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22202945
EEE-313-02

EEE-313 PROJECT REPORT

DESIGN PHASE

I affirm that I have not given or received any unauthorized help on this report and that this work is my own.

Design Specifications:

To begin with, a wideband amplifier delivering 40 dB of gain across the 200 kHz to 2 MHz frequency range was designed using two NPN BC238 bipolar junction transistors.

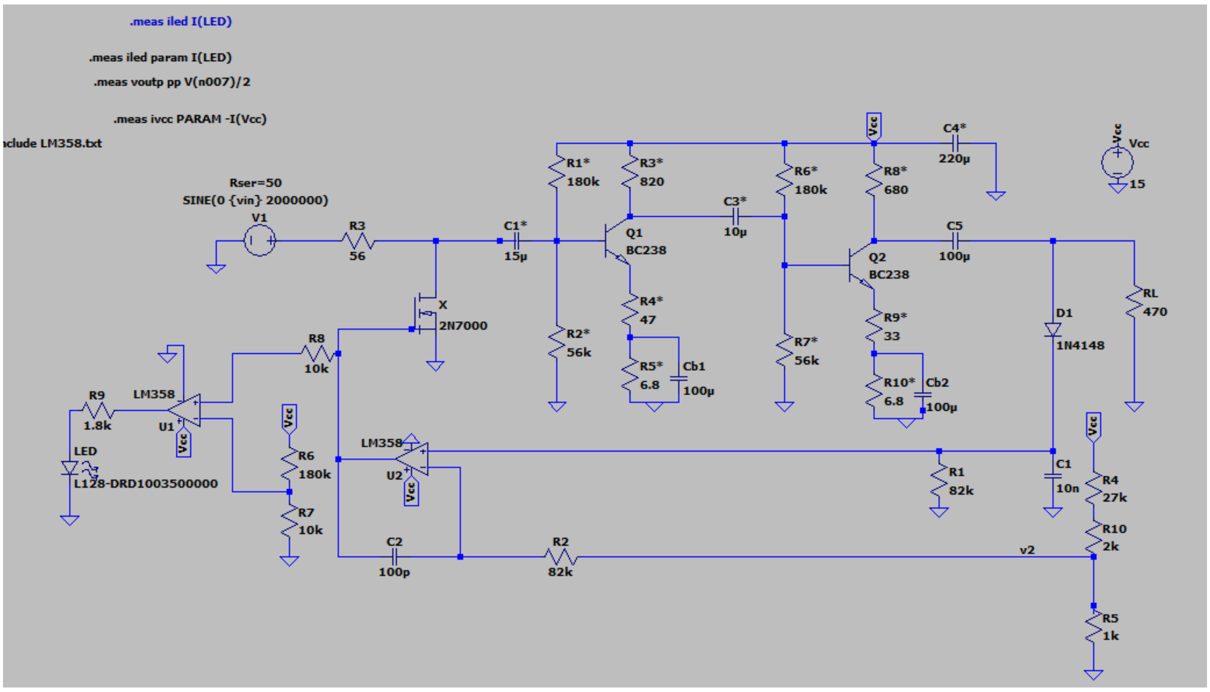

Figure 1 : LT Spice design of the circuit

Component values were selected based on the design criteria provided.

R4 = 27kΩ and R5 = 1kΩ set. R1 = 82kΩ and C1 = 10nF were chosen to ensure $\tau = R1 * C1 = 820\mu s > 200 * (1/f_{in})$, to minimize ripple at 2MHz. C2 = 100pF provides loop stability for the op-amp. R6 = 180kΩ and R7 = 10kΩ define the op-amp input bias.R8 = 10kΩ limits gate current and suppresses oscillation at the nMOS gate.

SPECIFICATIONS:

1. The peak output voltage is Voutp=1±0.1 V undistorted sinusoidal when the peak input voltage is between Vinp=0.01 V and 0.1 V while the frequency is between 200KHz and 2MHz:

Using the step param function, **vin has increased from 0.01V (10mV) to 0.1V (100mV) with step size 10mV.** And the frequencies has been manually measured for 200kHz and 2MegHz. The output of the circuit for varying vin variables and **f at 200kHz is the following:**

