

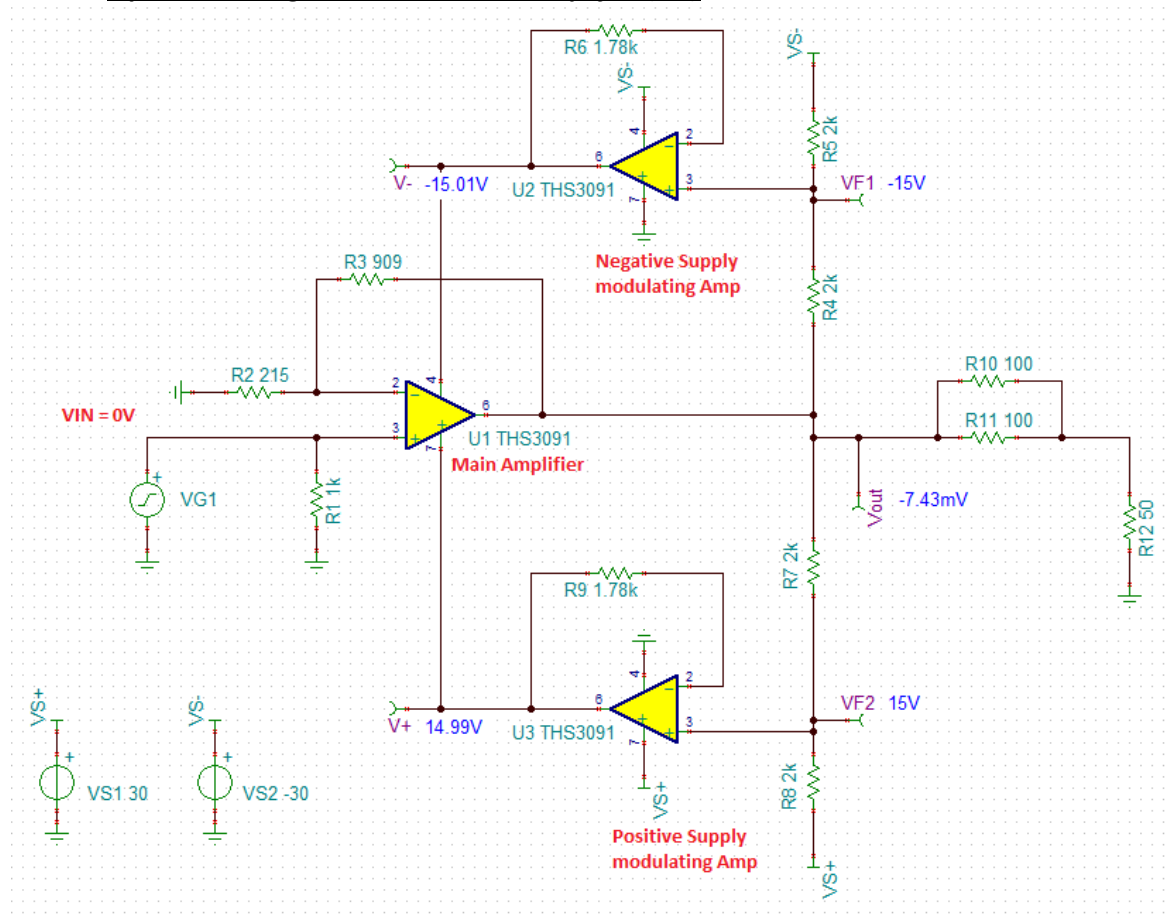
## High Output Voltage Extension Circuit using the THS3091/THS3491:

### 1. Working Concept:

The high output voltage extension circuit consists of the main driver amplifier (U1) and two supply modulating amplifiers (U2 & U3), as shown in Figure 1. The amplifier in the center (U1) is the main amplifier that will be driving the LCD tester, and whose output voltage needs to be extended. The supply modulating amplifiers (U2 & U3) are configured such that they modulate the supply voltage of the main amplifier (U1) by sensing a portion of the main amplifier output voltage swing. The THS3091 or THS3491 has Class AB style output stage whose output swing is limited by the supply voltage range. As a result, it is beneficial to employ supply modulation scheme in-order to extend its output swing capability.

