt position and a reference voltage of approximately 1900 millivolts.

5. Adjust the 10K trim pot R9 until the display shows the correct input voltage.

6. Repeat steps 1 and 2 with the range switch in the 20 millivolt position and a reference voltage of approximately 19 millivolts.

7. Adjust the 100 ohm trim pot R13 until the display shows the correct input voltage.
Operation.

The layout of the front panel of the receiver is illustrated in Figure 2.

Operation is extremely simple. Before transmission any S.P. voltage present is automatically compensated by momentarily pressing the auto buck switch. Complete cancellation of the input noise voltage is indicated by a zero display on the digital meter and after which quieting transients and signal reception can proceed.

Since the auto S.P. bucking facility can accommodate noise voltages in the range ±150% of full scale for all voltage ranges it may be necessary (particularly on the 20 millivolt range) to adjust the incoming signal as indicated by the analogue meter, as by means of the manual S.P. bucking potentiometer. It is recalled that CVF has a set full scale range of -180 - 0 +180 millivolts.

The following table indicates the maximum auto buck capabilities on all three voltage ranges of the receiver:

<table>
<thead>
<tr>
<th>Range</th>
<th>Maximum S.P. Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 millivolts</td>
<td>±3000 millivolts</td>
</tr>
<tr>
<td>deo</td>
<td>±500</td>
</tr>
<tr>
<td>20</td>
<td>±30</td>
</tr>
</tbody>
</table>
The state of the internal batteries is monitored on switch M2 with lamps switched in the BATT TEST position. Normally batteries should be replaced when the meter reads less than 14 volts although the receiver is still operable until the battery voltage drops to just above 7 volts. However, with battery voltages less than 14 volts the full automatic S.P. learning capabilities of the instrument will be reduced. In most situations, however, this will be no great disadvantage and if necessary the instrument can be powered by two batteries only (≈ 9 volts).

Manually the manual S.P. lever (1.5 volt) will only require changing once a year or so.

Before each day and perhaps occasionally during operation, the instrument will have to be adjusted for offsets in the track and hold IC's. The meter for this operation is indicated by a near-zero display on the digital meter when the auto-latch output is disconnected. The offset procedure follows:

1. With the calibrating switch closed and the range switch in any of the voltage ranges positions, adjust the manual S.P. lever potentiometer so that the analogue meter reads in the vicinity of zero volts by changing for the pointer to be in the center of the scale.

2. With auto-latch switch depressed, adjust the offset adjustment potentiometer...
with a thumb until the digitalDisplay shows zero and the polarity indicator is alternating between + and -.

(3) Release the auto back writer and put the calibrating switch into the up (off) position. The instrument is now ready for use.

Methods precautions relevant to the handling of delicate electronics should be observed with this instrument. These include:

(1) Carefully protecting the instrument against vibration (including transport etc.).

(2) Storing in an air conditioned environment particularly during the wet season.

(3) Removing all batteries during storage, etc.

