CHAPTER V

TEST, CALIBRATION, AND THE RESULTS

5.1 Introduction

This chapter handles test, and calibration of the instrument. The discussion will be made first on the adjustment of the digital circuits starting from AS:5 then on practical adjustment of the analog circuit from AS:1 to AS:4, and finally on the test and calibration briefly. The results of V, A and power measurements will be shown in the last section in form of tables and curves.

5.2 Adjustment of Digital Section (AS:5 to AS:9)

Before proceeding to adjust the Digital Section, we must remove assembly AS:2 from the chassis but keep other assemblies inserted unless otherwise specified.

5.2.1 Power Supply-2 (AS:5)

Make adjustments to obtain the following DC output voltages in Table 5-1 at the power voltage specified for this instrument (220V $\pm$ 5%).

Test point	Output DC Voltage	Adjustor
+ 15 V	+ 15 V $\pm$ 0.03 V	R 104
- 15 V	- 15 V $\pm$ 0.03 V	R 108
+ 5 V	+ 5 V $\pm$ 0.01 V	R 114
- 5 V	- 5 V $\pm$ 0,01 V	R 119

Table 5-1 AS:1 Power supply check table

5.2.2 Point, unit, and ranging encoder (AS:8)

Obtain the output signals in the following manner when applying the input signals according to the truth-value Table 4-6. Send out a combination of signals from the function and range by means of the function (V, A, W), V-range and A-range selector switches. Make sure that this signal is applied to the input side of AS:8. Then examine the output signal combination of A-drive, V drive, $\sqrt{10}$ signal, range, point and unit signals.

5.2.3 Control signal isolator (AS:6)

Check up for function codes and range signals at the input and output of the Assembly 6. The converting conditions of the logical polarities are as shown in Figs. 4-26 and 4-27.

5.2.4 A-to-D converter (AS:7)

Measuring instruments to be provided are as follows.

a. Programmable DC voltage source : Takeda reiken model TR-6141 or an equivalent.

b. $4\frac{1}{2}$ Digit digital multimeter : Takeda Reiken model TR-6855 or an equivalent.

Step 1 : For about 3 readings per second, adjust the sampling clock to 120 kHz by adjusting R119

Step 2 : For accurately reading, apply the DC voltage source vary the voltage from 10 mV to 2.000 V full scale between an analog input and the ground terminals, and compare the reading with that of a standard digital voltmeter. If the reading is not correct, adjust a reference voltage by adjusting R102. In such a case, the input voltage required to give the full scale reading is two times referemce voltage. For this puepose the reference voltage must be set to 1.000 V exactly.

Step 3 : Make sure that the whole numeric display is flashed when an input of 2.000 V or more of either polarity is applied.

Step 4 : Make sure that the numeric display cannot update a result value while depressing a HOLD switch.

Up to this point the adjustment of the Digital Section is over. After the adjustment, insert AS:2 back into the original position.

5.3 Adjustment of the Analog Section (AS:1 to AS:4)

The discussion will be made on the adjustment of the Analog Section by makign use of the Digital Section (AS:5 to AS:9). In this adjustment, keep all the assemblies inserted in position unless otherwise specified.

5.3.1 Power supply -1 (AS:1)

Test Point	Output DC voltage	Adjustor
+ 15 V	+ 15 V ± 0.03 V	R 104
- 15 V	- 15 V ± 0.03 V	R 108
- 10 V	- 10 V ± 0.50 V	Zener diode D 109
+ 5 V	+ 5 V ± 0.01 V	R 114
- 5 V	- 5 V ± 0.01 V	R 11

Table 5-2 Power supply check table

Obtain the following DC output voltages in Table 5-2 at the power input voltage specified for this instrument (220V ± 5%)

5.3.2 Preamplifier and ranging circuit (AS:3)

A) Adjustment of preamplifier : Connect the COM terminal of the DMM to the COM terminal of AS:3, set function selector to W, and set range selector to AUX.