The below section will describe the supply modulation scheme of the main amplifier using a sinusoidal signal, which should be equally applicable for a square wave pulse.

#### a. Input CM voltage = 0V to the main amplifier (U1)



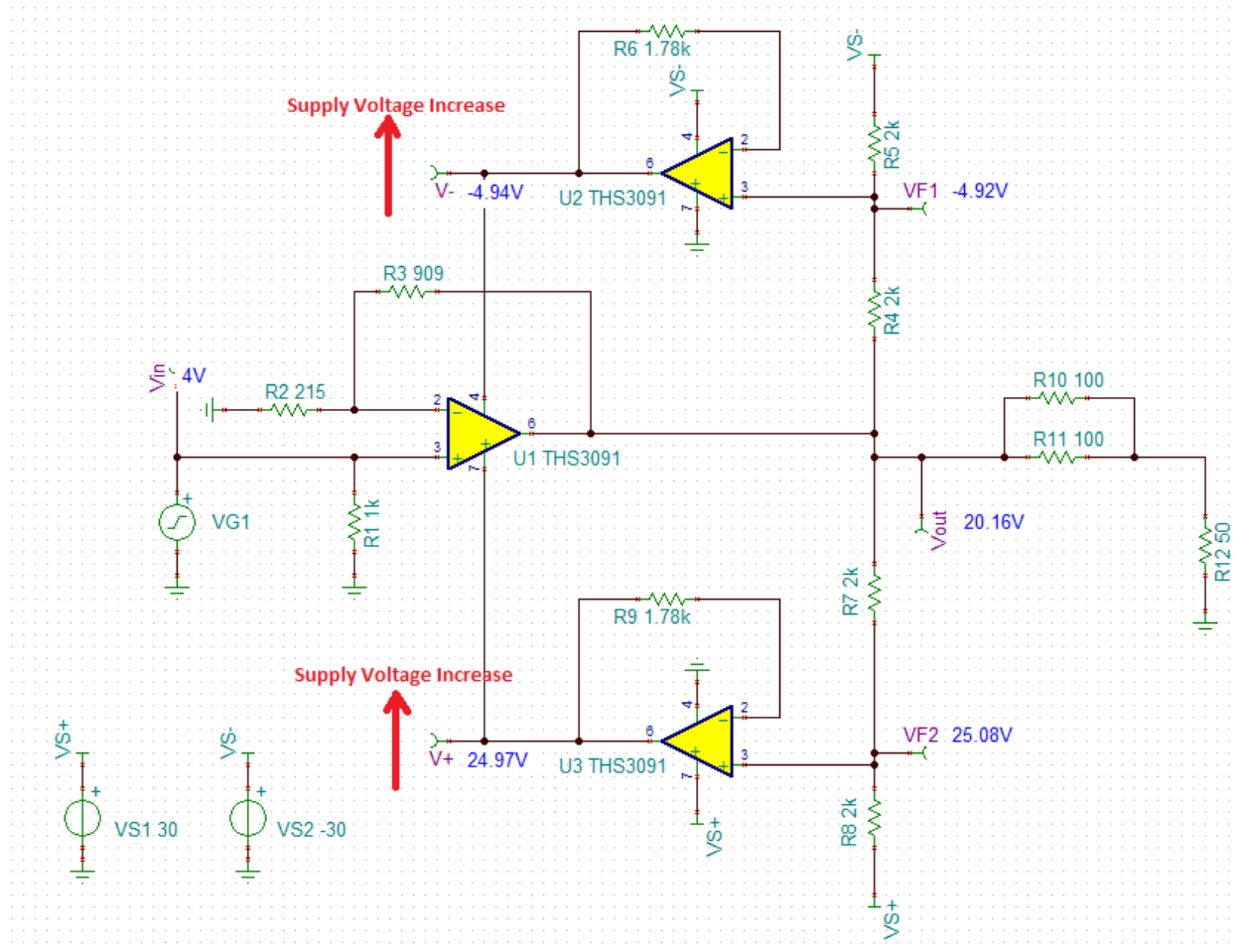
**Figure 1:** +/-15V supply Voltage to the main amplifier (U1) with 0V DC input

