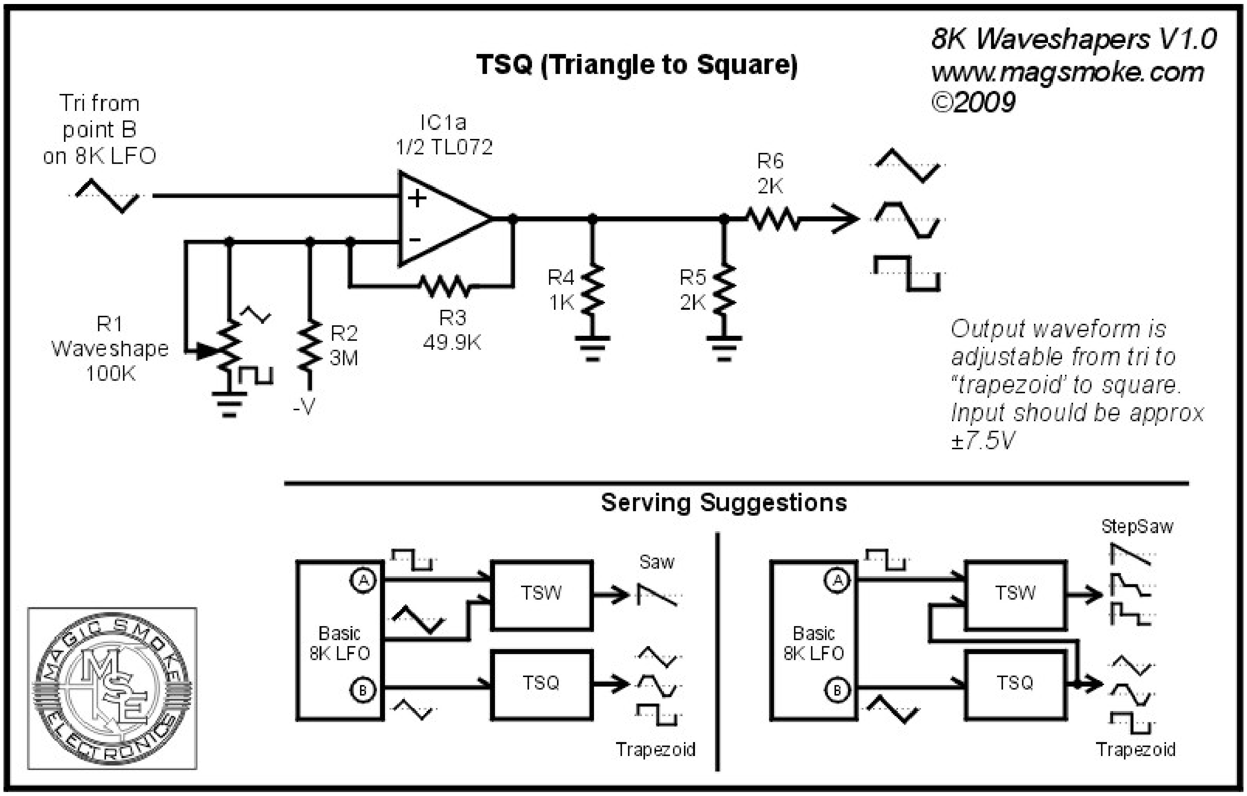
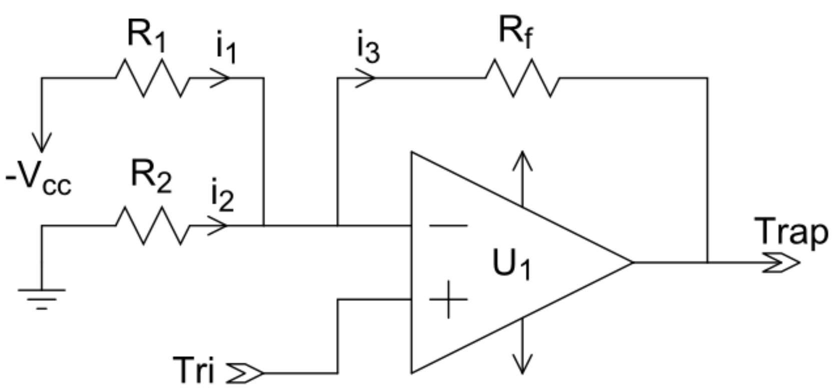
Analysis of Tim Servo's TSQ Waveshaper

http://electro-music.com/forum/topic-32372.html&postorder=asc





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In an effort to understand what's going on with this circuit, I'm going to try to derive its transfer function $\frac{Trap}{Tri}$:

The only assumption I'll make (and it's usually a good one for op amps with negative feedback) is that the op amp outputs whatever voltage is needed to keep the inputs at the same voltage. Well, until it hits the power rails :P Usually one of the inputs is grounded, but here the positive input is connected directly to a triangle wave. So the assumption is that **the inverting input is equal to Tri**.

So, standard analysis:

$$i_1 = \frac{-V_{cc} - Tri}{R_1}$$
$$i_2 = \frac{0 - Tri}{R_2}$$
$$i_3 = \frac{Tri - Trap}{R_f}$$

Since no current goes into the op amp inputs (the ideal model is **always** accurate!! D:)

$$i_3 = i_1 + i_2$$

$$\frac{Tri - Trap}{R_f} = \frac{-V_{cc} - Tri}{R_1} + \frac{0 - Tri}{R_2}$$

Split apart:

$$\frac{Tri}{R_f} - \frac{Trap}{R_f} = -\frac{V_{cc}}{R_1} - \frac{Tri}{R_1} - \frac{Tri}{R_2}$$

Rearrange terms:

$$-\frac{Trap}{R_f} = -\frac{Tri}{R_f} - \frac{Tri}{R_1} - \frac{Tri}{R_2} - \frac{V_{cc}}{R_1}$$

Well, that's a lot of negatives…

$$\frac{Trap}{R_f} = \frac{Tri}{R_f} + \frac{Tri}{R_1} + \frac{Tri}{R_2} + \frac{V_{cc}}{R_1}$$

Factor

$$Trap\, R_f = Tri\left(\frac{1}{R_f} + \frac{1}{R_1} + \frac{1}{R_2}\right) + V_{cc}\left(\frac{1}{R_1}\right)$$

$$Trap = Tri \times R_f\left(\frac{1}{R_f} + \frac{1}{R_1} + \frac{1}{R_2}\right) + V_{cc}\left(\frac{R_f}{R_1}\right)$$

Fun time:

$$Trap = Tri\left(1 + \frac{R_f}{R_1||R_2}\right) + V_{cc}\left(\frac{R_f}{R_1}\right)$$

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So it looks like I can't get it into standard form for a transfer function. But hey, it's linear! (If you consider the resistor values and V_{cc} constant.)

So here's the strange part. I have no idea what the purpose of R_2 and the connection to $-V_{cc}$ is. R_2 is 30 times bigger than the largest value of R_1, so paralleling them mostly ignores R2. Also, the ratio of R_f to R_1 is very small, practically removing the constant term from the equation. If you apply these simplifications, you get this,

$$Trap = Tri\left(1 + \frac{R_f}{R_1}\right)$$

which is identical to the formula for a non-inverting amplifier op amp circuit.

So my question is this: **Why is there that connection?**