Opamp report on LPV821 and AD8065

- Done by Karun Mathews Manoj (SC19B120)

Table on specifications of both opamps

| Specification | LPV821 | AD8065 | Ideal value |
|---|---|---|---|
| Open loop gain | 135 dB | 113 dB | infinite |
| Input impedance:<br>- Differential mode<br>- Common mode | - | 1000 GΩ \|\| 4.5 pF<br><br>1000 GΩ \|\| 2.1 pF | Infinite<br><br>Infinite |
| Input offset voltage | 10 µV | 1.5 mV | Zero |
| Input offset voltage drift | 0.096 µV/°C | 17 µV/°C | Zero |
| Input bias current | 7 pA | 125 pA | Zero |
| Input offset current | 14 pA | 125 pA | Zero |
| Voltage range:<br>- Input<br>- Output | 12mV swing from both positive and negative rails | -5 V to +1.7 V<br>-4.88 V to +4.90 V | |
| Bandwidth | (Bandwidth wasn't clearly specified)<br>Gain bandwidth product (GBW) = 8 kHz | (G=+1 and Vo=0.2Vpp) 145MHz (-3dB bandwidth)<br>(G=+2 and Vo=0.2Vpp) 7MHz (0.1dB flatness) | Infinite |
| Phase shift | | 0.02° error | Zero |
| Slew rate | (G=+1 and CL=20 pF) 3.3 V/ms | 155 V/µs | Infinite |
| Output impedance | (f = 100 Hz and Io = 0 A) 80 kΩ | - | Zero |
| Noise:<br>- Input voltage noise<br>- Input Current noise | (f = 0.1 Hz to 10 Hz) 3.9 µVpp | (f = 10 kHz) 7 nV/√Hz<br><br>(f = 10 kHz) 0.6 fA/√Hz | Zero<br><br>Zero |
| CMRR | 125 dB | 82 dB | Infinite |
| Power supply rejection ratio | -53.46787 dB (4.5 µV/V) | -85 dB | Infinite |
| Supply voltage range | 1.7 V to 3.6 V | 5 V to 24 V | |
| Quiescent current | 650 nA | 6.4 mA | Zero |

* '-' indicates that that specification wasn't clearly specified.

*the values seen above are the worst values seen when taken over the entire operating temperature range.

As can be seen from the above specifications, the AD8065 opamp has the upper hand in speed and frequency response. The opamp has a (3 dB) bandwidth of 145 MHz, and 0.1 dB flatness out to 7 MHz (this means that it's gain doesn't have a ripple of more than 0.1 dB up to 7 MHz). Additionally, it also offers a very high slew rate (180 V/µs – at it's best) and excellent distortion (SFDR of -88 dBc @ 1 MHz) (SFDR is the ratio of the rms value of the carrier wave to the next largest noise or harmonic distortion component at it's output (- wiki)). Additionally, it also offers very low differential gain and phase errors (0.02% and 0.02°, respectively). All these factors make the AD8065 ideal for video applications which demand huge bandwidths and very high speeds.

