CHAPTER VI

CONCLUSION AND SUGGESTIONS

6.1 Introduction

The concept of an AC power measurement employing the feed-back time division multiplier and true RMS measurement based on the steepest descent method has been described in the research. A prototype of a digital AC power meter has been built. In this chapter the results of this prototype will be concluded, followed by some applications and the suggestion to improve the ability of this instrument.

6.2 Conclusion

The test results of this prototype digital AC power meter can be concluded as follows

6.2.1 The accuracy of the Multiplier (AS:4)

$\pm$0.5% of reading for DC, 30 Hz to 500 Hz

$\pm$0.7% of reading for 500 Hz to 1,500 Hz

6.2.2 Final specifications of the prototype

Type of input	:	Floating
Display	:	LED display (with $4\frac{1}{2}$ digits)
Sampling rate	:	Approx. 3 times per second

Maximum reading : 19999 (effective reading max. = 11000)

Range selection : manual

Function selection : manual

Unit marks : V, mA, A, mW, W, and kW

Effective measuring range : 30 to 110% of rated value

Power fluctuation : ±0.03% of range against the power supply variation of ±10% from 220 Vac

Temperature drift : ±0.05% of range against the temperature variation from 20°C to 40°C

Power consumption : Approx. 35 VA

Dimension : Approx. 143 × 357 × 390 mm.

Weight : Approx. 12 kg

6.2.3 Voltage measurement (single-phase V)

Ranges : 3V, 10V, 30V, 100V, 300V, 600V (6 ranges)

Resolution : 1 mV/digit

Frequency range : DC and 30 Hz to 1,500 Hz

Accuracy : (Sine wave input)

±(0.5% of reading+0.03% of range+1 digit) for 50 Hz to 500 Hz

±(1.0% of reading+0.05% of range+1 digit) for DC, 30 Hz to 50 Hz and 500 Hz to 1,500 Hz

Input impedance : Approx. 10 kΩ on 3 V to 100V ranges and approx. 1 MΩ on 300V and 600V ranges

6.2.4 Current measurement (single-phase A. Test without CT on the current input side. Then, these results treat as no CT error) Ranges 100 mA, 300 mA, 1A, 3A, 6A (5 range)

Resolution : 10 μA/digit

Frequency range : 30 Hz to 1,500 Hz

Accuracy : (sine wave input)

±(0.3% of reading+0.02% of ranging+1 digit) for 50 Hz to 500 Hz

±(0.5% of reading+0.03% of ranging+1 digit) for 30 Hz to 50 Hz and 500 Hz to 1,500 Hz

6.2.5 Power measurement (Single-phase W, test with the same condition as the current measurement)

Range : 300 mW to 3.6 kW (V range × A range)

Resolution : 0.1 mW/digit

Frequency range : 40 Hz to 1,200 Hz

Accuracy : (sine wave input at cos Ø =1)

±(0.5% of reading+0.03% of ranging+1 digit) for 50 Hz to 400 Hz

$\pm$(1.0% of reading+0.05% of ranging+1 digit) for 40 Hz to 50 Hz and 400 Hz to 1,200 Hz

Effect againt variation of power factor : Less than $\pm$ 1.0% of reading (test with cos ϕ from 1 to 0.5 at 50 Hz)

Note that the above accuracy supposes that the following standard or master instruments have no error in all of the measuring ranges.

(1) True RMS mesurement standard for both voltage and current is a $3\frac{1}{2}$-digit true-RMS digital multi-meter from FLUKE model 8030A with specifications are as follows

- AC voltage accuracy : $\pm$ (0.5% of reading+2 digits) for 45 Hz to 1,000 Hz for all ranges and to 5,000 Hz on the 20V range and lower.

- AC current accuracy : $\pm$ (0.5% of reading+2 digits) from 45 to 5,000 Hz for all ranges.

(2) Power measurement standard is a analog type watt meter class 0.2% from SIEMENS model 1-3052181 with average-responding rms calibrated for sines

6.3 Applications

6.3.1 Measuring range within specified value

As shown in Fig. 6-1, connect the $\pm$ voltage terminal to the load side and connect $\pm$ voltage terminal to the current terminal of 0 to 6A. In this case, displayed numerals are the

measured value.

