ME 360: FUNDAMENTALS OF SIGNAL PROCESSING, INSTRUMENTATION, AND CONTROL

Experiment No. 1 – Introduction to Laboratory Instruments Data Sheet

FIXED POWER SUPPLY VOLTAGE (2 PTS)

Red Lead (DMM "HI")	Black Lead (DMM "LO")	Expected Reading [V]	Actual Reading [V]
+5 VDC output ("HI")	+5 VDC ground ("LO")	5.0000	

VARIABLE POWER SUPPLY VOLTAGE (3 PTS)

	DMM – 4-1/2 Digit [V]		DMM – 5-1/2 Digit [V]		DMM – 6-1/2 Digit [V]	
Power Supply Setting	Reading	NDD*	Reading	NDD*	Reading	NDD*
1.123						
1.234						

* Number of Digits Displayed before and after decimal point include zeros

NOMINAL AND MEASURED RESISTANCES (10 PTS)

Resistor	Band 1	Band 2	Band 3	Band 4	Nominal R_{nom} [Ω]	±	Tolerance [Ω]
1	Value printed on resistor				5 Ω	±	
2					510 Ω	±	
3					22 kΩ	±	

Resistor	Nominal R_{nom} [Ω]	Measured R [Ω]	$\Delta R = R - R_{nom}$ [Ω]	100 % (ΔR / R)	Within Tolerance?
1	5 Ω				
2	510 Ω				
3	22 kΩ				

COMPARISON OF TWO-WIRE AND FOUR-WIRE RESISTANCE MEASUREMENTS (10 PTS)

Nominal R_{nom} [Ω]	Two-wire Measurement R_{2W} [Ω]*	Four-wire Measurement R_{4W} [Ω]	$\Delta R_{24} = R_{2W} - R_{4W}$ [Ω]	100%(ΔR_{24} / R_{4W})
5 Ω				
		$\Delta R = R_{4W} - R_{nom}$ [Ω]	100 % (ΔR / R_{4W})	Within Tolerance?

* copy from table of resistance measurements above (nominally 5 Ω)

DC CURRENT MEASUREMENT (10 PTS)

Power Supply Voltage V [V]	Load Resistor R [Ω]*	Calculated Current i_{calc} = V / R [mA]	Measured Current i [mA]	Difference $\Delta i = i_{calc} - i$ [mA]	100 % (Δi / i)

* copy from table of resistance measurements above (nominally 510 Ω)

OSCILLOSCOPE CHARACTERISTICS (5 PTS)

Characteristic	Hewlett Packard DSO6012A Oscilloscope
number of input channels	
range of discrete time-base settings	
range of discrete vertical voltage settings	
input coupling options (list)	
trigger slope (list)	

DC WAVEFORM MEASUREMENTS (5 PTS)

Input*	Coupling	Cursor [V]	DMM** [V]
+5 V	DC		

Action	Description of Effect
Change coupling from DC to AC	

* connect to specified output of station power supply ** DMM in DC-voltage mode

AC WAVEFORM MEASUREMENTS (10 PTS)

Function Generator			Oscilloscope				DMM
Freq. [kHz]	Amp. [Vp-p]	Offset [V]	Period [μs]	Freq. [kHz]	Amp. [Vp-p]	Offset [V]	RMS [VAC] *
10.000	2.000	1.000					

* RMS = root mean square = peak-to-peak / $\sqrt{8}$ for a perfect sinusoid

Action	Description of Effect
Change channel coupling from DC to AC	
Change trigger level up and down	
Trigger level greater than signal level	
Change trigger slope	

GAIN AND PHASE SHIFT OF LOW-PASS, RC FILTER (15 PTS)

Resistance R of Filter Resistor [Ω]	

* copy from table of resistance measurements above (nominally 22 kΩ)

V_{pin} = Peak-to-peak Level of Filter Input (Channel 1) [V]		
V_{pout} = Peak-to-peak Level of Filter Output (Channel 2) [V]		
τ_{delay} = Time Delay between Input and Output [s]		
T_{in} = Period of Filter Input (Channel 1) [s]		
T_{out} = Period of Filter Output (Channel 2) [s]		
ϕ_d = Phase Shift based on Time Delay [°]	$\phi_d = 360° \, \tau_{delay} / T_{in}$	
C_d = Capacitance based on Time Delay [F]	$C_d = \frac{T_{in} \tan(\phi_d)}{2\pi R}$	
G = Gain based on Peak-to-peak Levels [–]	$G = \frac{V_{pout}}{V_{pin}}$	
C = Capacitance based on Peak-to-Peak Levels [F]	$C = \frac{T_{in}}{2\pi R}\sqrt{\frac{1 - G^2}{G^2}}$	

Capacitance Calculation for an RC circuit.

You may remember from your first circuits class that the relationship between the input and output voltage of a simple RC circuit is $V_{out} = \frac{1}{1 + RC(jw)} V_{in}$. Also remember the magnitude (gain) and phase of an imaginary number $a + jb$ is $G = \sqrt{a^2 + b^2}$ and $\phi = \tan^{-1}(b/a)$. Using that information you can solve for C with both the gain and phase equation.

$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + jRCw}\frac{1 - jRCw}{1 - jRCw} = \frac{1 - jRCw}{1 + (RCw)^2} = \frac{1}{1 + (RCw)^2} - j\frac{RCw}{1 + (RCw)^2}$$

Gain Equation:

$G^2 = \left(\frac{1}{1 + (RCw)^2}\right)^2 + \left(\frac{RCw}{1 + (RCw)^2}\right)^2 = \frac{1}{1 + (RCw)^2}$ then, solving for C, $C = \frac{1}{Rw}\sqrt{\frac{1 - G^2}{G^2}}$

$w = \frac{2\pi}{T_{in}}$ so $C = \frac{T_{in}}{2\pi R}\sqrt{\frac{1 - G^2}{G^2}}$

Phase Equation:

$\phi = \tan^{-1}\left(\frac{\frac{RCw}{1 + (RCw)^2}}{\frac{1}{1 + (RCw)^2}}\right) = \tan^{-1}\left(RCw\right)$, then solving for C, $C = \frac{\tan(\phi)}{Rw}$

$w = \frac{2\pi}{T_{in}}$ so $C = \frac{T_{in}\tan(\phi)}{2\pi R}$.