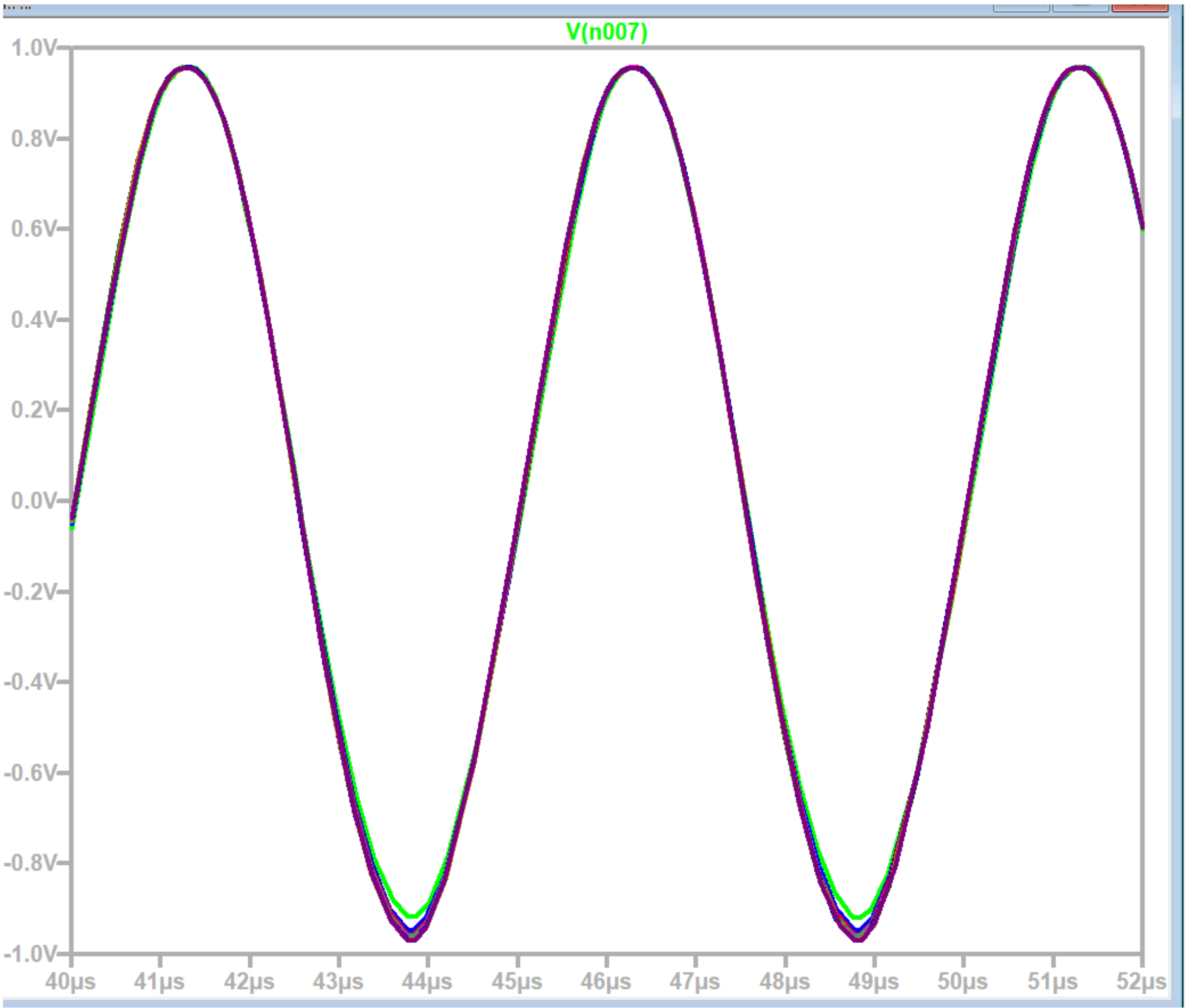

Figure 2: Vout for varying vin and f is at 200kHz

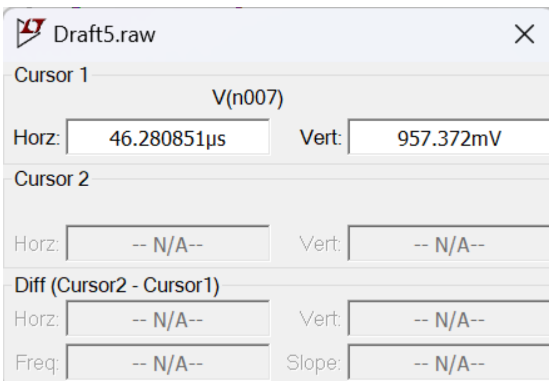

Figure 3: The upper vpeak

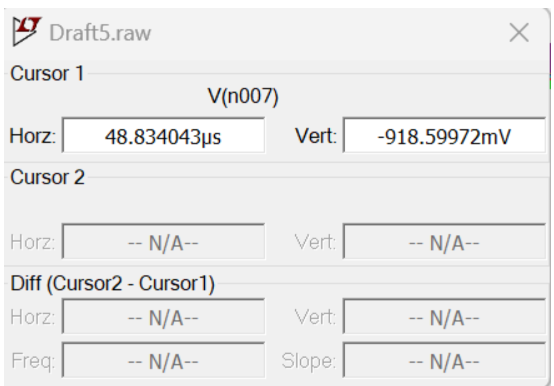

Figure 4: The lower vpeak

It appears that there is a low offset, which has happened due to the 2-stage amplifier controlling different halves of the sinusoidal outputs, hence it can be considered as accurate and close to 1V. For more accuracy, for each input voltage varying from 10mV and 100mV witht 10mV is the following:

Measurement: voutp

step	PP(V(n007)/2)	FROM	TO
1	0.940459609032	0	0.0001
2	0.953300714493	0	0.0001
3	0.957575410604	0	0.0001
4	0.959862887859	0	0.0001
5	0.961573511362	0	0.0001
6	0.962385743856	0	0.0001
7	0.963222742081	0	0.0001
8	0.963418334723	0	0.0001
9	0.96408623457	0	0.0001
10	0.964082479477	0	0.0001

Figure 5: Results of Voutpeak with changing Vin variables for f=200kHz

Output voltage for changing Vin variables from 10mV and 100mV with step size 10mV at frequency at 2MegHz is the following:

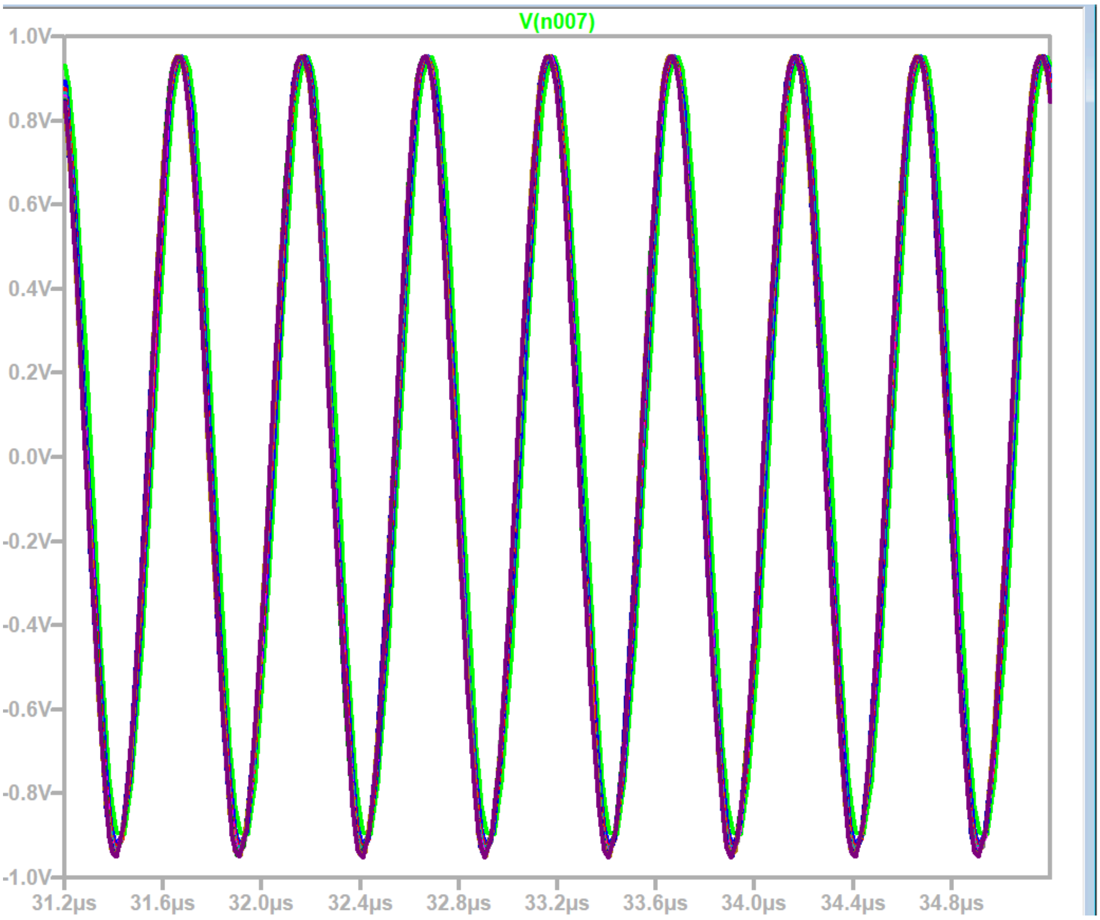

Figure 6: Vout for varying vin and f is at 2MegHz

Cursor 1			
	V(n007)		
Horz:	32.929614µs	Vert:	-894.69746mV
Cursor 2			
	V(n007)		
Horz:	33.2µs	Vert:	932.25804mV
Diff (Cursor2 - Cursor1)			
Horz:	270.38627ns	Vert:	1.8269555V
Freq:	3.6984127MHz	Slope:	6.75684e+06

Figure 7: The cursor at peaks of the output plot

Again, the offset problem is encountered due to the lower errors in half-period arrangements, can still be considered as accurate. For more clear view, outputs for each varying inputs at 2MegHz is the following:

Measurement: voutp

step	PP(V(n007)/2)	FROM	TO
1	0.933876156807	0	0.0001
2	0.939989298582	0	0.0001
3	0.945706814528	0	0.0001
4	0.948755741119	0	0.0001
5	0.950112760067	0	0.0001
6	0.951538085938	0	0.0001
7	0.952418088913	0	0.0001
8	0.952938258648	0	0.0001
9	0.953448474407	0	0.0001
10	0.953875809908	0	0.0001

Figure 8: Results of Voutpeak at each step of vin at frequency is at 2MegHz

Hence the specification of Voutpeak being 1±0.1 V when vin varying in between 10mV and 100mV at frequencies from 200kHz to 2MegHz specification is satisfied.

<u>2. The power supply current, ICC, is less than 100mA:</u>

This specification requires that the power supply current **Icc** should be less than 100mA. For this criterion, again, for the sake of more accurate plotting, only the vin variables have been written as step functions, where the frequencies of the highest and lowest values are plotted manually. With the same input step size parameters, the power supply current Icc plotting is the following for the frequency at **200 kHz.**