For 0V at the main amplifier (U1) input, its output will also be centered near 0V as shown in Figure 1. Since VS+ and VS- are at +/-30V respectively, the CM input to the supply modulating amplifiers (U2 & U3) will be one half of VS+/- (or at +/-15V) because of the resistive division of the 2k-ohm and the high

input impedance of the THS3091. The U2 & U3 amplifiers are in unity gain configuration, thus resulting in +/-15V supply voltage at the main amplifier (U1).

[**Note:** The maximum recommended supply voltage of the THS3091 is 30V single supply, as specified in the device datasheet. That's the reason why the positive supply modulating amplifier (U3) is powered up with  $V_{S+/-} = +30V/0V$  supply and the negative supply modulating amplifier (U2) is powered with  $V_{S+/-} = 0V/-30V$ .]

**b. During Positive half cycle of the Input sine wave (VG1) to the main amplifier (U1):**



**Figure 2:** +25V/-5V supply at the main amplifier (U1) during positive half cycle of the sine wave

When the input sine wave is in the positive half cycle, the output of the main amplifier will increase by the non-inverting gain of 5 V/V. This subsequently increases the input CM voltage of U2 and U3, and is tracked by its output due to their unity gain configuration.

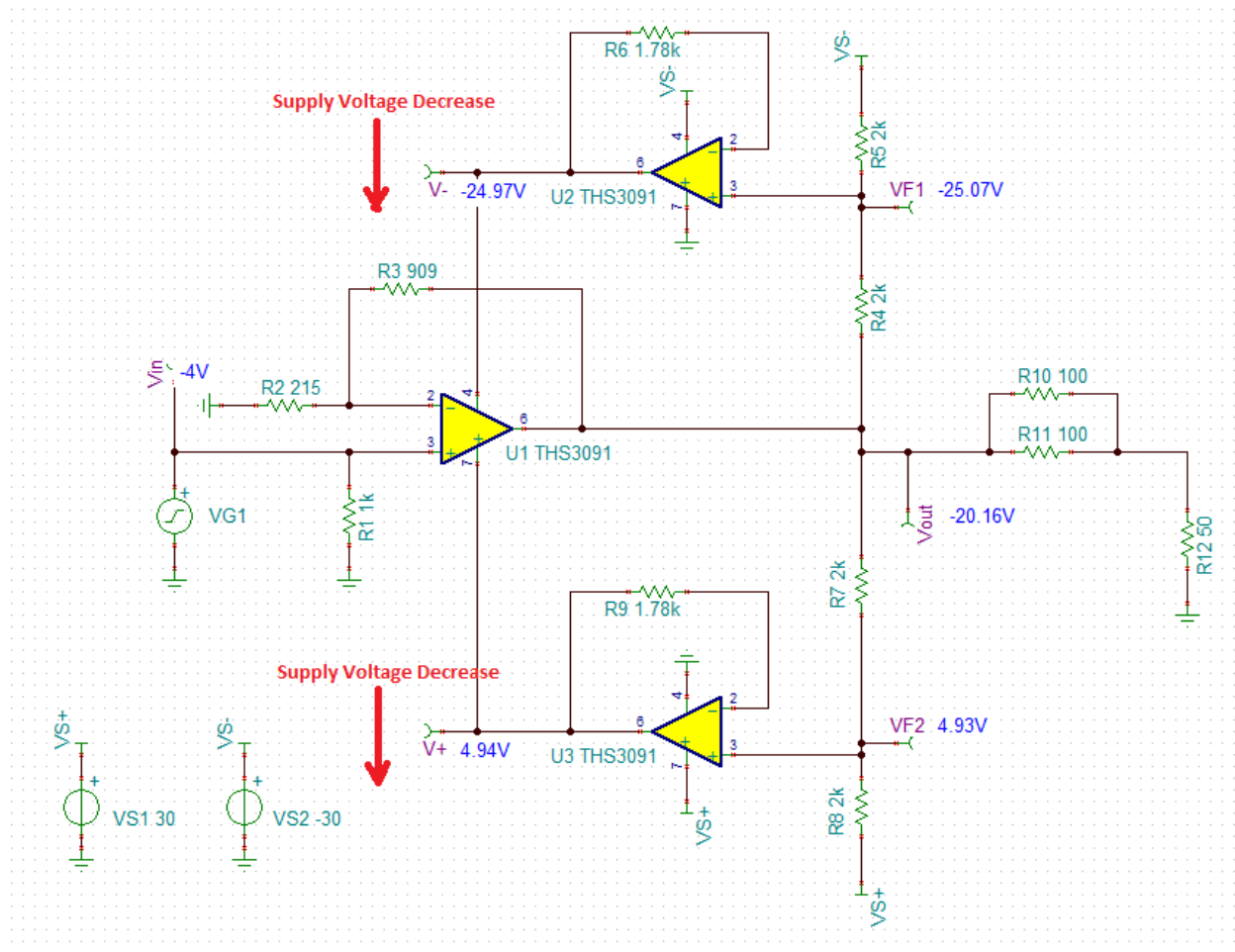
When the input sine wave reaches peak voltage of 4V at the input, the main amplifier output will be at 20V as shown in Figure 2. Due to the 2k-ohm resistive division and the THS3091 supply modulating

