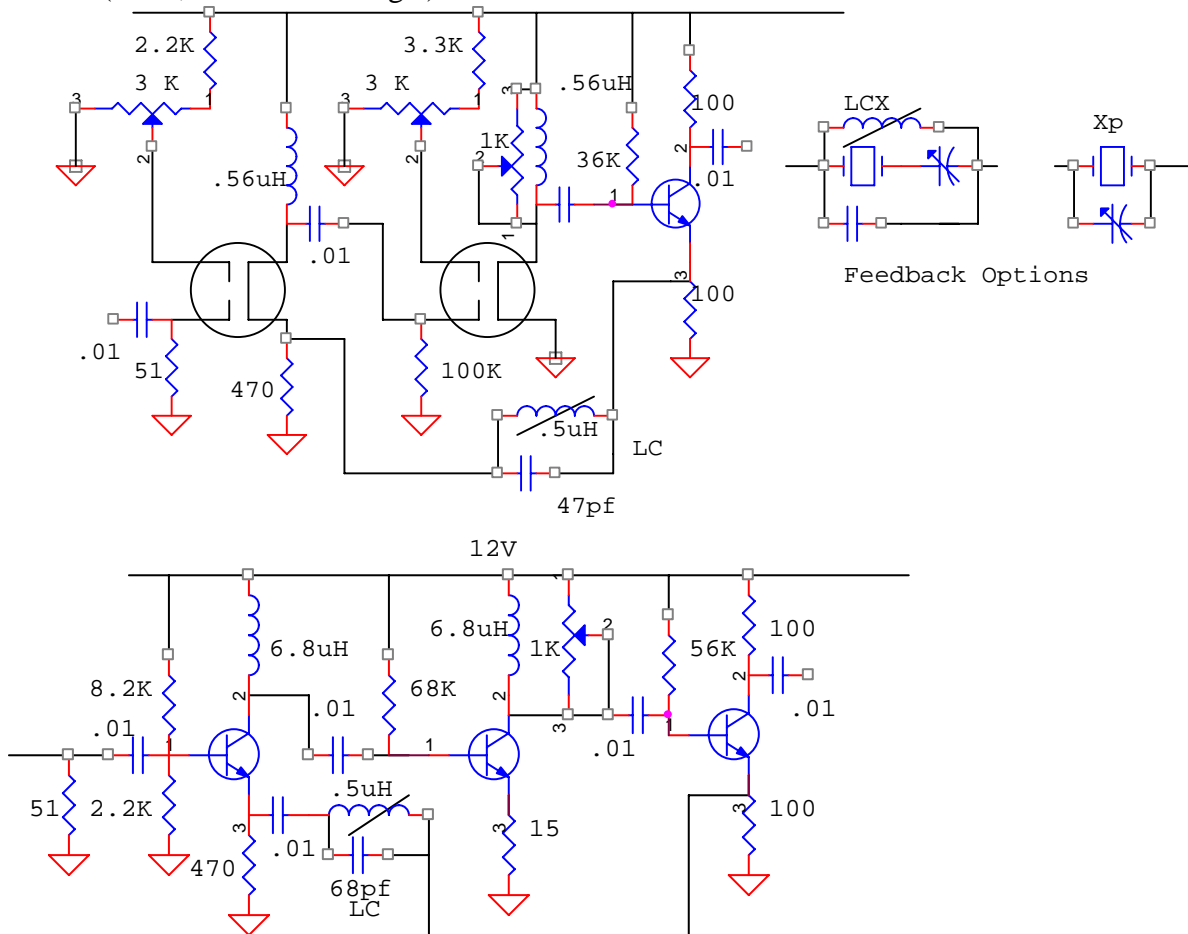


The ZQM Filter

Reviewed 10/30/07

The 'Zero Group Delay Q Multiplier' filter (ZQM) is unusual in several ways.

- 1) It shows a very low (near zero) group delay when using an LC feed back resonator, or a crystal resonator.
- 2) It does not conform to the $T_g = [1/(\Delta f)]$ or $T_g = Q/[IF]$ rule (Where IF is the filter center freq.).
- 3) It could be said to confirm the "If the signal does not pass through the resonator, there is no group delay" statement.
- 4) It is not dependent upon the 'infection point' as in the half lattice crystal filter circuits (TRS, Shunt and Bridge).



