A VC-Delay/Echo Circuit Using the PT2395 Rev1.01

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Introduction:

The PT2395 is the most flexible delay IC from Princeton Technologies. This is a 40pin device. I've chosen this chip for my VC-delay/echo module. The circuit shown below is for an echo circuit and will not give delays less than a few tens of milliseconds. The maximum delay is around 1.5 seconds. Bandwidth of the circuit is dependent on the delay time. Delay time and feedback levels are voltage controlled.

The circuit I'm using started with the datasheet's example, but is very different at this point. About half of the circuit will fit onto Ken Stone's PT2395 delay development board and this is recommended if you plan to experiment with the PT2395 (see references for link).

Circuit Description:

The PT2395 allows the use of an external clock, which determines the sample rate and delay time. In order to get VC control I'm using the VCO from a 74HC4046. This is a fairly standard setup. This portion is very similar to Ken Stone's development board except the RC values were changed. I'm using a 33pF cap and 100K for the 74HC4046's R2 value and a trimmed 10K value for the 74HC4046's R1 value. The trimmer is used to set the minimum delay time of the module. If the 4046 frequency is too high then the PT2395 will become unstable and you'll hear pops and clicks as the delay time is modulated and eventually it won't work at all.

The comparator (U6), integrators, and 41256 RAM (U2) sections of the circuit are straight from the datasheet's example. The PT2395 provides internal opamps for filtering and level shifting the input and output, but I didn't like the bandwidth using that setup so, I've gotten a pair of 5th order Butterworth switched capacitor filter ICs from Linear Technology. The LTC1063 (U5 and U7), has a 100:1 clock:cutoff ratio. The 74HC4046 output is fed into a 74HC393 binary counter (U4). I have the counter configured as divide by 16. The divided signal clocks the LTC1063 filters. The filter cutoff tracks the PT2395's clock frequency. This allows a better bandwidth for shorter delays without as much aliasing/distortion on the long delays. I've tested several configurations of the clock:cutoff ratio and decided upon 1/16th. The PT2395 data sheet is lacking information and experimenting with different cutoff frequencies of the filters may give better results. The PT2395's internal opamps are still used for level shifting and a lowpass filter on the input of the LTC1063's input (U7) to prevent aliasing in the output filter itself.

A VCA is used to control the amount of feedback. Currently I'm using a OTA based VCA. It is very similar to the ASM-1's VCA sections. This particular VCA was chosen due to low parts count and price. The output from the VCA is brought out to front panel jacks for external processing before cycling back through the delay chip.

Acquiring Parts:

Most of the components can be bought from general suppliers such as Mouser or Digi-key although a few are more difficult to obtain. The Princeton Technology PT2395 delay IC can be purchased from smallbear electronics (http://www.smallbearelec.com/) for $5.95 USD. The 41256 256K-DRAM ICs can also be purchased at small bear. They are found in the same stock section as the PT2395. Alternatively BG-Micro sells them (http://www.bgmicro.com/) slightly cheaper. The LTC1063 filters can be purchased directly from Linear Technology (http://www.linear.com/) or also at Futurlec (http://www.futurlec.com/). These are around $6USD each.

Four capacitors labeled HP on the schematic, C18, C19, C20, and C21 should be high precision low tolerance types. I've bought some 2% polypropylene capacitors from Mouser for these. These capacitors are used in the integrators of the encoder and decoder circuits in the PT2395. Any variation in the values can lead to error in the output from the delay. You may prefer matching these capacitors although I didn't go any closer than the 2% tolerance.

I've used 1% metal film resistors all around although it's not critical that any of these resistors be exact. As for the opamps, they can all be TL072. I've used an OPA2277 for the CV inputs instead. If you want even better sound quality, the OP275 is a good choice for the audio path although, if you do change this, I recommend an upgrade to the VCA section. (see below).

Modifications:

After having this module built and playing with it for some time, I've noticed some parts of the circuit that may have a bit of room for improvement. The circuit sounds nice as is, but I'd like to think it could always be better. If I were to build another one, which I am seriously considering, I would use a higher quality VCA. The current VCA is taken from the ASM-1's VCA sections. The CA3080 requires small signal inputs in order to prevent distortion; the input to the VCA is scaled down and then amplified back to acceptable levels at the output. This method is prone to noise and distortion caused by the small signal approximation. Higher quality VCAs like THAT Corporation's THAT2180/1 would be a good choice if exponential control is acceptable. I think for this application exponential control would make adjusting the feedback amount slightly easier. For linear VCAs, there's a very nice circuit built around both sections of an LM13700 OTA. This circuit was designed by Mike Sims and published in EDN magazine in 1995 (see references for a link).

There are three resistors in the circuit that could be changed in order to adjust the gain at different places. The resistor R7 (2.7K) is part of the PT2395's internal inverting opamp circuit. This opamp performs level shifting as well as adds a little gain to make up for the losses at the PT2395 outputs. The PT2395 has an internal resistance of 3.5K as the feedback resistor across this opamp, so that the gain is 3.5K/2.7K. This gain is important because it affects how evenly the dry and wet signals mix in the mix output. You may find a value for R7 that suits you better but it's all a matter of preference.

I have opted for lower noise in the circuit by not attenuating the input/amplifying the output (except in the VCA). Because of this, the input levels are limited. With normal synthesizer levels (+-5V) the input level pot will need to be kept at about 1/3 to ½ of it's maximum position in order to prevent clipping when the feedback is added to the input. Inputting higher voltages into the circuit will not harm anything but it won't sound great either. If you would prefer to have a larger output then some adjustments should be made to the input and output amplifiers.

One final resistance that could be changed is R26 (604K). If the same VCA circuit is used then this resistance will set the maximum gain of the VCA (at 5V CV), which affects the maximum amount of feedback you will be able to get. Increase this value for more gain in the VCA decrease it for less.

Calibration:

Initially, start with the VCOTRIM and VCATRIM set to their center positions. With nothing connected to the INPUT jack, connect one end of a patch cord to the FDBK IN jack and ground the other end. Then set the feedback pot to its maximum position. Adjust the VCATRIM so that the FDBK OUT jack is at 0V. Next, disconnect everything and set the feedback pot and the delay pot to its minimum position. Connect some audio input to the INPUT jack. Adjust VCOTRIM so that you get the smallest delay time with the delay pot set at minimum. Do this so that the circuit is still able to smoothly vary the delay pot from minimum to maximum. Check that the changes are smooth on long and short mode readjusting till you are happy with it. This trimmer will end up close to its center position anyway. If you adjust it too much the PT2395 won't behave. On mine, there was a large jump in the delay time and above that point, adjusting the pot did almost nothing. Make sure there is a small amount of room between the setting you choose and the point where the PT2395 starts misbehaving to allow for very big CV values that could potentially cause the PT2395 to misbehave. If you have any questions or comments, email me at the address shown at the end of this document.

References and Links:

CGS Syths – Ken Stone's Delay Development Board: http://www.cgs.synth.net/

Scott Bernardi's PT2399 Delay:
http://home.comcast.net/~sbernardi/elec/og2/og2_home.html

PT2395 Data sheet. Princeton Technology

"Low-cost audio VCA has high performance". Mike Sims. EDN Magazine. 1995:
http://www.reed-electronics.com/ednmag/archives/1995/011995/02DI1.htm

THAT corporation (maker of fine audio ICs): http://www.thatcorp.com/