Step 1 : Shorting and opening of the V-AUX input and the COM terminal. Adjust the adjustor R145 so that the voltage at TP145 will be within ± 0.2 mV when shorting, and within ± 0.3 mV when opening.

: Shorting and opening of the A-AUX input and the COM terminal. Adjust the adjustor R147 so that the voltage at TP147 will be within ± 0.2 mV when shorting, and within ± 0.3 mV when opening.

: Open A-, V-AUX inputs, and A-, V-input terminals and adjust R146 so that the voltage at TP146 will be within ± 0.2 mV

Step 2 : Apply + 1.000 Vdc to V-AUX input and A-AUX input. Make sure that the voltage at TP145 and TP147 respectively, will be within -3V ± 1.5 mV.

: Set A selector switch to 3A and make sure that the voltage at TP147 is within -2.8461 V ± 1.5 mV. If the voltage at TP147 is not as specified above, the resistance of R118, R116 or R114 may be excessively deviated.

B) Adjustment of the ranging circuit

Step 1 : Short the W/RMS input pin to ground terminal. Adjust R148 so that the voltage at TP148 will be within ± 0.3 mV.

Step 2 : Make sure that the operation and the voltage of the ranging circuit are correct as will be described below

Remove AS:4, connect the DVM between TP148 and ground (for approximate test, the display on this instrument may be referred to, provided that the decimal point is neglected). Apply +3.000 Vdc between the W/RMS input pin and ground.

AS:3 W. RMS input pin 12	setting			check		remark	
	function selector	A-range	V-range	sig input pin no.	DVM (Vdc)	Relay (on)	range signal
+3.000Vdc	W	6A	3V	19	-2.00V ±1.5mV	RL 104	3 (011)
	W	1A	3V	18	-3.1623V ±2.0mV	RL 105	4 (100)
	W	6A	600V	17	-4.00V ±2.5mV	RL 106	5 (101)
	W	1A	600V	16	-6.3246V ±3.0mV	RL 107	6 (110)
	W	1A	10V	-	-10.00V ±4.0mV	All relays off	7 (111)

Table 5-3 AS:3 Ranging check table

Carry out the setting according to Table 5-3. Make sure that the corresponding range signal (2.4V min) is applied to the input pin and take a reading on the DVM. If an undesirable output voltage appears, or signal 3 (011) enters, check R120, R119 and R126. If another signal enters, judge the ranging resistors to be checked according to the relay given in Table. 4-6 and refer to the wiring diagram. After the above check up and adjustment, insert AS:4 back in the original position.

5.3.3 V, A, W Selector and alarm circuit (AS:2)

A) Adjustment of V, A, W Selector

Step 1 : Apply +1.000 V to both V-and A-AUX inputs. Set the function selector switch to W, the V-range selector switch to AUX, and the A-range selector switch to 3A. Check the relay drive operation as follows. Make sure that -3 V is present at V-output (pin 2), -2.8461 V is present at A-output (pin 3), and the circuit between X2-output (pin 10) and Y2-output (pin 9), and the COM pin are shorted.

Set the function selector switch to V. Make sure that -3 V is present at V-and A-outputs.

Set the function selector switch to A. Make sure that -2.8461 V is present at A- and V- outputs.

Make sure that there is contnuity between TP113 and X2 output, TP113 and W/RMS output (pin 5) and TP117 and Y2-output.

Step 2 : Connect a 10-kΩ resistor across C101 in the integrator circuit, and remove AS:3. Put a jumper between M-out (pin 16) and the COM terminal, adjust R113 (Linear adj) so that the voltage measured at TP113 will be within ± 0.5 mV. Put a Jumper between TP.113 and the COM terminal. Adjust R117 (ϵadj) so that the voltage measured at TP 117 will be within ± 0.5 mV.

Remove the 10-kΩ resistor connected across C101, and insert AS:3 in position.

B) Underrange detector circuit

Set the function selector switch to V and V-range selector to AUX. Apply ± 0.12 to ± 0.15 Vdc to the V-AUX input. The light of the V-under-range lamp should appear. It must be gone when the input is higher than 0.15 Vdc. If improper phenomenon occurs, check the underrange detector U102, U105 and RL103.