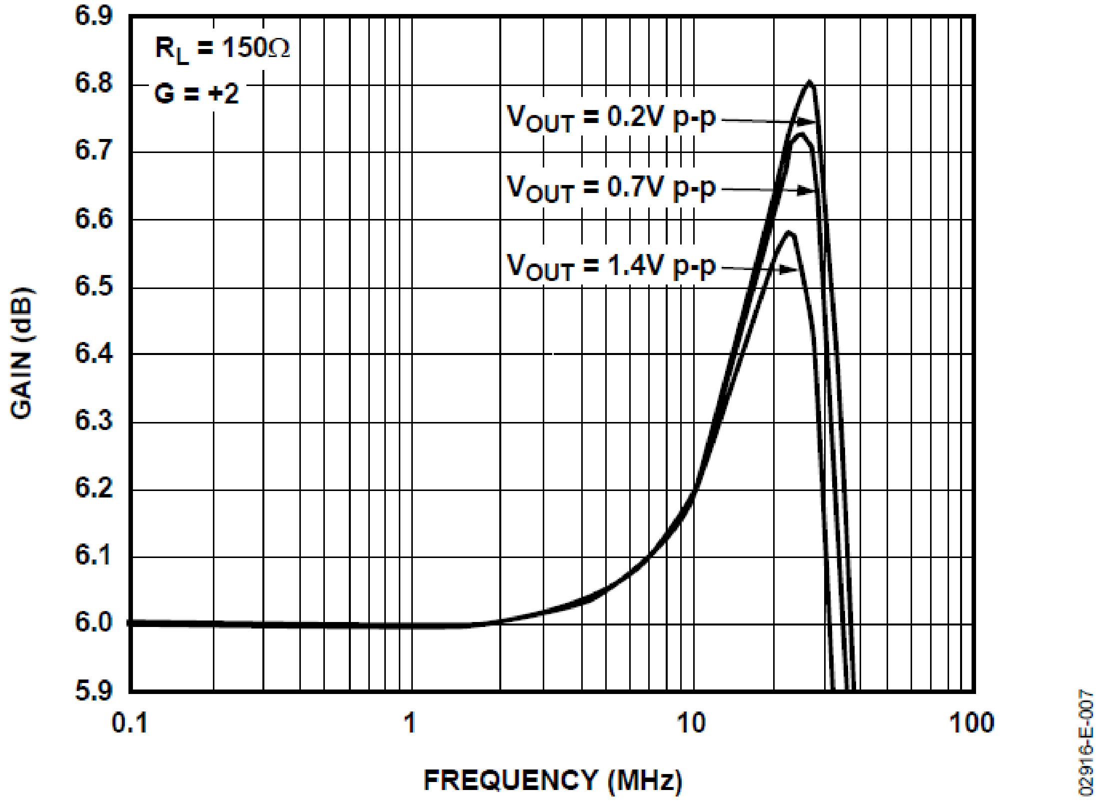



*Figure 7. 0.1 dB Flatness Frequency Response (See Figure 43)*

The above graph, shows that the AD8065 exhibits a 0.1 dB flatness up to 7 MHz, beyond which the gain changes significantly. This is in the Gain (G) = +2 and RL = 150 ohm configuration.

On the other hand the LPV821 has significantly lower input offset (both voltage and current), lower input bias current, lower offset drift and lower power requirements. As seen above, the LPV821 has very low quiescent current (650 nA), as compared to the 6.4 mA of the AD8065 (Quiescent current is the current used by the opamp during no-load or non switching conditions). This makes it one of the lowest power zero drift amplifiers in the industry. These features make the LPV821 very useful in “Always ON” sensing applications – in which the sensors are required to be very power efficient, since they have to remain active all the time, even if the device is not [1].

It must also be noted that the LPV821 opamp uses a certain auto-calibration technique to provide both low offset voltage and minimial drift over temperature and time.