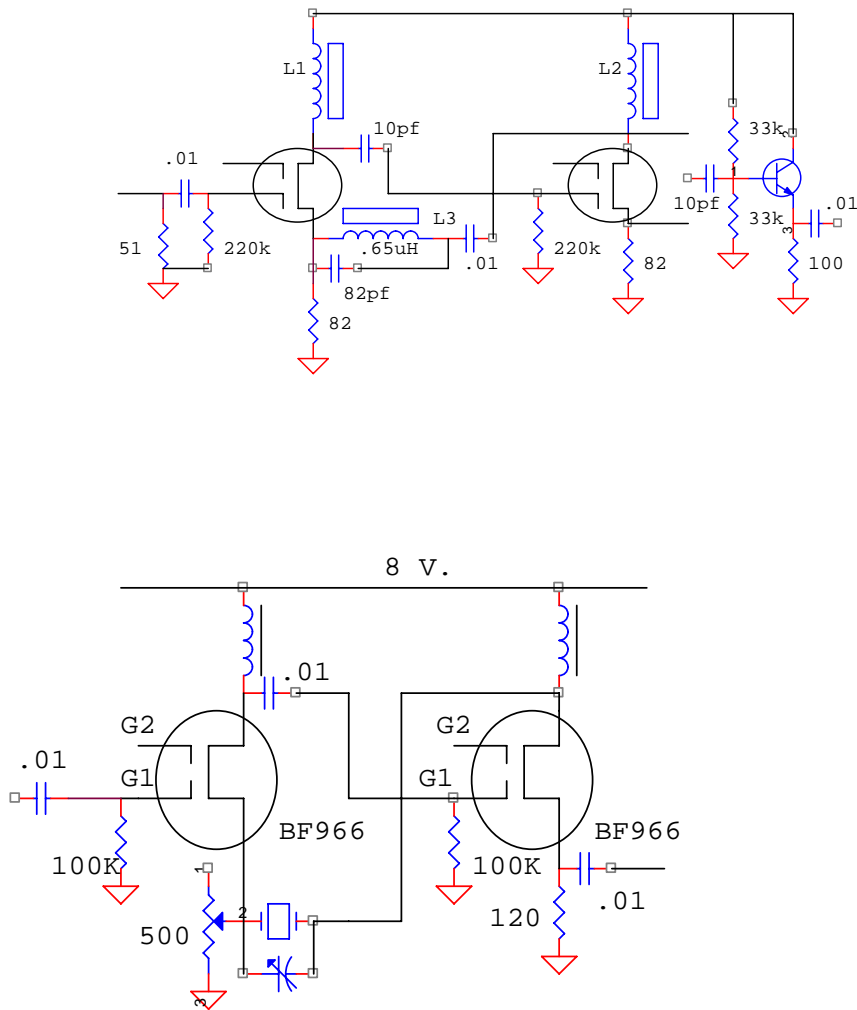


Fig. 1. The ZQM Filter in several variations. The values are for 32 MHz.

The circuit in figure 1a utilizes a parallel LC as the feedback resonator. The circuit has negative feed back except at the resonant frequency. At the resonant frequency the circuit can be made to oscillate when the gain is raised. Q can be controlled by the gain as in any oscillating circuit. The resonator can also consist of a crystal alone, or a crystal plus LC.

When dual gate FETs are used, the gain is controlled by the voltage on Gate 2. The gain can also be controlled by shunting the drain or collector load with a resistor.