(4) Keeping the liquid crystal display as clean as possible and out of the direct rays of the sun.
<table>
<thead>
<tr>
<th>Designation</th>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Potentiometer</td>
<td>1K ohm, 10 turn</td>
</tr>
<tr>
<td>R8</td>
<td>Resistor</td>
<td>3KΩ</td>
</tr>
<tr>
<td>R3</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>R4</td>
<td>&quot;</td>
<td>330</td>
</tr>
<tr>
<td>R5</td>
<td>&quot;</td>
<td>10K</td>
</tr>
<tr>
<td>R6</td>
<td>&quot;</td>
<td>10K</td>
</tr>
<tr>
<td>R7</td>
<td>&quot;</td>
<td>82K</td>
</tr>
<tr>
<td>R8</td>
<td>&quot;</td>
<td>12K</td>
</tr>
<tr>
<td>R9</td>
<td>Trimpot</td>
<td>10K, 15 turn</td>
</tr>
<tr>
<td>R10</td>
<td>Resistor</td>
<td>10K</td>
</tr>
<tr>
<td>R11</td>
<td>&quot;</td>
<td>820</td>
</tr>
<tr>
<td>R12</td>
<td>&quot;</td>
<td>120</td>
</tr>
<tr>
<td>R13</td>
<td>Trimpot</td>
<td>100, 15 turn</td>
</tr>
<tr>
<td>R14</td>
<td>Resistor</td>
<td>10K</td>
</tr>
<tr>
<td>R15</td>
<td>&quot;</td>
<td>10K</td>
</tr>
<tr>
<td>R16</td>
<td>&quot;</td>
<td>10K</td>
</tr>
<tr>
<td>R17</td>
<td>&quot;</td>
<td>1K</td>
</tr>
<tr>
<td>R18</td>
<td>&quot;</td>
<td>1K</td>
</tr>
<tr>
<td>R19</td>
<td>&quot;</td>
<td>82K</td>
</tr>
<tr>
<td>R20</td>
<td>&quot;</td>
<td>1K</td>
</tr>
<tr>
<td>R21</td>
<td>Potentiometer</td>
<td>25K, linear</td>
</tr>
<tr>
<td>R22</td>
<td>Resistor</td>
<td>100K</td>
</tr>
<tr>
<td>R23</td>
<td>&quot;</td>
<td>105Ω</td>
</tr>
<tr>
<td>C1</td>
<td>Capacitor</td>
<td>100pF, disc Ceramic</td>
</tr>
<tr>
<td>C2</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>C3</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>C4</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>C5</td>
<td>&quot;</td>
<td>0.1 µF, polyester</td>
</tr>
<tr>
<td>C6</td>
<td>&quot;</td>
<td>0.0 µF, polyester</td>
</tr>
<tr>
<td>C7</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
</tbody>
</table>
D1        Diode                1N914
D2
1C1      Operational amplifier   LM308
1C2
1C3
1C4
1C5
1C6
1C7      Voltage regulator      LM156
1M1      analogue milliammeter   1mA, ±12, 100Ω
1M2      D.P.M.                 PM 551/200 mv.
81       Battery                1.5V, "C" cell
82
83
84
85
Sw1      Switch                SPST, toggle
Sw2
Sw3
Sw4
PM-351 3½-DIGIT DIGITAL PANEL METER

INTRODUCTION.

The PM-351 Digital Panel Meter is a three and one-half-digit, fixed-range instrument with automatic polarity. The meter is available in any one of five ranges: ±199 millivolts F.S., ±19.99 volts F.S., ±199.9 volts F.S., ±1999 volts F.S. or ±1000 volts F.S.

Except for the ±199 millivolt range, modification from one range to another may be easily accomplished by the substitution, addition or deletion of one or two resistors. Calibration is readily accomplished by the adjustment of one potentiometer, accessible at the rear of the instrument. For operation, an external ±5 vdc (±5%) power supply is required. See figure 1 for a typical power supply circuit.

Figure 1. Typical Power Supply Schematic

SPECIFICATIONS.

Range: 0 to ±199 mVDC
or 0 to ±19.99 VDC
or 0 to ±199.9 VDC
or 0 to ±1999 VDC
or 0 to ±1000 VDC

Accuracy: ±0.05% Rdg. ± 0.05% F.S.

Update Rate: 3 readings/second nominal

Display: 0.3" high

Operating Temperature: 0° C to 55° C

Power: ±5 vdc (±5%) @ 6 mA maximum

Size: 15/16" H x 2-1/2" W x 3-1/4" D
(25, 6 mm H x 63, 5 mm W x 95, 6 mm D)

Weight: 4 oz (113 grams)

T/C: ±0.02% Rdg/°C on 200 mV & 2V ranges; ±0.02% Rdg/°C on other ranges

Input Z: 200 mV range, 100 MΩ; 2V range, 1000 MΩ; 20V range, 1 MΩ; 200V & 1000 V ranges, 10 MΩ

Common-Mode Rejection: 80 db minimum

Common Mode ±100 mV between SIG LO & COM Compliance: neg. terminal of B+ supply

Decimal Location: May be positioned by jumper on connector to any one of three locations: ±X, X.X, X

Input Current: 250 μA maximum (room temp.)

Input Voltage ±50 vdc or 50 vrms maximum, Protection: 200 mV or 2V ranges; ±150 vdc or 150 vrms maximum, 20V

INSTRUCTIONS.

range: ±1000 vdc or 700 vrms maximum, 200 V & 1000 V ranges.

Overload Positive overload: +1, negative indication: overload: -1 is displayed for inputs exceeding full scale.

OPERATING PRINCIPLES (See Figure 2.)

Analog-to-digital conversion is accomplished in a single monolithic integrated circuit. The output of the A/D converter drives an LCD display. Decimal point selection is accomplished by external jumpers.

Figure 2. Simplified Block Diagram

INSTALLATION.

1. Mount the PM-351 as follows:

   a. Cut hole in panel (figures 3 and 4).
   b. Slide trim plate over PM-351 housing, facing beveled edge of trim plate forward.
   c. Insert PM-351 through the cut-out in panel from front of panel.
   d. Fit mounting clips (2) into slots at sides of instrument. Foot of clip should face forward.
   e. Thread screws (2) into clips & tighten screws against rear surface of panel.