amplifiers (U2 & U3) being in unity gain configuration, this results in the main amplifier supply voltage to be at +25V on U3 and -5V on U2.

**c. During Negative half cycle of the Input sine wave (VG1) to the main amplifier (U1):**

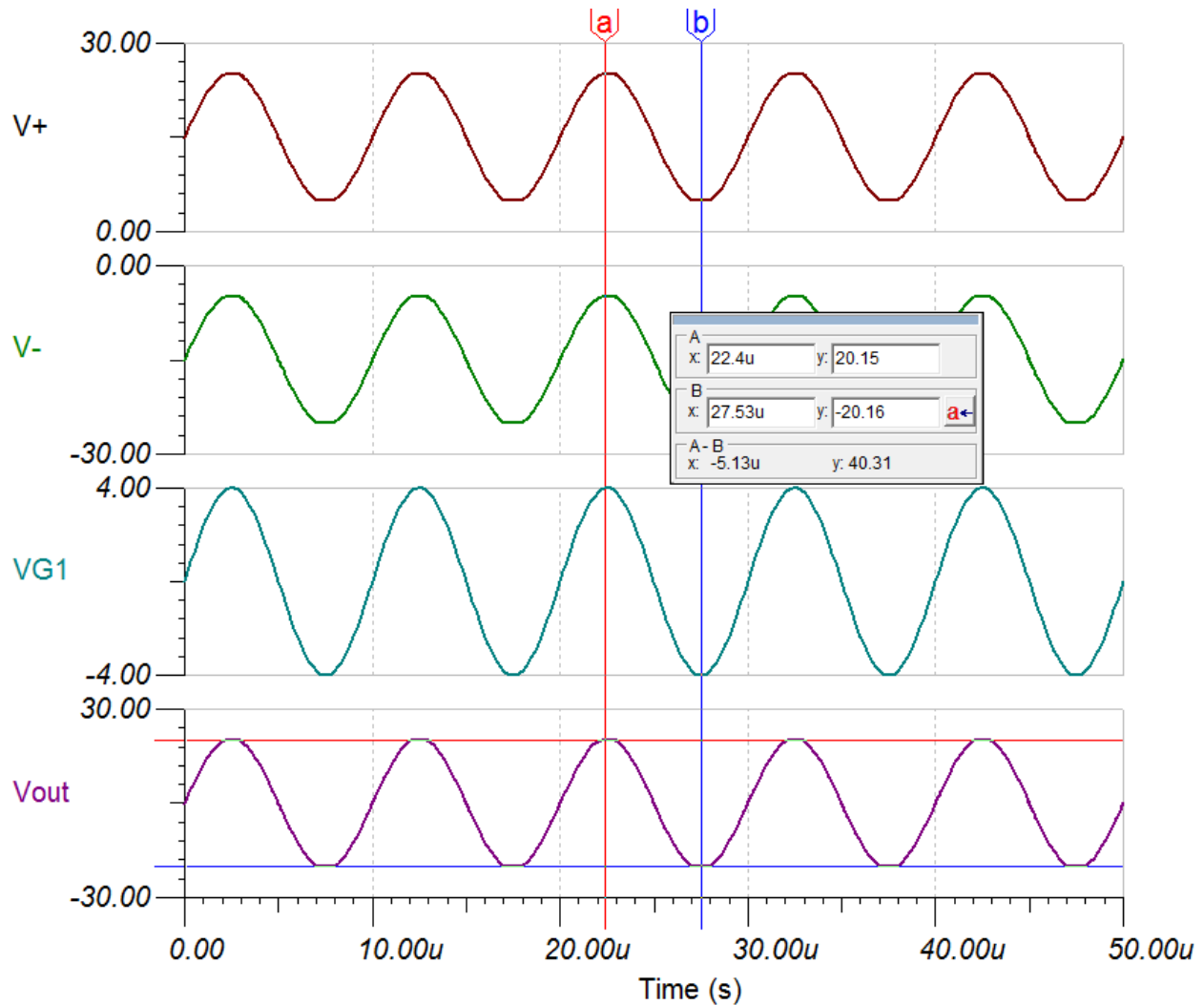
When the input sine wave is in the negative half cycle, the output of the main amplifier will decrease by the non-inverting gain of 5 V/V. This subsequently decreases the input CM voltage of U2 and U3, and is tracked by its output due to their unity gain configuration.