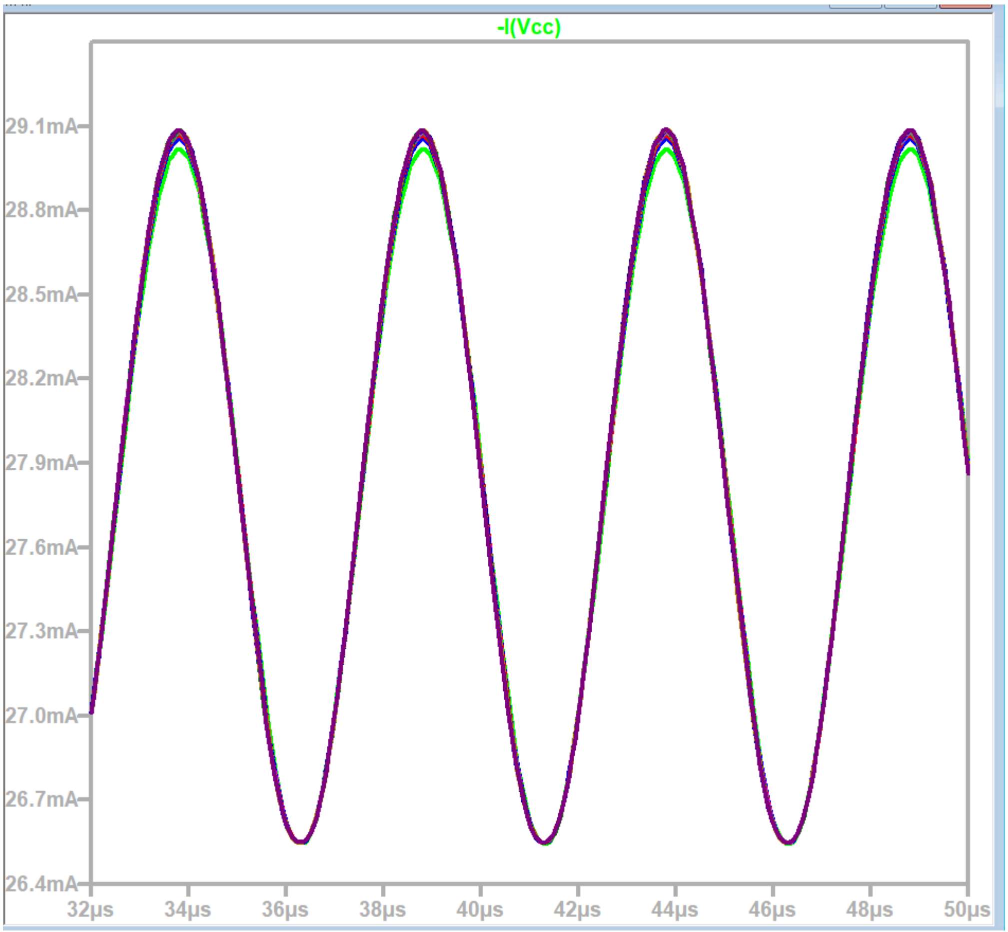

Figure 9: The value of power supply current Icc.

Again, for more accuracy, Icc values for each vin step have been shown on the following figure:

Measurement: ivcc

step	-I(Vcc)
1	0.0278981756419
2	0.0278794188052
3	0.0278736446053
4	0.0278702508658
5	0.0278678853065
6	0.0278666131198
7	0.0278654303402
8	0.0278643909842
9	0.0278643965721
10	0.0278638508171

Figure 10: Icc value for each vin step

The Icc function for the frequency at 2MegHz for changing variables are the following:

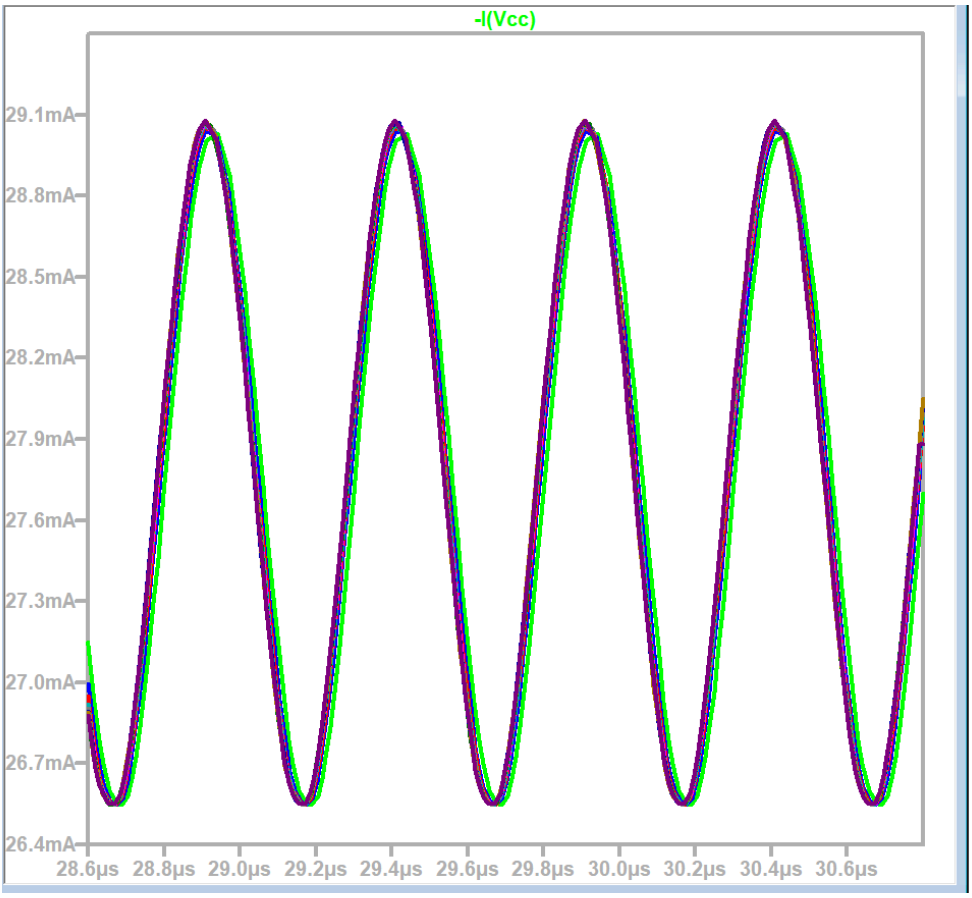

Figure 11: The value of power supply current Icc.

```
Measurement: ivcc
  step       -I(Vcc)
     1       0.0286067109555
     2       0.0284727811813
     3       0.0284280851483
     4       0.0284050423652
     5       0.0283846203238
     6       0.028378020972
     7       0.0283698383719
     8       0.0283604189754
     9       0.028361953795
    10       0.0283526536077
```

Figure 12: Icc value for each vin step

Hence, the second criterion has been satisfied. The power supply current Icc is no more than 100mA.

