Improved SPICE Models Modeling DSP difference equations using SPICE requires a model for z^{-1}. By definition, $z^{-1} = e^{-sT}$, where T is the sampling period. That is exactly the description of a transmission line. So the first cut at using SPICE is to use the transmission line model. The z-transform is only valid at the sampling instants, but the SPICE transmission line is a continuous model. When used to model control systems, the transmission line carries information above the Nyquist frequency; producing possible high frequency instability. The instability is all right for linear circuits, since the data at the sampling instants is correct. But when nonlinearity is introduced; for example, by limiting duty ratio between 0 and 1, the result is incorrect

A new SPICE primitive model, Z-Delay, acts as a delay line in the frequency domain; but in time domain looks like a sample and hold; no more high frequency oscillation! Classically it really is a z transform model, but when viewed from the outside, it looks like a zero order hold. It works by sampling data every T seconds and producing output after TCOMP, the computational delay. If a SPICE time step is encountered between TCOMP and T, the new value propagates to the z-delay output. The z-delay model also makes provisions for samples beginning later than time=0, limiting output levels and having predefined output values at time=0. With predefined output values, the SPICE matrix can be solved with no iterations, guaranteeing a solution for AC and DC analysis. Figure 1 shows the behavior one would expect using 2 sample and hold circuits. The first sample is taken every T seconds and the second, TCOMP later. The fine resolution is caused by setting VSECTOL=10n. Without VSECTOL, there would be an apparent ramp connecting the data point before TCOMP to the one just after TCOMP.

Figure 2 illustrates the z-delay model behavior when SPICE is allowed to take longer time steps.

z-delay is an IsSpic4 code model, available in CML.dll as z-delay and within our parts browser as ZDELAY.

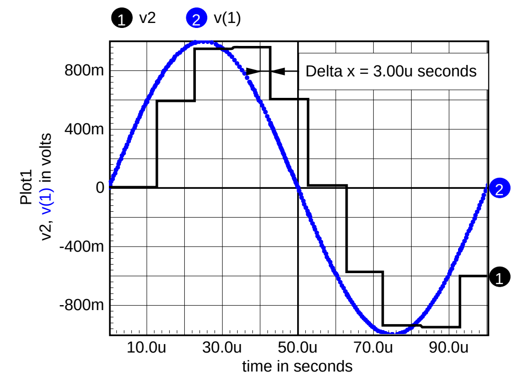

Figure 1, A 10KHz sine wave sampled every 10usec with a 3usec computational delay using the z-delay model.

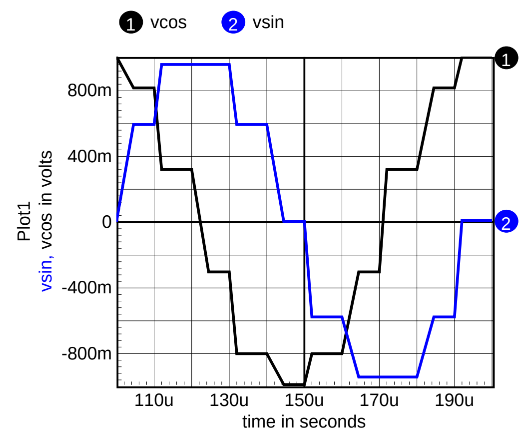

Figure 2, A 10KHz sine-cosine generator sampled every 10usec with a 1usec delay using the z-delay model.