So, when the input sine wave reaches negative peak voltage of -4V at the input, the output of the main amplifier will be at -20V. Due to the 2k-ohm resistive division and the THS3091 supply modulating amplifiers (U2 & U3) being in unity gain configuration, this results in the main amplifier supply voltage to be at +5V on U3 and -25V on U2.



**Figure 3:** +5V/-25V supply at the main amplifier (U1) during negative half cycle of the Input sine wave

The combined operation in both the positive and negative half cycle of the sine-wave thus results in modulating of the main amplifier (U1) supplies with respect to the input signal, as shown in Figure 4.



**Figure 4:** Sinusoidal waveforms at the input (VG1), output (Vout) and main amplifier supplies (V+ & V-)

**2. Factors to consider for proper operation of the Output voltage extension circuit:**

- a. **Supply Voltage Range:** The output voltage range for the extension circuit is still dictated by the maximum recommended supply voltage of the main amplifier (U1). It is not possible to use U2 & U3 supplies that will result in modulating supply voltage higher than the maximum recommended for the main amplifier (U1). For example, the supply modulating amplifiers cannot be operated with 40V/0V (U3) and 0V/-40V (U2), when the recommended max supply voltage for the main amplifier is only 30V as it will result in direct violation of the main amplifier supply voltage.

- b. **Unity vs Non-unity gain operation on the supply modulating amplifiers (U2 & U3):** It is possible to use either a unity gain or non-unity gain amplifier for supply voltage modulation. For non-unity gain operation on the U2 & U3, the one half resistor division ratio of 2k-ohms will change accordingly to compensate for the non-inverting gain in the supply modulating amplifiers U2 & U3. For example as shown in Figure 5, the output voltage sense at the supply modulating amplifiers has been reduced from  $\frac{1}{2}$  to one third ( $\frac{1}{3}$ ) because of the non-unity gain in the supply modulating amplifiers. Also, careful attention needs to be paid to the input CM voltage requirements at the supply modulating amplifiers while sensing the main amplifier output voltage.