3. LED turns ON when the peak output voltage is Voutp=1±0.1 V. It should turn off if the peak output is less than Voutp< 0.9 V:

As in all previous steps, again there will be a separate section for f is 200kHz and 2MegHz. For vin starting from 10mV to 100mV with step size 10mV (first figure) the following 11 steps demonstrates that the output peak is greater than 900mV which also showing that LED is on each time (since output is greater tha 900mV. For the second figure, the vin starts from 6mV to 10mV and observes when the output peak voltage is greater than 900mV and hence the LED across the diode is on. (The current through it is greater than 5.5mA). Next two figures will demonstrate what is explained above for frequency is 200kHz.

Measurement: iled

step	I(LED)
1	0.00653078407049
2	0.00653078407049
3	0.00653078407049
4	0.00653078407049
5	0.00653078407049
6	0.00653078407049
7	0.00653078407049
8	0.00653078407049
9	0.00653078407049
10	0.00653078407049

Measurement: voutp

step	PP(V(n007)/2)	FROM
1	0.940477639437	0
2	0.953300714493	0
3	0.95758742094	0
4	0.959862887859	0
5	0.961725980043	0
6	0.962529838085	0
7	0.963005304337	0
8	0.963743418455	0
9	0.964122653008	0
10	0.964211732149	0

Figure 13: Vout and LED when Vin is from 10mV to 100mV

Measurement: iled

step	I(LED)
1	-1.19496602826e-13
2	-1.19492794565e-13
3	-1.19519493044e-13
4	0.00653078407049
5	0.00653078407049

Measurement: voutp

step	PP(V(n007)/2)	FROM
1	0.678369522095	0
2	0.789926618338	0
3	0.896097958088	0
4	0.937561511993	0
5	0.940477639437	0

Figure 14: Vout and LED when Vin is from 6mV to 10mV

Following two figures are the same explained hence for f is 2MegHz.

```
Measurement: iled
  step          I(LED)
     1          0.00653078407049
     2          0.00653078407049
     3          0.00653078407049
     4          0.00653078407049
     5          0.00653078407049
     6          0.00653078407049
     7          0.00653078407049
     8          0.00653078407049
     9          0.00653078407049
    10          0.00653078407049

Measurement: voutp
  step          PP(V(n007)/2)       FROM
     1          0.933876872063      0
     2          0.939989566803      0
     3          0.94569543004       0
     4          0.948764979839      0
     5          0.950108736753      0
     6          0.951514750719      0
     7          0.952417105436      0
     8          0.953052461147      0
     9          0.953468471766      0
    10          0.953829944134      0
```

Figure 15: Vout and LED when Vin is from 10mV to 100mV

```
Measurement: iled
  step          I(LED)
     1          -1.19527136669e-13
     2          -1.19527136669e-13
     3          -1.19534766742e-13
     4          -1.19504232898e-13
     5          0.00653078407049

Measurement: voutp
  step          PP(V(n007)/2)       FROM
     1          0.596684962511      0
     2          0.697067528963      0
     3          0.793683975935      0
     4          0.896097958088      0
     5          0.933895766735      0
```

Figure 16: Vout and LED when Vin is from 6mV to 10mV

With the previous four figures, it can be concluded that the LED is ON (current through the diode is higher than 5.5mA) when the peak output voltage for varying input voltages is more than 0.9V criterion is satisfied for f is 200kHz and 2MegHz.

	V_{inp} (mV)	V_{outp} (V)	LED ON/OFF	I_{CC} (mA)
0.2MHz	10	0.940 V	ON	6.53
0.2MHz	Vinpmin= 9mV	1±0.1	ON	6.53
0.2MHz	100	0.964V	ON	6.53
0.2MHz	Vinpmax= 520mV	1±0.1	ON	6.53
2MHz	10	0.933 V	ON	6.53
2MHz	Vinmin= 10mV	1±0.1	ON	6.53
2MHz	100	0.954 V	ON	6.53
2MHz	Vinpmax= 540mV	1± 0.1	ON	6.53

Figure 17: The final and summarizing graph of the output, LED values for varying input and f values.