2. Install a keying tab in connector to mate with PM-351 between contacts 1 and 2. The connector should be NLS part number 39-180, or equivalent. (See table 1 for connector pin information.)

Figure 3. Mounting Data

Table 1. Connector Pin Information

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Top of Bd.)</td>
<td>(Bottom of Bd.)</td>
</tr>
<tr>
<td>1</td>
<td>Decimal Pl. Com.</td>
</tr>
<tr>
<td>2</td>
<td>N/C</td>
</tr>
<tr>
<td>3</td>
<td>N/C</td>
</tr>
<tr>
<td>4</td>
<td>N/C</td>
</tr>
<tr>
<td>5</td>
<td>Signal Low</td>
</tr>
<tr>
<td>6</td>
<td>N/C</td>
</tr>
<tr>
<td>7</td>
<td>N/C</td>
</tr>
<tr>
<td>8</td>
<td>N/C</td>
</tr>
<tr>
<td>9</td>
<td>+5V Power</td>
</tr>
<tr>
<td>10</td>
<td>N/C</td>
</tr>
</tbody>
</table>
OPERATION.

1. Power Supply. Connect the negative side of your 5V supply to pins K and L of the connector and the positive side to pin 9.

2. Signal. Connect the signal to be measured to pin H of the connector. A shielded lead may be needed if the signal has a high source resistance. Connect the low side of the signal to be measured to pins 5 and K of the connector. This will usually be better to do this with two separate wires rather than a jumper across 5 and K at the connector. This will eliminate current flow through the signal low connection to pin 5.

3. Decimal Indicator. Jumper between pin 1 and pins B, C or D depending upon which decimal point is to be illuminated. See below. If a decimal is not desired, do not install a jumper.

Decimal Location  1.0.0.0.0
                        DCB

4. Connector. Plug connector onto P/C fingers at rear of PM-351. Orient connector so the keying tab mates with the slot in the P/C board.

5. Readings. Apply power and signal. Within 10 seconds the PM-351 will display the correct reading.

NOTE

If it is desired to power the PM-351 from a 5V supply which is not floating with respect to the signal to be measured, the following conditions must be met. The supply must be noise-free. The negative side of the supply and the low side of the signal must be within 100 mV of each other.

CALIBRATION.

1. Ensure a 5-minute warm-up period.

2. Verify the +5 volt power supply voltage. If necessary, adjust to +5V (±0.1V).

3. 200 Millivolt Meter. With a precision DC power supply, apply +190 mVDC. Adjust potentiometer R4 at rear of meter until read-out displays +190.

NOTE

As in paragraph 3 above, for a 2-volt meter, apply +1,900 VDC; a 20-volt meter, apply +19,00 VDC; a 200-volt meter, apply +190,0 VDC; and a 1000-volt meter, apply 900 VDC.

RANGE MODIFICATION (Except 200 mV unit.)

1. Insert a small screwdriver or pen knife between case and rear cover, midway on case above printed circuit connector, and pry gently outward. Remove rear cover.

2. Slide panel meter assembly from case. Observe that red filter is now a loose piece and will be required for reassembly.

3. Observe resistor values that are in unit and compare to figure 5 and table II below. Install values of resistors as specified in table II to attain desired range. Note that resistors R9 and R10 plug in. No soldering is required.

4. If a decimal indicator is desired, refer to paragraph 4 under Operation.

5. Reassemble unit by reversing steps 1 and 2.

6. A range modification resistor set covering the four higher ranges of the PM-351 is available from your distributor, specify NLS part number 39-356.

Figure 5. Component Location

<table>
<thead>
<tr>
<th>RANGE</th>
<th>R9</th>
<th>R10</th>
</tr>
</thead>
<tbody>
<tr>
<td>2V</td>
<td>100 kΩ (±5%)</td>
<td>OMT</td>
</tr>
<tr>
<td>20V</td>
<td>909 kΩ (±1%)</td>
<td>100 kΩ (±1%)</td>
</tr>
<tr>
<td>200V</td>
<td>10 MΩ (±1%)</td>
<td>OMT</td>
</tr>
<tr>
<td>1000V</td>
<td>10 MΩ (±1%)</td>
<td>10 kΩ (±1%)</td>
</tr>
</tbody>
</table>

MAINTENANCE:

To facilitate maintenance, all three integrated circuits plug into the printed circuit board and can be easily removed without soldering. These include the LCD display, the ICL7016-CPL chip and the CD4049AE chip.
Figure 2