It is important that the supply modulating amplifiers don't exhibit any ringing or oscillation at their output because this will result in direct coupling at the main amplifier output through the supplies. In fact, the PSRR of the main amplifier is directly proportional to the supply modulating amplifier's PSRR.

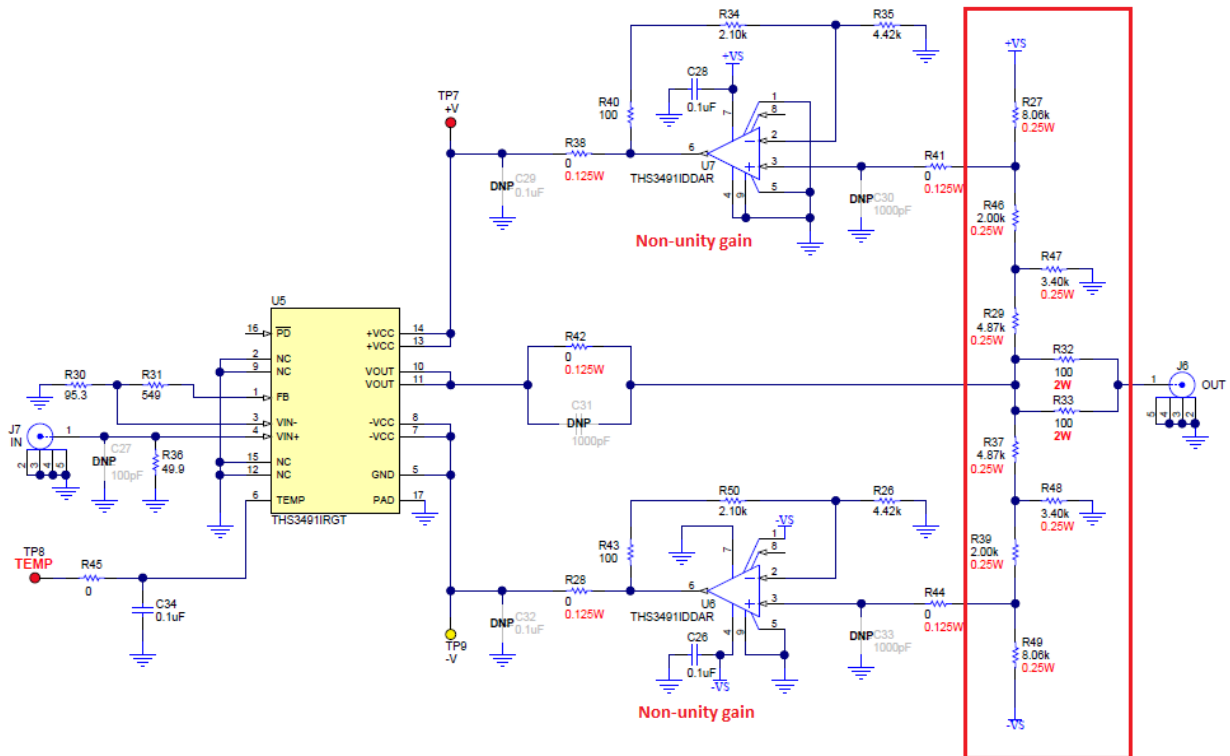


Figure 5: Non-unity gain operation on the supply modulating amplifiers (U2 & U3)

- c. **High slew rate requirements:** It is important that the main amplifier (U1) as well as the supply modulating amplifiers (U2 & U3) have high slew rate performance

in-order to not limit the output drive capability of the main amplifier. This is especially true for time domain pulse applications where the main amplifier is supposed to drive high voltage into high capacitive loads. While driving high capacitive loads, the charging and discharging of the capacitor is mainly determined by the slew rate of the amplifier.

$$\frac{I_{OUT}}{C_L} \leq \frac{dV_{OUT}}{dT} \text{ (Slew Rate)}$$

Since the output current of the main amplifier is primarily supplied by the supply modulating amplifiers, it is important that the supply modulating loop is fast enough in-order to not slew limit the output current driving the capacitive load.