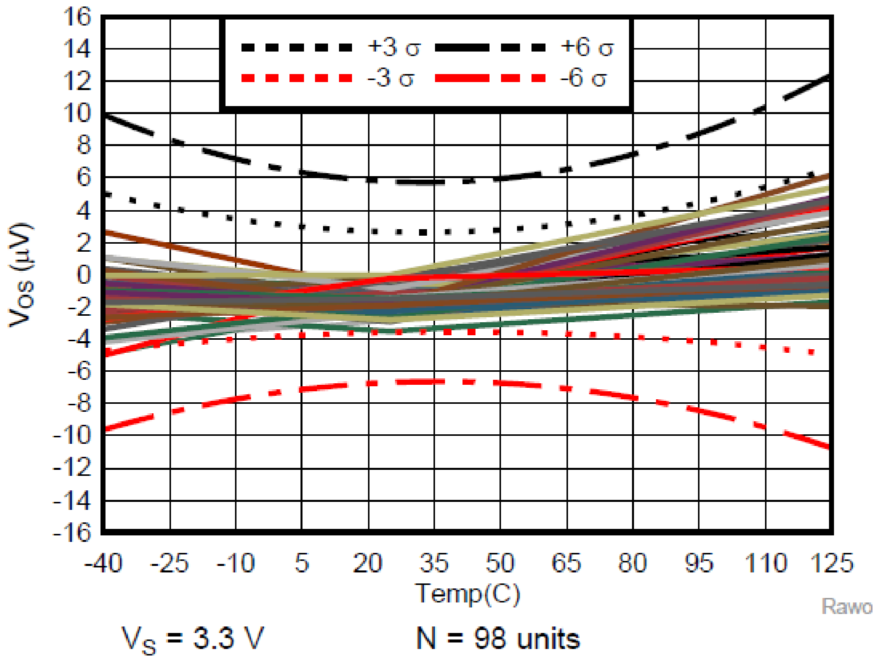



**Figure 9. Offset Voltage vs Temperature, Vs = 3.3 V**

The above graph gives an idea of how low input offset voltage is, and how it drifts with respect to temperature. (Please ignore the N and sigma symbol, I'm not sure what they refer to). Broadly, this graph shows that the offset voltage is very small (maximum 10 µv) and it's drift (within the operating temperature range) is quite minimal as well.

<u>Application circuits for LPV821 and AD8065:</u>

Low side current sensing circuit and video buffer amplifier circuit circuit, respectively.

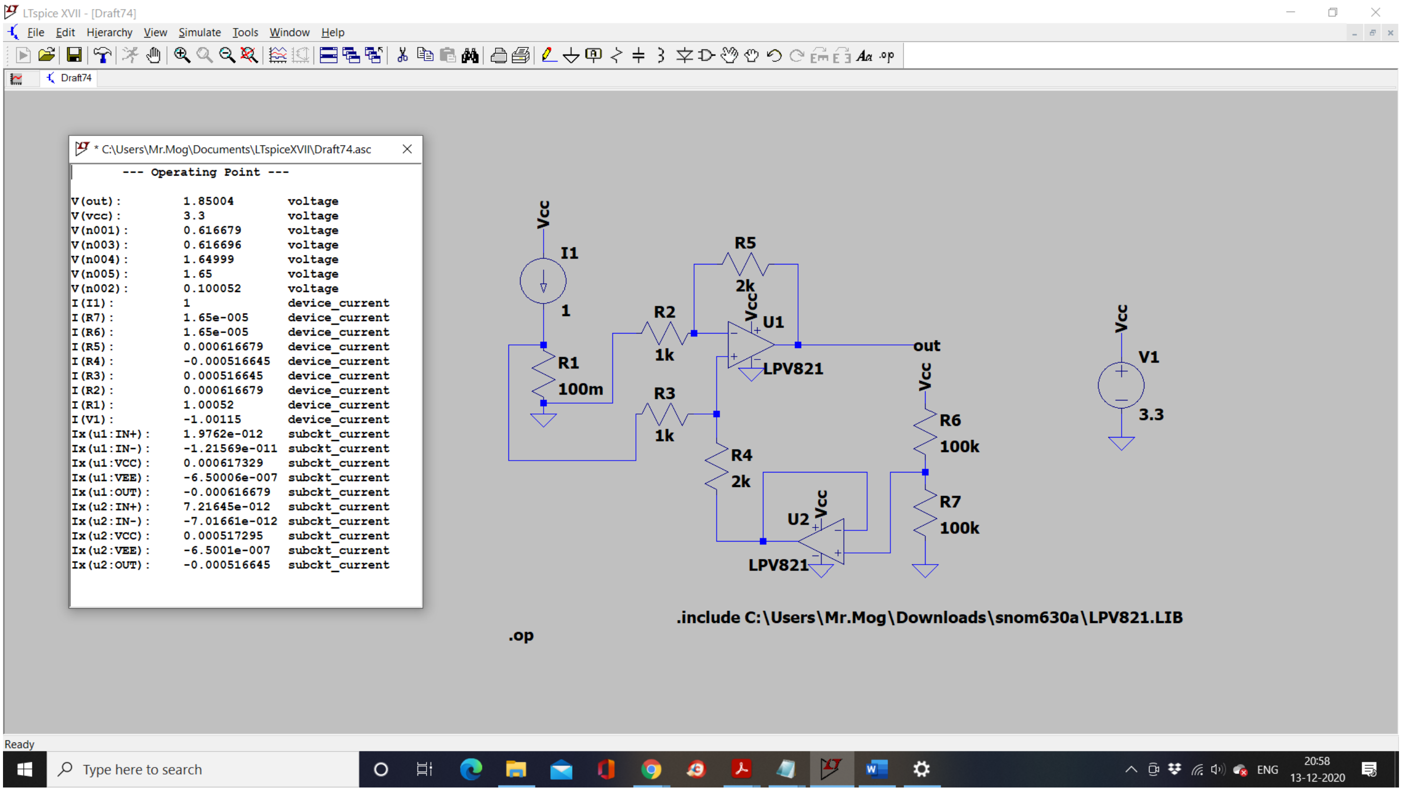
<u>LPV821 application circuit (low side current sensing circuit)</u>

