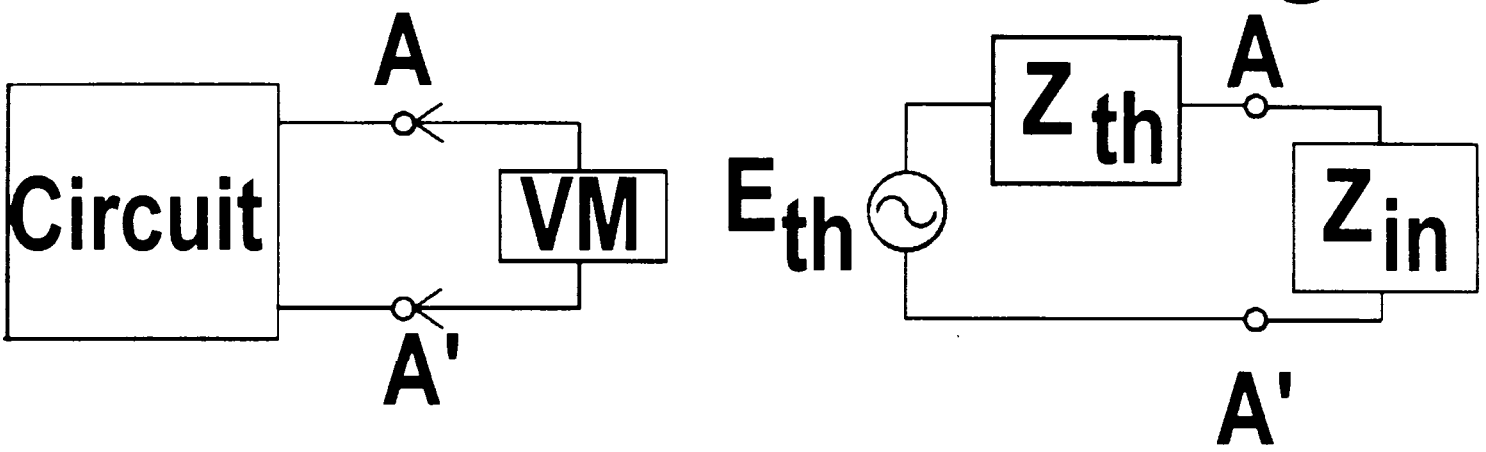
AC Voltmeter Loading



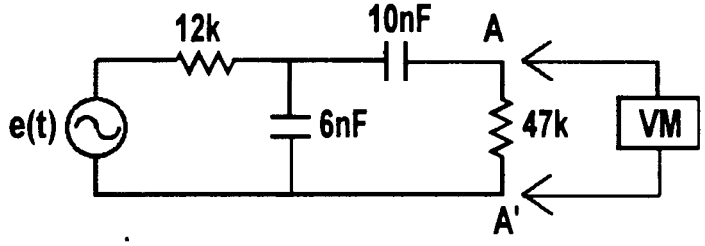
When an AC voltmeter is connected across nodes AA' to measure the voltage both the magnitude and phase of the AC voltage change. Prior to connecting the voltmeter the voltage is $\overline{V}$ and after it is connected the voltage is $\overline{V}'$. The type of voltmeter that will be considered measures only the rms magnitude of the AC voltage; phase changes cannot be measured. Therefore, the percentage error due to AC voltmeter loading in the measurement of the rms magnitude of an AC voltage is defined

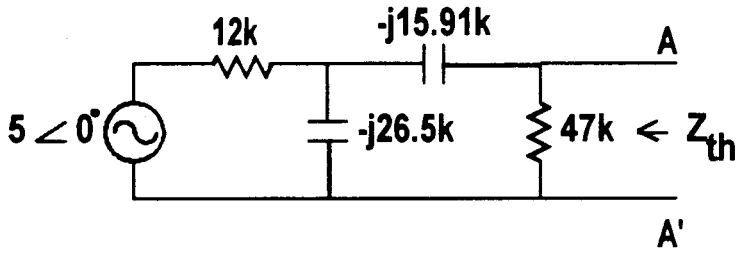
$$\% \; error = 100 \times \frac{|\,\overline{V'}\,| - |\,\overline{V}\,|}{|\,\overline{V}\,|}$$

iff $\overline{V} \neq 0$ and is zero if $\overline{V} = 0$.

Example.

$e(t)=5\sqrt{2}\cos(\omega t)$
$f=1kHz$





$$\overline{E}_{th} = 5\angle 0^\circ \times \frac{-j26.5 \| \, [-j15.91 + 47]}{12 + (-j26.5 \| \, [-j15.91 + 47])}$$

$$\times \frac{47}{47 - j15.91} = 3.54\angle -4.62^\circ V$$

$$\overline{Z}_{th} = 47 \| [-j15.91 + 12 \| (-j26.5)]$$

$$= 17.65 \angle -44.27^{\circ} k\Omega$$

$$\overline{V}'_{AA'} = \overline{E}_{th} \frac{\overline{Z}_{in}}{\overline{Z}_{in} + \overline{Z}_{th}}$$

For the measurement of AC voltages the input impedances of the three voltmeter used in lab may be modeled as simply a resistor. The input impedance of the Fluke 73 HHDMM is 10 $M\Omega$; the input impedance of the Hewlett-Packard 34401A DMM is only 1 $M\Omega$; the input impedance of the Simpson Model 260-7 is $Z_{in} = SV_{fs}$ where S is the AC sensitivity which is 5 $k\Omega/Volt$ and V_{fs} is the range voltage.

So, if a Simpson meter is being used and is set to the $10V$ range the input impedance is $Z_{in} = SV_{fs} =$

$5k\Omega \times 10 = 50.0k\Omega$. The voltage measured by the AC voltmeter is then

$$\overline{V'}_{AA'} = \overline{E}_{th}\frac{\overline{Z}_{in}}{\overline{Z}_{in} + \overline{Z}_{th}} =$$

$$3.54\angle -4.62^\circ \times \frac{50}{50 + 17.65\angle -44.27^\circ} = 2.77\angle 6.51^\circ V$$

$$\%\ error = 100 \times \frac{|\ \overline{V'}\ | - |\ \overline{V}\ |}{|\ \overline{V}\ |} =$$

$$100 \times \frac{2.77 - 3.54}{3.54} = -21.67\%$$

Note:

$$\%\ error \neq -100\frac{\overline{Z}_{th}}{\overline{Z}_{th} + \overline{Z}_{in}}\ because\ of\ the\ phase\ of\ \overline{Z}_{th}$$

$$\% \, error = 100 \left[\frac{1}{\left| 1 + \frac{\overline{Z}_{th}}{\overline{Z}_{in}} \right|} - 1 \right]$$