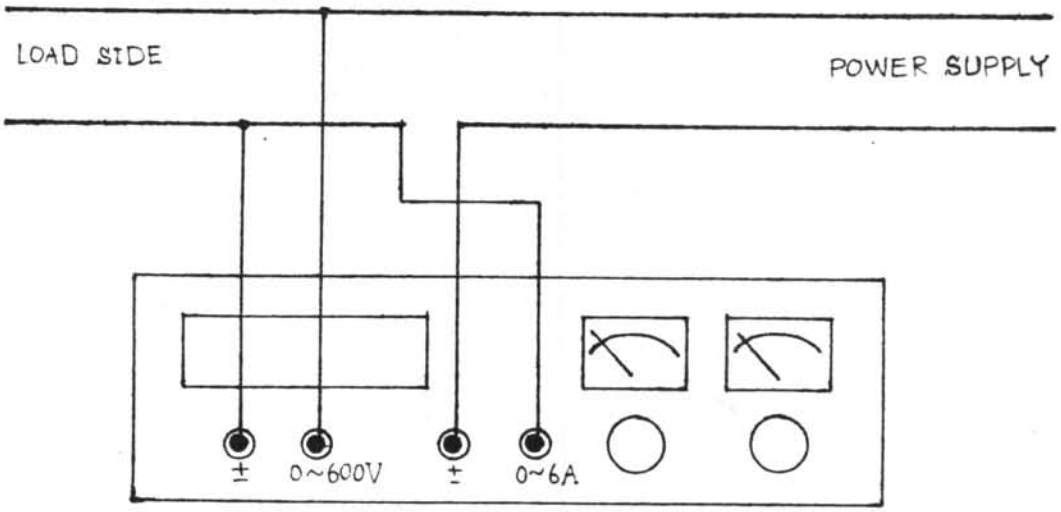

Fig. 6-1 Wiring for measuring range within specified value

6.3.2 Measuring range above specified value

When measured in higher range than those of specified, we connect a current transformer (CT) and a potential transformer (PT) as shown in Fig. 6-2. In this case, if a secondary winding of PT = 110V and a secondary winding of CT = 5A, then we have to set the V-range selector to 100V, A-range selector to 6A and obtain the value from the following equations.

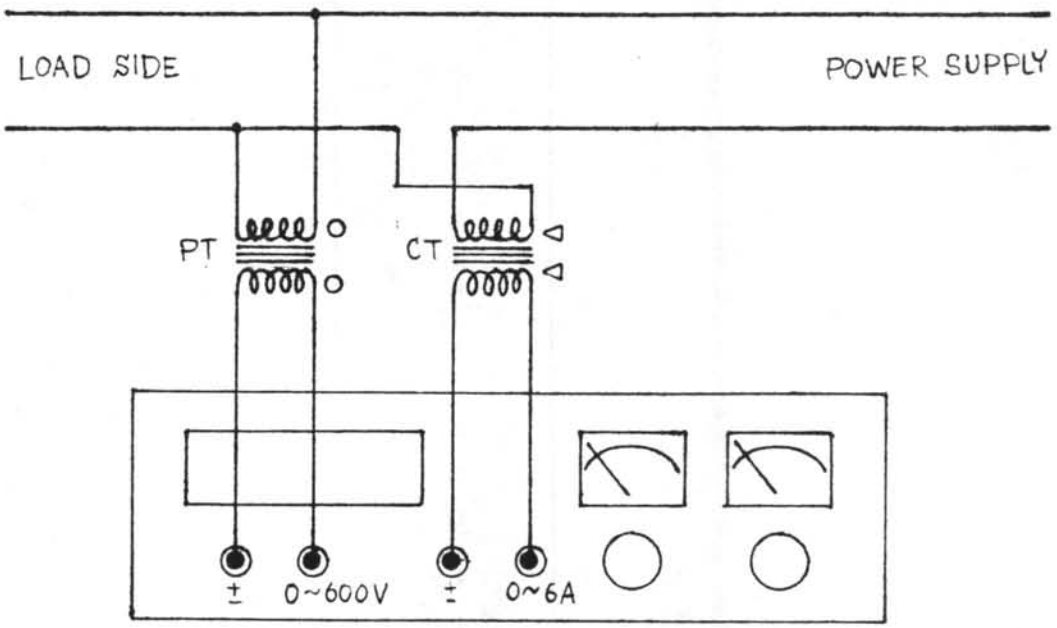

Fig. 6-2 Wiring for measuring range above specified value

(1) Voltage measurement

An actual voltage = meter reading ×PT ratio (6-1)

Ex. Meter reading = 70.00V

PT ratio = 3300/110V = 30

∴ actual voltage = 70V×30 = 2,100V

(2) Current measurement

An actual current = meter reading×CT ratio (6-2)

Ex. Meter reading = 3.000A

CT ratio = 50/5A = 10

∴ actual current = 3A×10 = 30A

(3) Power measurement

An actual wattage = meter reading×PT ratio × CT ratio (6-3)

Ex. Meter reading = 800.0W

PT ratio = 3300/110V = 30

CT ratio = 50/54 = 10

$\therefore$ actual wattage = 800W×30×10 = 240 kW

6.4 The Suggestions for Future Research

After finished this thesis the two suggestions from the author are as follows

1. To improves the accuracy of measurement

Because, in each measuring step the measuring input must be sent pass through many stages of op-amp circuit, such as V-and/or A-preamplifier, inverter, summing integrator, ranging, and also in multiplier circuit too. In basically, these circuits employed the ratio of a feedback resistor and input resistor to performed the gain of amplification. We found that, more than 70% of the measuring accuracy is depends upon the tolerance of these resistors. At present we have only resistors with tolerance $\pm$ 1% in the local market. The better one which may be the tolerance lower than $\pm$0.5% is not easily to obtained due to it take a long time to purchase from abroad and their prices is more times expensive. In future if the precision meter is required we can do by changing all of the mentioned resistors.

2. To extends the current measurement up to 30A

At present this prototype can measures the current up to 6A only. But a function decoder, ranging circuit, selector switch,

and also a space is prepared for future extend to 30A full scale. By installation a specified current transformer on the current input side according to a manual changes in appendix E. The specified type is a current transformer from YOKOGAWA model 2503-CT155 which the same ranges and resolution as designed.