MARK 5 MEMO #072

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To: Mark 5 Development Group
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Subject: Simulations of NLTL pulse enhancement

The non-linear transmission line (NLTL) can be used to improve the transition time of one edge of a square wave.

Figure 1 shows the circuit of a conventional right-handed (RH) NLTL (Rodwell et al. 1994) using short sections of transmission line which act as inductors in series with G*a*As varactors which form variable capacitance to ground. The circuit was simulated by numerical solution of the circuit equations:

$$\Delta i_{j-1} = (1/L)\left(v_{j-1} v_j\right)\Delta t$$

$$\Delta v_j = \left(1/c\left(v_{j-1-v_j}\right)\right)\left(i_{j-1} - i_j\right)\Delta t$$

a driving resistance and termination resistance were also included. Figure 2 shows the simulated input waveform in blue and the NLTL output in red. The parameters to give the best performance were as follows:

1] MA46H120 diode reverse bias 3v

2] #diodes 18

3] Inductance between diodes 0.35 nH

4] Source resistance 25 ohms

5] Termination resistance 150 ohms

6] Source voltage 1 volt p-p

There are a number of problems with the RH-NLTL

1] The driving voltage of 1 volt peak to peak is too small to cause enough change in the varactors capacitance.

2] The MaCom MA46H120 flip-chip was the best diode I could find (the mdtcorp MV39002-P2715 might be slightly better as the gamma is 1.25 compared with 1.00 for the MA46H120). With the relatively small driving voltage the NLTL needs a diode with a larger gamma.

3] The NLTL has a delay of about 200 ps which is likely to be temperature dependent.

Based on this initial study I am not confident that in practice the RH-NLTL would provide much improvement over gating the falling edge of HMC672LC3C with a diode switch. To reduce the step width to an absolute minimum the VR control could be set to -1.2 volts in which case the HMC672LC3C fall time (20%-80%) should be around 17 ps. LH circuitry (Kozyrev and Weide, 2005) might be worth investigating but using one edge of the HMC672LC3C should already be fast enough for new phase calibration up to 20 GHz.

Rodwell, M.J.w.: 'Active and nonlinear propagation devices in ultrafast electronics and optoelectronics', *Proc. IEEE,* 1994, **82,** (7), pp. 1035-1059

Krozyrev, A.B., D.W. van der Weide, *IEEE Transactions On Microwave Theory And Techniques*, **53**, (1), January 2005

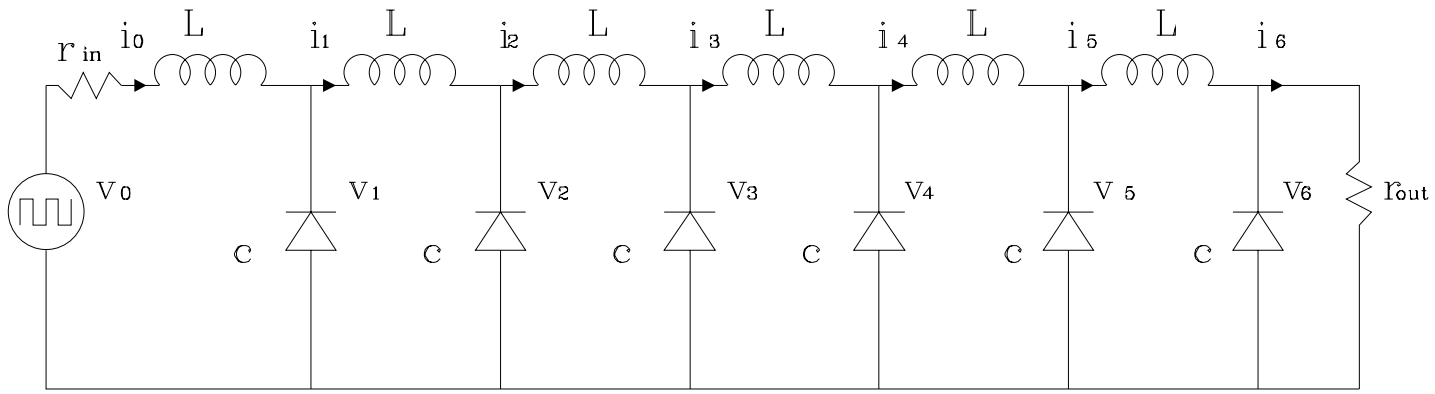

Figure 1. Non-linear transmission line.