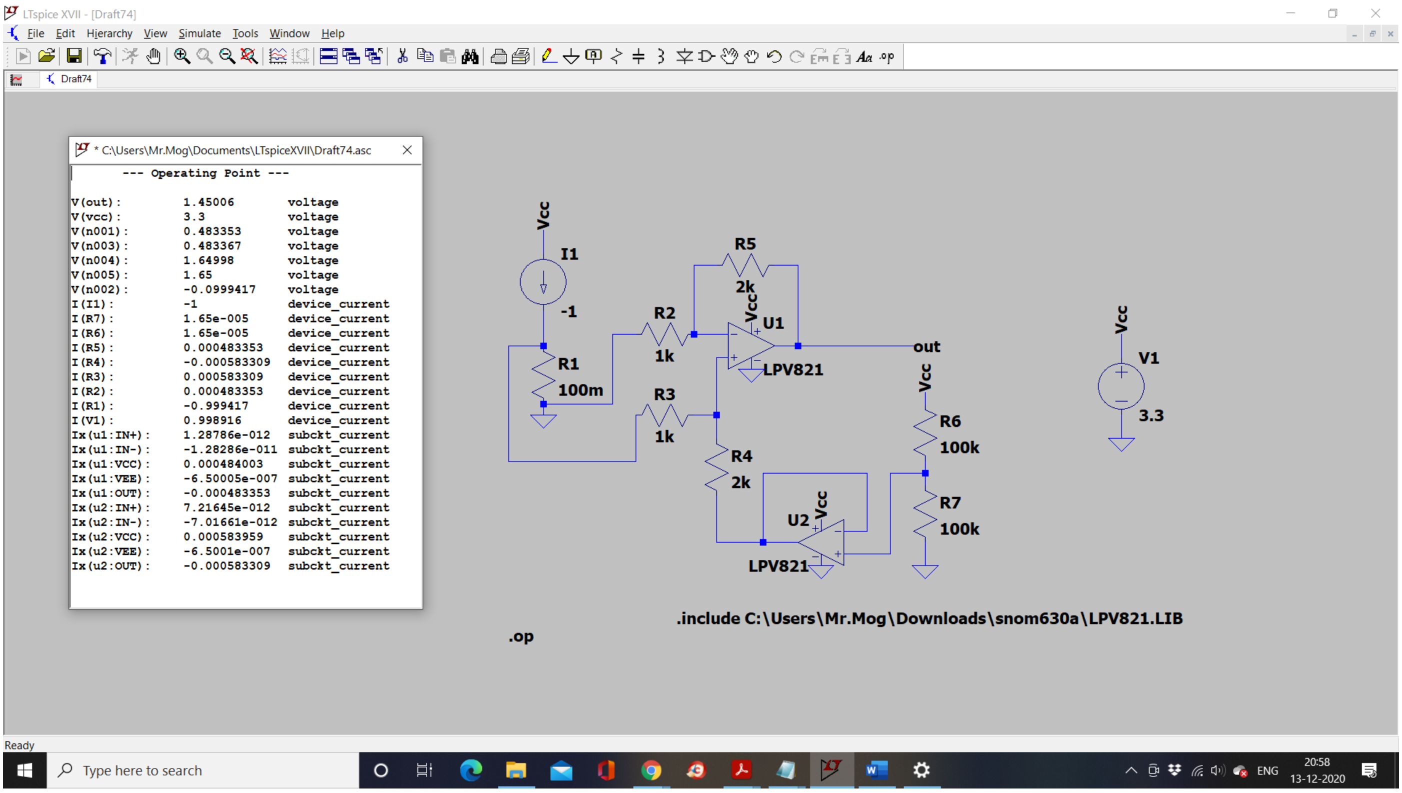
In a low side current sensing circuit, we add a low resistance (100 m ohm) in between the low side of the load and ground. Since, this is a low resistance the load current is not much affected. The voltage across this load resistance is fed to the input terminals (through R2 and R3) of a LPV821 opamp which behaves as a difference amplifier. Also another LPV821 opamp is used to provide a buffered bias voltage directly, to the non-inverting terminal of the first opamp. This allows us to have bidirectional current sensing.

