1. **(15%)** A circuit behaves as a 0.01 μF capacitor in series with a 15 kΩ resistance when measured at a frequency of 1 kHz. If the terminal resistance is measured as 31.9 kΩ, determine the circuit components and the connection method.
2. **(15%)** A PMMC instrument with I_{FSD}=100 μA (average) and R_m=200 Ω is used in the **half-wave rectifier voltmeter** circuit as shown above (**Fig. 1**). Diodes D1 and D2 have an average forward resistance of 50 Ω and are assumed to have an infinite resistance in the reverse direction. $R_{SH} = 200\,\Omega$ and $V_{FSD} = 10\,V\,(rms)$. Calculate the value of the multiplier R_S.

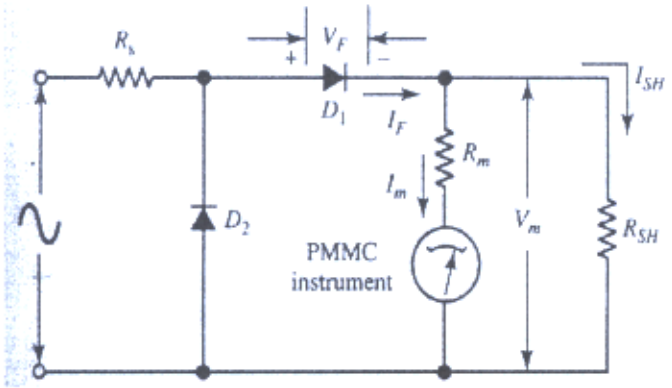

Fig. 1. A half-wave rectifier voltmeter

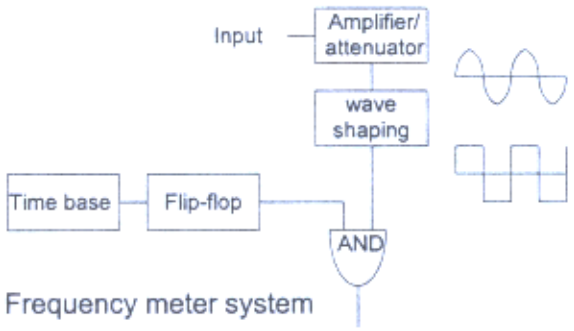

Fig. 2. Basic frequency meter.

3. **(20%)** **(a)**Explain the operation of a 「basic frequency meter」 as shown above (**Fig. 2**). Define reciprocal counting. Draw the basic block diagram of the digital frequency meter rearranged for reciprocal counting. Explain its operation, and show why reciprocal counting is sometimes used in preference to the straight counting method. (b) A frequency meter with an accuracy of ± 1 LSD $\pm\left(1\times10^{-6}\right)$ is used to measure frequencies of 100 Hz and 100 MHz. Calculate the percentage error for each measurement. (c) If a 1 MHz oscillator frequency from the time base is used for reciprocal counting, determine the error that can occur when a 100 Hz frequency is measured on this system.
4. **(10%)** The relative error in C is about equal to the sum of the relative errors of A and B when C=A/B. Prove it and check the neglected items.
5. **(15%)** To measure the capacitance, describe the similar angle bridge and Schering bridge with the derivation of their formulae. What is the difference between these two bridges?
6. **(15%)** For a low-capacitance probe (a compensating 13 pF capacitor in parallel with 9 MΩ resistor are series-added in the probe), explain why its operation bandwidth can be prolonged up to more than 10 MHz in comparison to a regular probe. Assume that the equivalent circuit of an oscilloscope is a 90 pF capacitor shunted by 1 MΩ resistor, the cable capacitance of a low-capacitance probe or a regular probe is 30 pF, and the internal resistor of a signal generator is 600 Ω. Note that the cable capacitance of a probe can be regarded as shunted with the oscilloscope. Explain the reason by comparing the operation bandwidth between a low-capacitance probe and a regular probe.
7. **(10%)** In IEEE-488 GPIB interface, describe the definition of controller, listener, and talker.