Noise Fundamentals

High Level Electronics

1. **Gain**
   a. Make a table listing the gains and clipping voltages (max. voltage output possible at the amplifier **output**) corresponding to each gain setting of the HLE *that you will actually use later in your noise measurements*.

Gain Setting	Actual Gain G_3	Clipping Voltage

   b. Roughly verify the linear operation of each setting.

2. **Multiplier or Squarer**
   a. Demonstrate using the oscilloscope the square relation between the output (V_{sq}) and the input (V_{in}) of the multiplier. Save a screen-shot of your demonstration.
   b. Plot $< V_{sq} >$ vs. $< V_{in}^2 >$ for multiplier corresponding to a given input sinusoidal signal from the signal generator.
   c. Verify the following relation between V_{in} and V_{sq}.

$$< V_{sq} > = \frac{< V_{in}^2 >}{10\ V}$$

   d. Are there any limits to the input voltage amplitude that it can deal with?
   e. Are there any limits to the input frequency?

3. **Output**
   a. Check what does the output module do? What is the effect of time constant?

4. **High Pass and Low Pass filters.**

a. Observe how the phase between the input and output signal changes with f. Draw a brief sketch.
b. For $f_1 = 1\ kHz$ and $f_2 = 10\ kHz$, plot the gain $G(f) = |V_{out}/V_{in}|$ as a function of frequency of the input frequency f. At least sweep from 0.1 kHz to 100 kHz. Identify the high pass corner and the low pass corner and the band width of the filter from the plot.

Measuring Johnson's noise at Room Temperature

1. Correcting for amplifier noise and dependence on R_{in}

FEEDBACK $R_f = 10\ k\Omega$. For a certain value of bandwidth $f_1 = 1kHz,\ f_2 = 10\ kHz$, make the following table:

R_{in}	$Gain\ G_1$ (LLE)	$Gain\ G_2$ (LLE)	$Gain\ G_2$ (HLE)	Total Gain G	$< V_{sq} > (V)$	$< V_J^2 + V_N^2 >$
$1\ \Omega$						
$10\ \Omega$						
$100\ \Omega$						
$1k\ \Omega$						
$10\ k\Omega$						
$100\ k\Omega$						
$1\ M\Omega$						

a. Plot $< V_J^2 + V_N^2 >$ as a function of R_{in} (log-log)
b. Find Boltzmann's constant.

Note:

a. For the HLE amplifiers, linear operation is possible in the range $\pm 10\ V$ (as you have found). Adjust the gains such that, output of the amplifier should fit easily in this range. If this is so, $< V_{sq} >$ should not exceed 1 V.
b. Note down value of temperature T.
c. You should list $< V_{sq} >$ along with the errors.

2. Johnson's noise dependence on Bandwidth

Make the following table to understand the Johnson's noise dependence on bandwidth for a given resistor $R_{in} = 10\ k\Omega$:

*(**Note**: $< V_N^2 >$ may be different for different bandwidths. Hence, for each bandwidth, it must be measured using a low resistor, say $R = 10\Omega$.)*

$\Delta f = \lvert f_1 - f_2 \rvert$	**ENBW**	**Amplifier Noise**			**Johnson's noise**		
			$< V_{sq} >_{R=10\Omega}$	$< V_N^2 >$		$< V_{sq} >_{R=10\ k\Omega}$	$< V_J^2 + V_N^2 >$
$\lvert 330 - 100 \rvert\ Hz$							
$\lvert 330\ Hz - 10\ Hz \rvert$							
$\lvert 1kHz - 300\ Hz \rvert$							
$\lvert 1kHz - 30\ Hz \rvert$							
$\lvert 3.3\ kHz - 100\ Hz \rvert$							
$\lvert 10\ kHz - 1\ kHz \rvert$							
$\lvert 10\ kHz - 300\ Hz \rvert$							
$\lvert 33\ kHz - 3\ kHz \rvert$							
$\lvert 33\ kHz - 1\ kHz \rvert$							
$\lvert 100\ kHz - 3\ kHz \rvert$							
$\lvert 100\ kHz - 100\ Hz \rvert$							
$\lvert 100\ kHz - 10\ Hz \rvert$							

a. Plot $< V_J^2(t) >$ as a function $(f_2 - f_1)$
b. and ENBW (Equivalent noise bandwidth).
c. Note down temperature.
d. What is the noise power spectral density.
e. What is the Boltzmann constant?