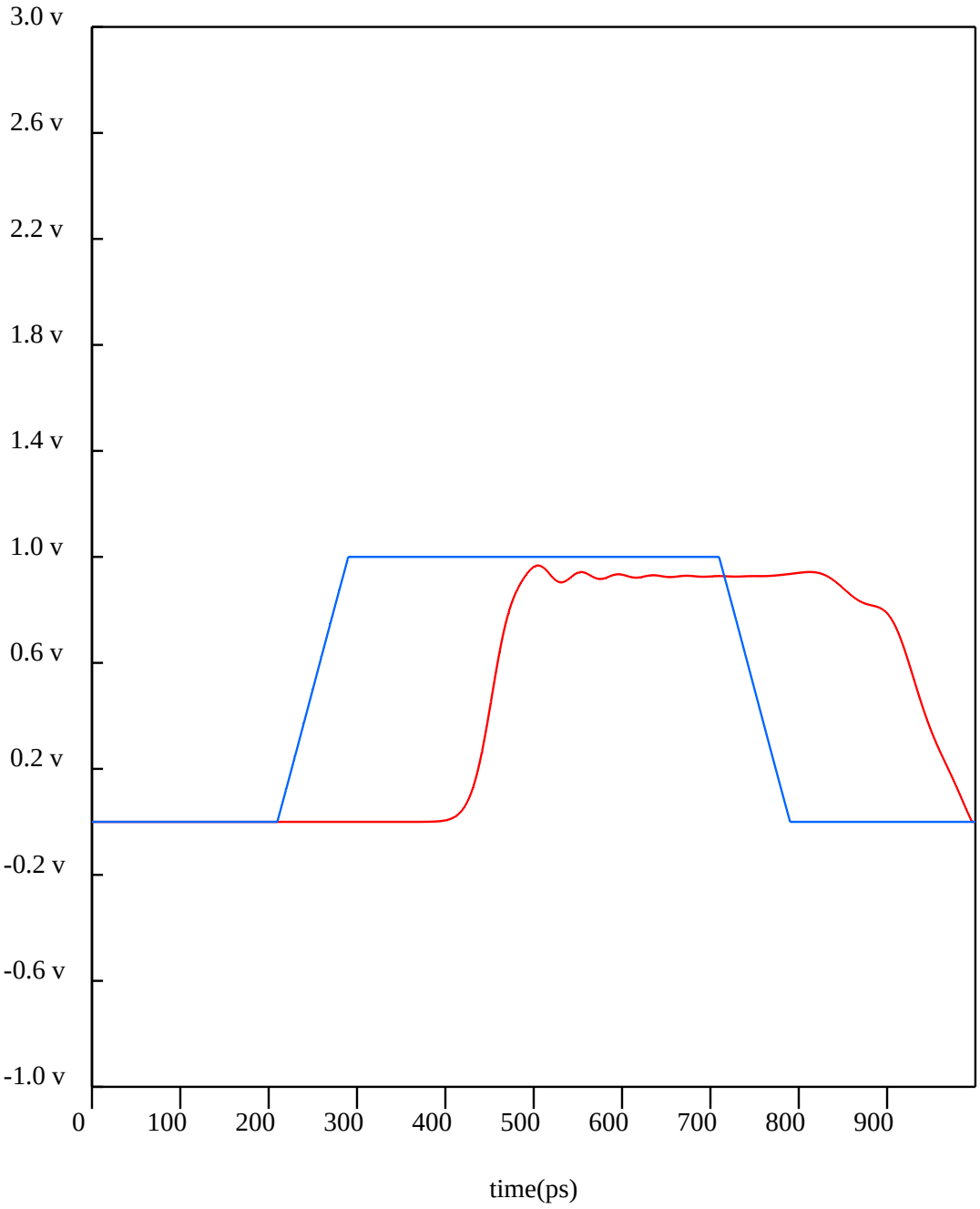

Figure 2. NLTL enhancement of input pulse risetime. Blue curve is input and red curve is the output.