Below, I have shown the output voltages for a load current of 1A and -1A.

The output ranges from ~1.45V to ~1.85V for a load current of -1A to 1A. (We can use this to calculate the corresponding load current).

In the datasheet for LPV821, it said that this current sensing circuit could handle a maximum load current of 1A (or -1A). However, in the ltspice circuit, a load current above this limit posed no problem. This was probably due to this not being a real life experiment.

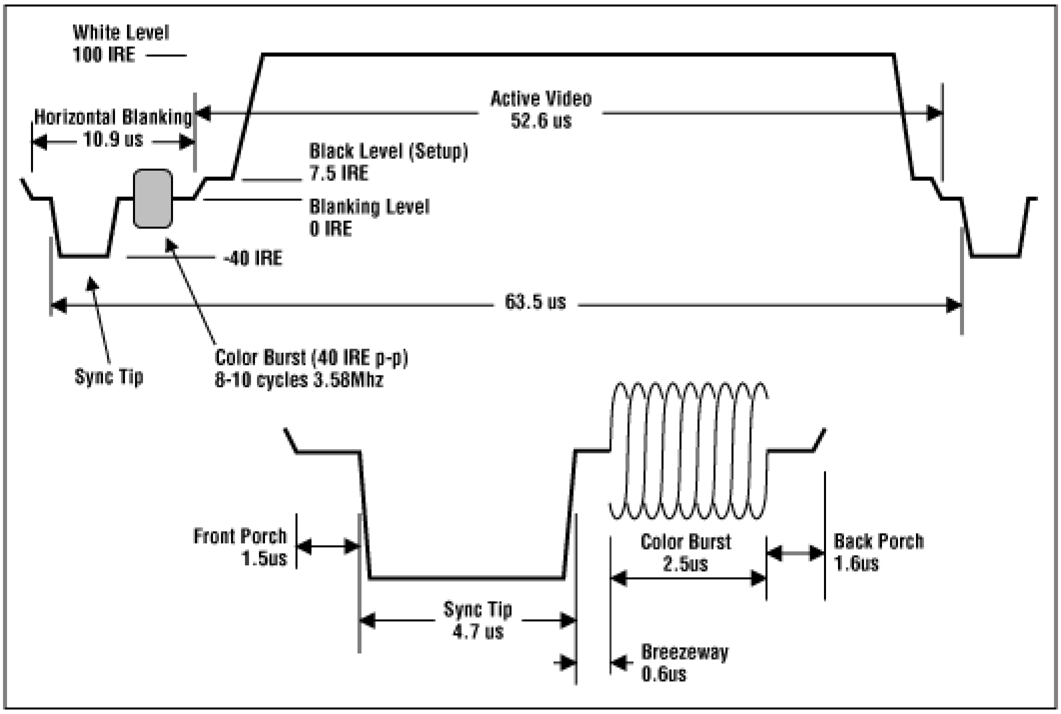


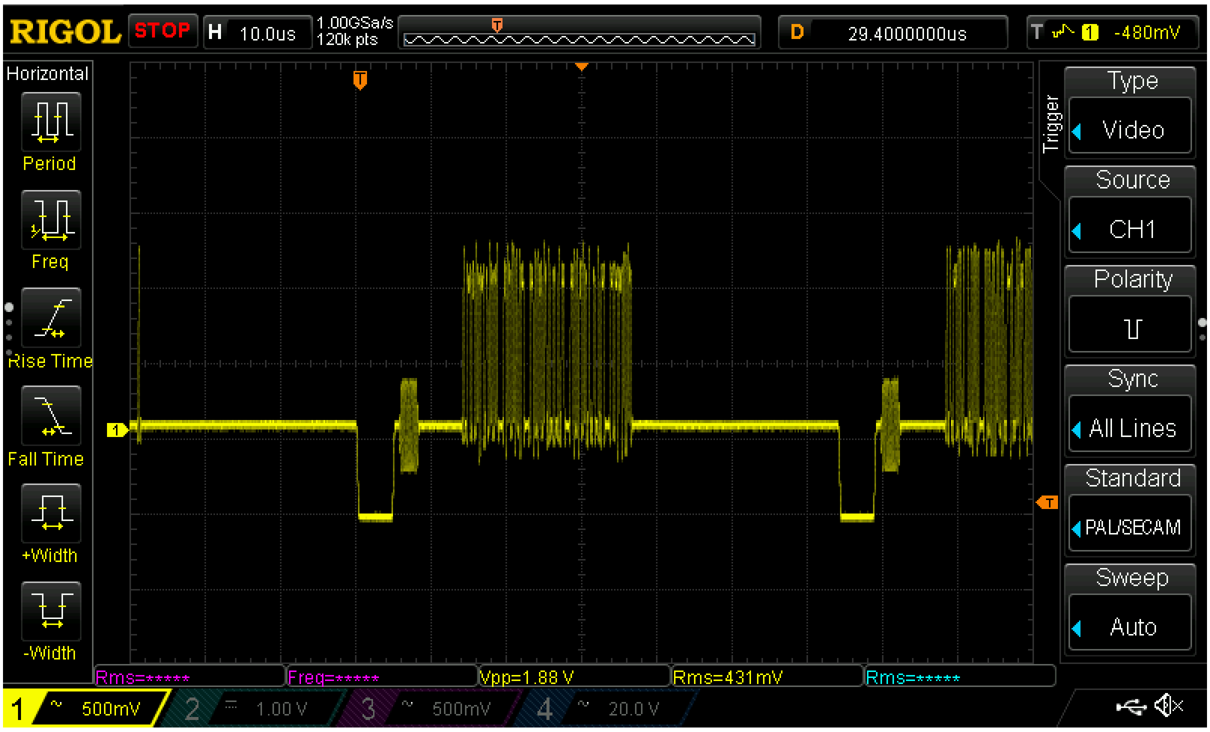

## AD8065 application circuit (video buffer)

The huge bandwidth and high speed of the AD8065 opamp make it useful as a video buffer circuit.