In the same manner as above, check the A-underrange lamp operation.

C) Overrange detector and monitor circuit

Step 1 : Observe the V-and A-overrange lamps in the following manner.

Apply ± 3 to ± 3.1 Vdc or 2.1 to 2.2 Vac to AUX input. Adjust R165 for positive value and R166 for negative value so that their respective lamps will just come on. Those are the points where the over range alarm signals are sent out.

Step 2 : Monitor meter. Apply 1 Vdc to the V- and A-AUX inputs, and adjust R155 (V-meter) and R159 (A-meter) so that the monitor meter corresponding to them will indicate 100%

5.3.4 Multiplier (AS:4)

Step 1 : In the W measuring mode, observe the voltage level at TP104 or TP105. If the voltage is zero, check the duty

(50%) and one cycle durations of the square waveform. Adjustment of duration of one cycle is made by means of C138 or C139 in the clock generator when T <13.9 μs, and by means of C140 or C141 when T >15.7 μs.

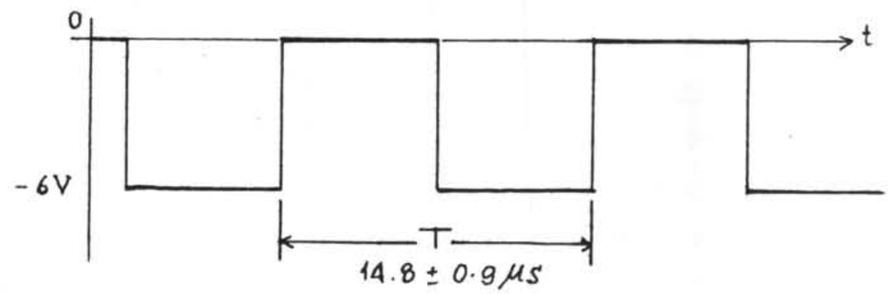

Fig. 5-1 Waveform at TP104 and TP105 on AS:4

Step 2 : Set the function selector switch to W and the range selectors to AUX.

Apply + 1.000 V and -1.000 V alternately to the V-AUX input. Put a jumper between Y1-input (pin 21) and Y2-input (pin 22), and measure the voltage at TP108 (multi out). Adjust R172 (Y-bal) so that the polarity will correspond by changing it, and that the difference in the absolute values of the voltages will be within 3 mV.

Apply + 1.000 V and -1.000 V alternately to the A-AUX input. Put a jumper between X1-input (pin 4) and X2-input (pin 7), and measure the voltage at TP108. Adjust R171 (X-bal) so that the polarity will correspond by changing it, and that the difference in the absolute values of the voltage will be within 3 mV.

leave the V- and A-inputs open. Adjust R176 (zero adj) so that the voltage level measured at TP148 (AS:3) will be within 3 mV.

Step 3 : Apply + 1.000 V and then -1.000 V to both V-and A-AUX inputs. Adjust R175 (full scale coarse) and R174 (full scale fine) so that the arithmetic mean value of the digital readings on this instrument obtained at + and - voltage application will be 1000.0 W

Step 4 : Apply + 1.000 V to the V-AUX input. Set the function selector switch to V. Make sure that the values measured at AS:2 Y2-output and W/RMS output have opposite polarities and the same absolute value. Otherwise adjust R117 (ϵadj) on AS:2.

Apply + 1.000 V to the V-AUX input in the same manner as above. Set the function selector switch to V. Adjust R113 (linear adj) so that the voltage level measured at TP108 (AS:4) will be within $\pm$ 0.5 mV.

5.4 Overall Test and Calibration

The following test steps are tested without a current transformer T102 in the current measuring part. Because this transformer must be in instrumentation class with overall accuracy less than 0.1%, it is too difficult and costly for the author to construct. However, the author keeps a space for its installation, and specifies this current transformer from Yokogwa Electric, Ltd., model 2503-CT 155 within the same ratios and desired accuracy. A manual change is also provided in Appendix E for a future modification.

5.4.1 Test instruments to be prepared

- $4\frac{1}{2}$-digit true-RMS multimeter : Fluke model 8040A or an equivalent.

- Dual-trace oscilloscope : Tektronix model 465 or an equivalent.

- Programable DC voltage source : Takeda Reiken model TR-6141 or an equivalent.

- Pulse generator : Exact model 7260 or an equivalent.

- Phase shifter : 0-280° with 10 V and 10 mA minimum.

- Standard AC watmeter

- AC standard or variac

5.4.2 Test for operation and characteristic

a. Test for DC voltage range :

Display on the instrument is tested by applying rated voltage to the voltage input terminal from the DC voltage standard.

b. Test for AC voltage range and frequency characteristic : Display on the instrument is tested by applying rated voltages of the following frequencies to the voltage input terminal from the AC voltage standard. And compare the result with true RMS multimeter.

Test frequencies : 50, 400 and 1,500 Hz.

c. Test for current range and frequency characteristics : Display on the instrument is tested by applying rated currents of the same frequencies as in the previous step to the current input terminal from the AC current standard. The results are campared with those of the true-RMS meter

d. Test relevant to power

The following tests relevant to power are carried out by the calibration instruments for digital AC power meter given in Fig. 5-2

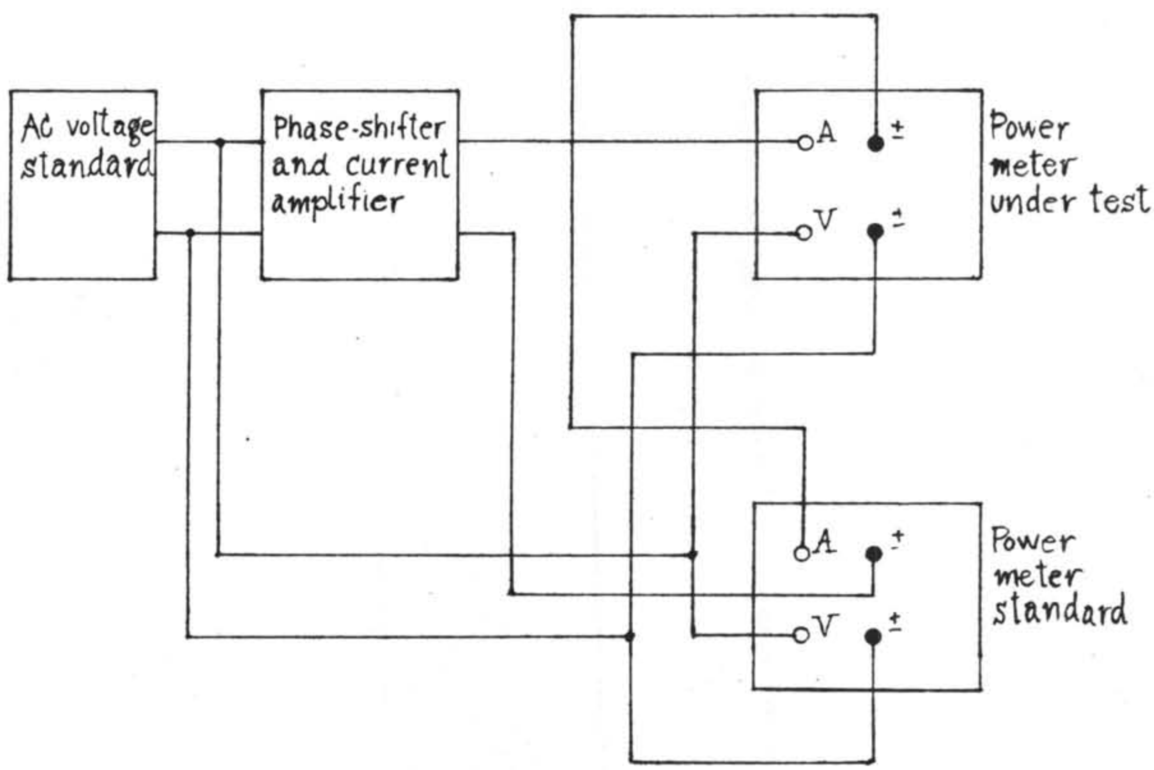

Fig. 5-2 Wiring for calibration of the Digital AC power meter

d.1 Test for power range (power factor = 1)