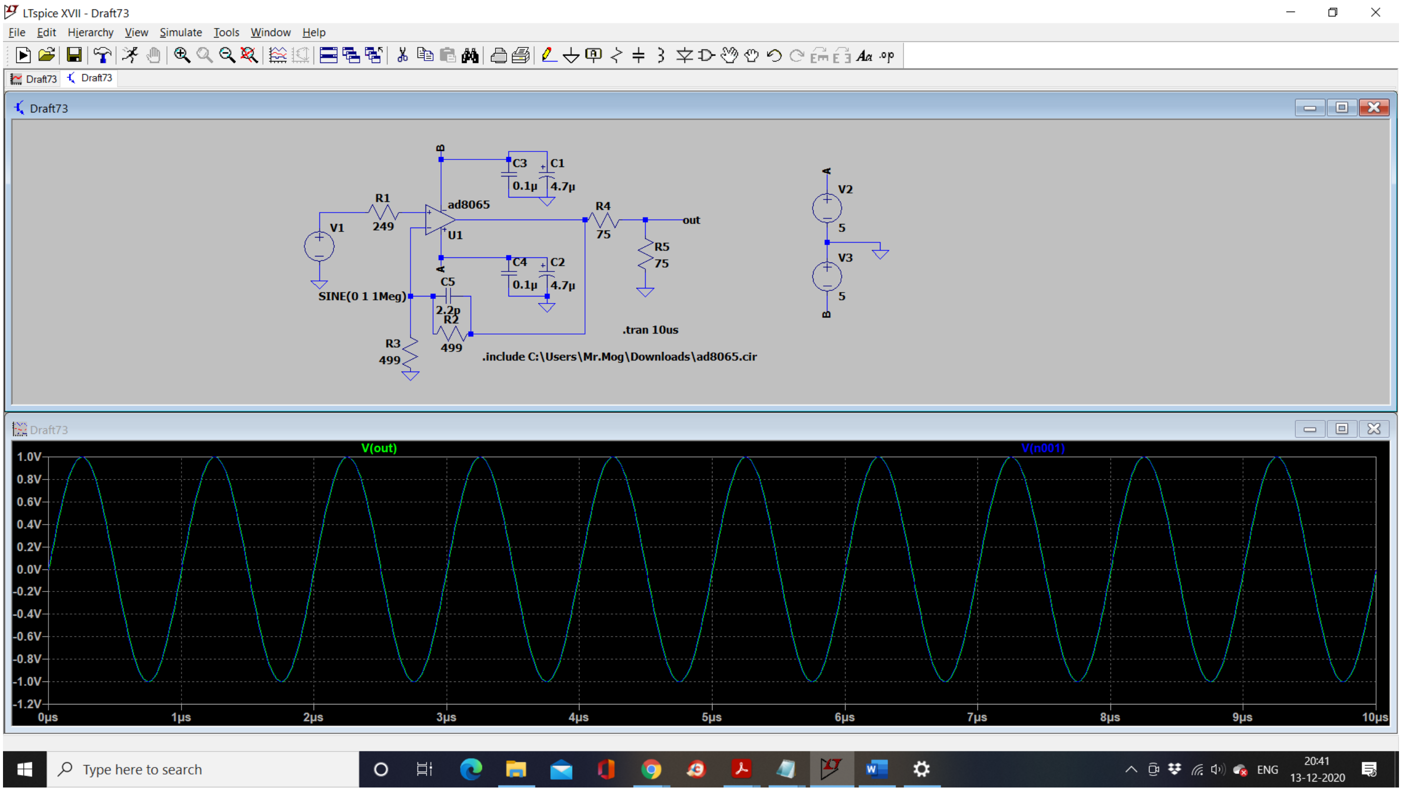
Below, is a diagram showing the general structure of a NTSC (a certain standard) composite video signal waveform [3].