Set the outputs of the AC voltage standard and AC current standard in phase by adjusting the output of phase-shifter & current amplifier circuit. Apply rated voltage and current to the instrument, and compare the display on the instrument with that on standard AC wattmeter.

d.2 Test for frequency characteristic

Compare the display on the instrument with that on standard AC wattmeter by changing the frequency of the generator to 50, 400, and 1,500 Hz at each range.

d.3 Linearity test

Compare the display on the instrument with that on standard AC wattmeter by changing the current to the current input terminal to 100, 80, 60 and 30% of the rated current successively, with a fixed rated voltage applied to the voltage input terminal.

d.4 Test for influence by power factor (power factor = 0.5)

Carry out this test with a voltage range of 10 V, a current range of 10 mA and a frequency of 50 Hz. Apply the rated voltage of 10 V to the voltage input terminal. Apply 10 mA current of the same phase as the voltage to the current input terminal, vary the current until approximately one half of the power range is applied, and take the reading of the display. Then apply 10 mA current with is $\pm 60°$ of the voltage. Vary the current until the same power as above is applied, and take the reading of the display.

The difference in both readings should be within $\pm$ 1%.

d.5 Check of power feedthrough error

Set the function to W, V-range to 10 V, and A-range to 10 A. Apply a rated voltage of 10 V to the voltage input terminal from the AC voltage standard, leave the current input terminal open, and take the rading of the display. In the same way, leave the voltage input terminal open, apply 10 mA to the current input terminal from the AC current standary, and take the reading of the display. If the absolute difference in the reading is two digits or less at the least significant digit (LSD), the instrument is working properly.

e. Test for true RMS measuring with distorted measuring signal.

Set the function switch to V, V-range selector to 10 V, apply a rated voltage of 10 V-peak with any waveforms shown in Table 5-2, observe the waveform with oscilloscope, and compare the results with those of a true-RMS meter of the same type.

The additional test results to find out the accuracies of the multiplier and all measurement functions is shown in Appendix F in form of tables and curves.

AC WAVEFORM CONVERSION

WAVEFORM		VOLTMETER TYPE					
		Peak-to-Peak	True Peak	Peak-Responding, rms cal for sines	True rms	Average-Responding, rms cal for sines	True Average
SINE:	pk-pk	1.000	2.000	2.828	2.828	2.828	3.140
	0-pk	0.500	1.000	1.414	1.414	1.414	1.570
	rms	0.353	0.707	1.000	1.000	1.000	1.111
	avg	0.318	0.637	0.900	0.900	0.900	1.000
RECTIFIED SINE: (FULL WAVE)	pk-pk	1.000	1.000	1.414	1.414	1.414	1.570
	0-pk	1.000	1.000	1.414	1.414	1.414	1.570
	rms	0.707	0.707	1.000	1.000	1.000	1.111
	avg	0.637	0.637	0.900	0.900	0.900	1.000
RECTIFIED SINE: (HALF WAVE)	pk-pk	1.000	1.000	1.414	2.000	2.828	3.140
	0-pk	1.000	1.000	1.414	2.000	2.828	3.140
	rms	0.500	0.500	0.707	1.000	1.414	1.570
	avg	0.318	0.318	0.450	0.637	0.900	1.000
SQUARE:	pk-pk	1.000	2.000	2.828	2.000	1.800	2.000
	0-pk	0.500	1.000	1.414	1.000	0.900	1.000
	rms	0.500	1.000	1.414	1.000	0.900	1.000
	avg	0.500	1.000	1.414	1.000	0.900	1.000
RECTIFIED SQUARE: (HALF WAVE)	pk-pk	1.000	1.000	1.414	1.414	1.800	2.000
	0-pk	1.000	1.000	1.414	1.414	1.800	2.000
	rms	0.707	0.707	1.000	1.000	1.272	1.414
	avg	0.500	0.500	0.707	0.707	0.900	1.000
RECTANGULAR PULSE: (D = X/Y)	pk-pk	1.000	1.000	1.414	$1/D^{1/2}$	0.9/D	1/D
	0-pk	1.000	1.000	1.414	$1/D^{1/2}$	0.9/D	1/D
	rms	$D^{1/2}$	$D^{1/2}$	$1.414\ D^{1/2}$	1.000	$0.9/D^{1/2}$	$1/D^{1/2}$
	avg	D	D	1.414 D	$D^{1/2}$	0.9 D	1.000
TRIANGLE AND SAWTOOTH:	pk-pk	1.000	2.000	2.828	3.464	3.600	4.000
	0-pk	0.500	1.000	1.414	1.732	1.800	2.000
	rms	0.289	0.577	0.816	1.000	1.038	1.153
	avg	0.250	0.500	0.707	0.867	0.900	1.000

Table 5-4 AC Waveform conversion table

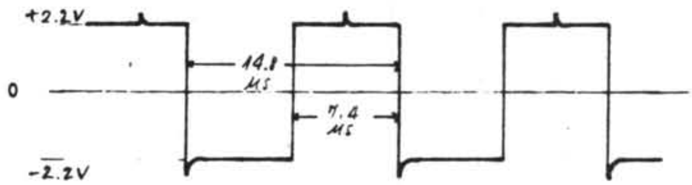

Fig. 5-3 Multiplier's clock waveform (TP 110)

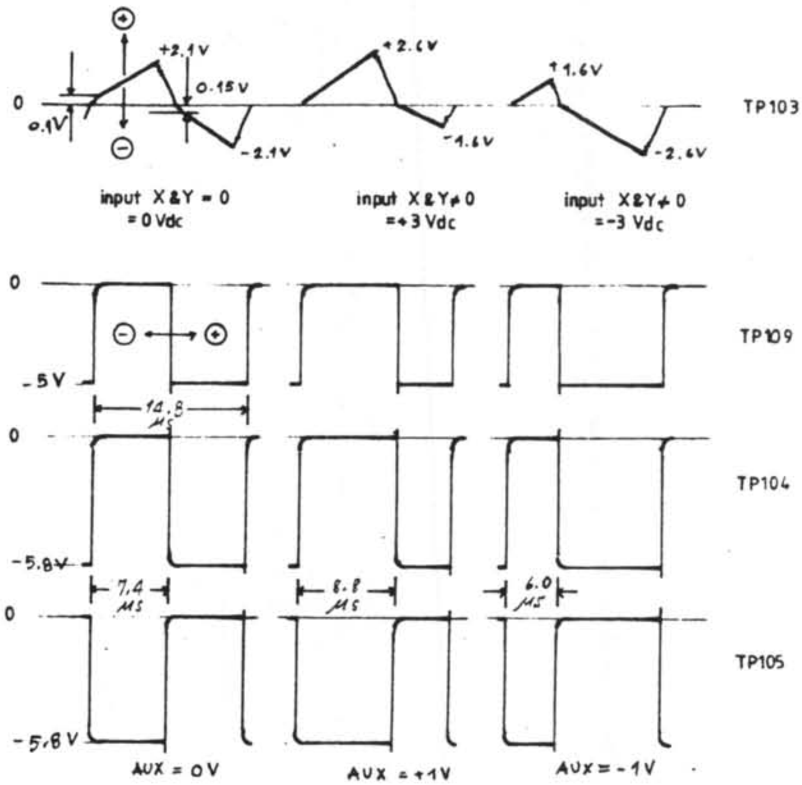

Fig. 5-4 Waveforms of comparator (U103) input and output, and switch driver (U104) output on AS:4