Practically, this is how the waveform looks as seen on an oscilloscope [2]:

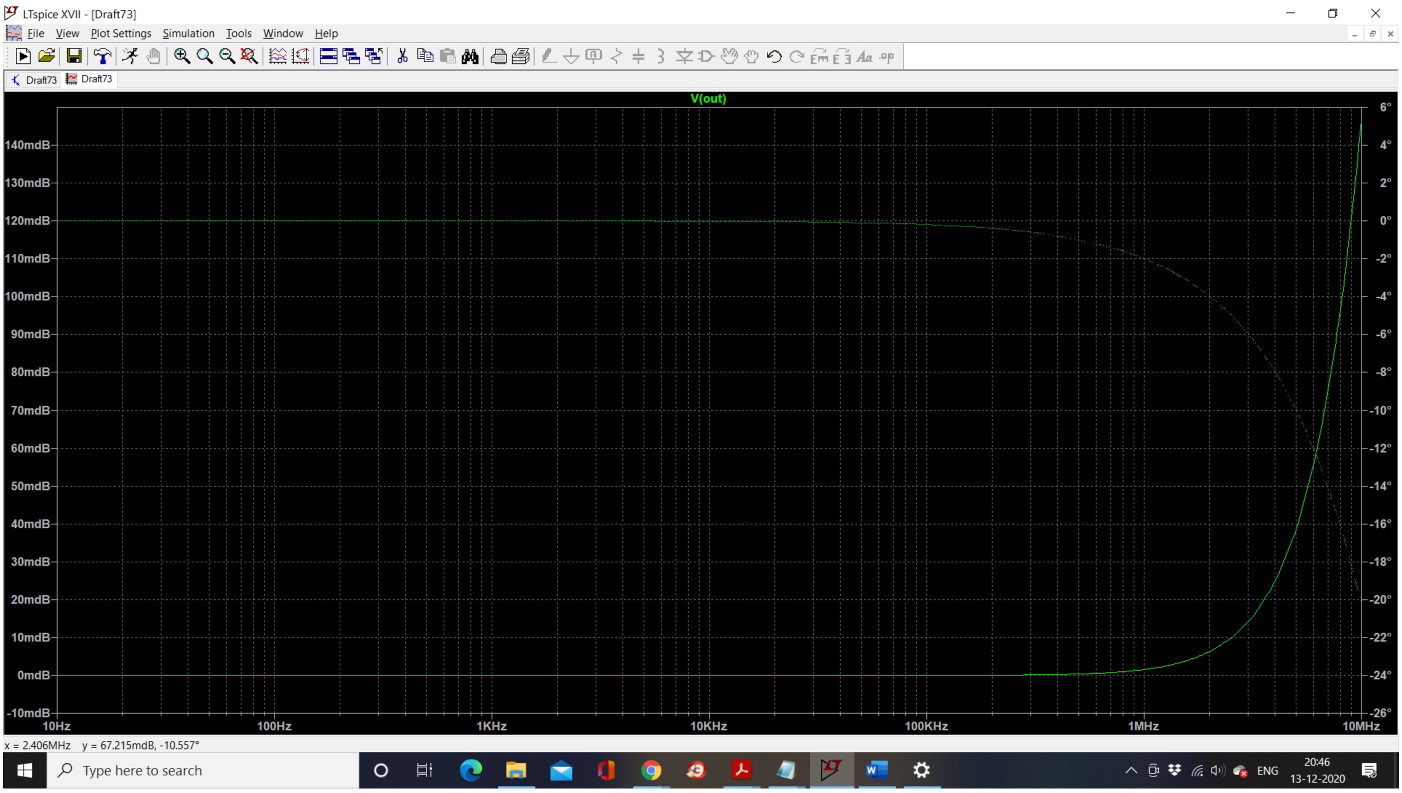



However, I've not found a sample file to replicate the above waveform – so I just show the output when the input is a simple 1MHz sinusoidal signal.




As seen above, there is no phase change and the gain is 1.

Also, I have shown the frequency response for the video buffer circuit below.




As is expected, from the frequency response we see that only beyond ~8 MHz does the gain go beyond 0.1 dB of the regular gain (0 mdB). However, beyond 1 MHz we see that there is a significant amount of phase change (at output) – so keeping it within the 1 MHz range would be advisable.

References:

[1] Always-On Sensing Changes Everything | FierceElectronics

[2] https://hackaday.com/2018/01/18/know-your-video-waveform/

[3] http://www.labguysworld.com/VideoCookBook_004.htm