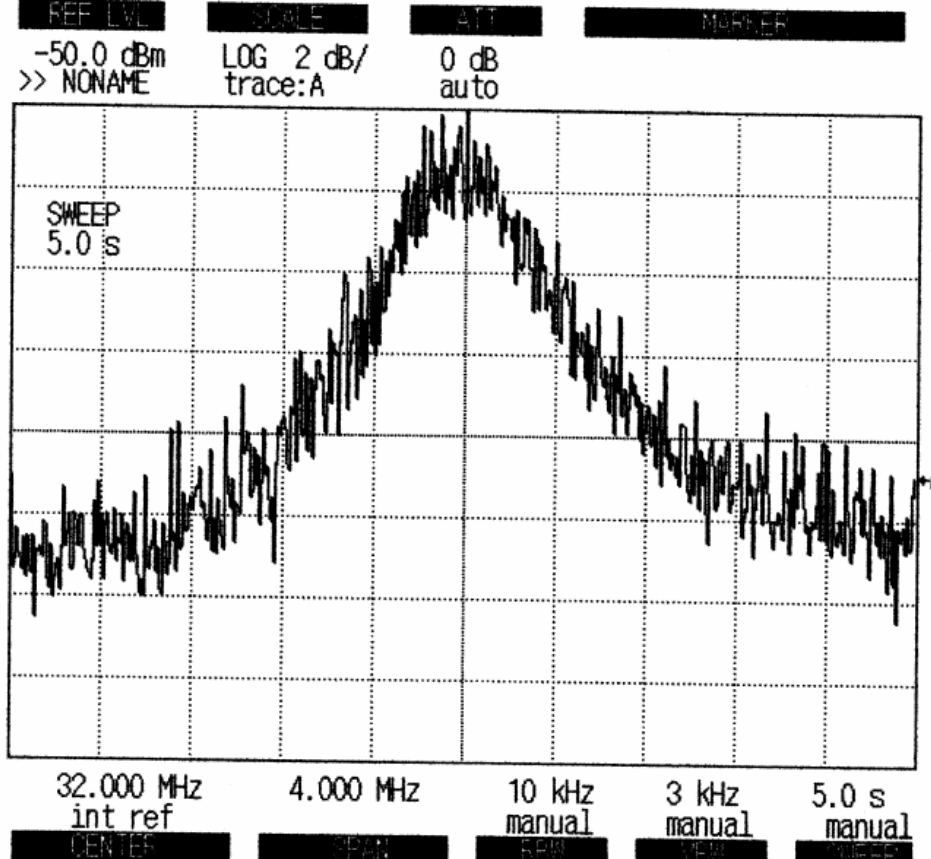


Figure 2. Bandpass of the ZQM filter as tested. The 3 dB bandwidth is approximately 600 kHz. $Q=53$. Normal group delay = 416 nanoseconds from $T_g = [1/(\Delta f)]$ or $T_g = Q/[IF]$ Where IF is the filter center freq.

This filter used an LC parallel filter $L=.5 \mu\text{H}$ and $C = 47\text{pf}$. (Note: the amplitude scale is 2 dB per division). Shoulders can be 30 dB below peak further off center.

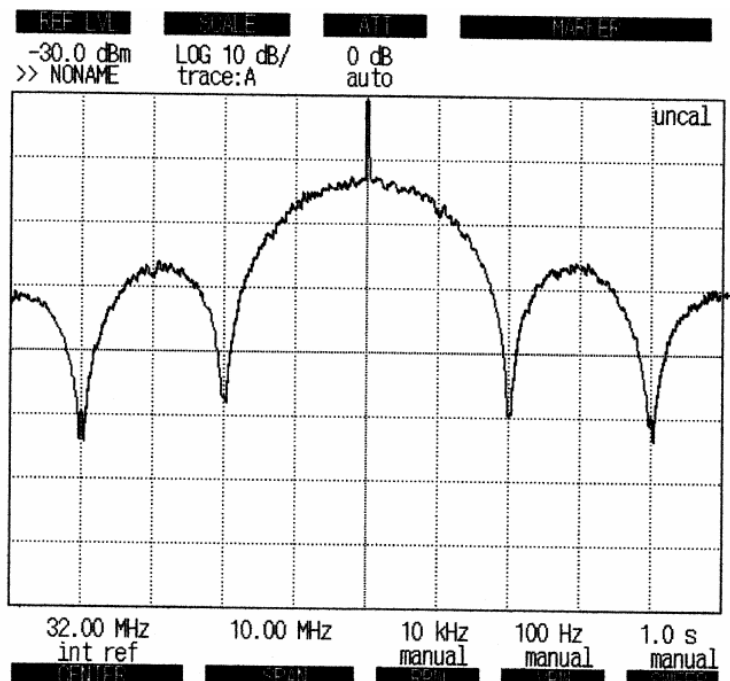


Figure 3. Random Data Input Spectrum at 2 Mb/s. Bit period = 500 nanoseconds.

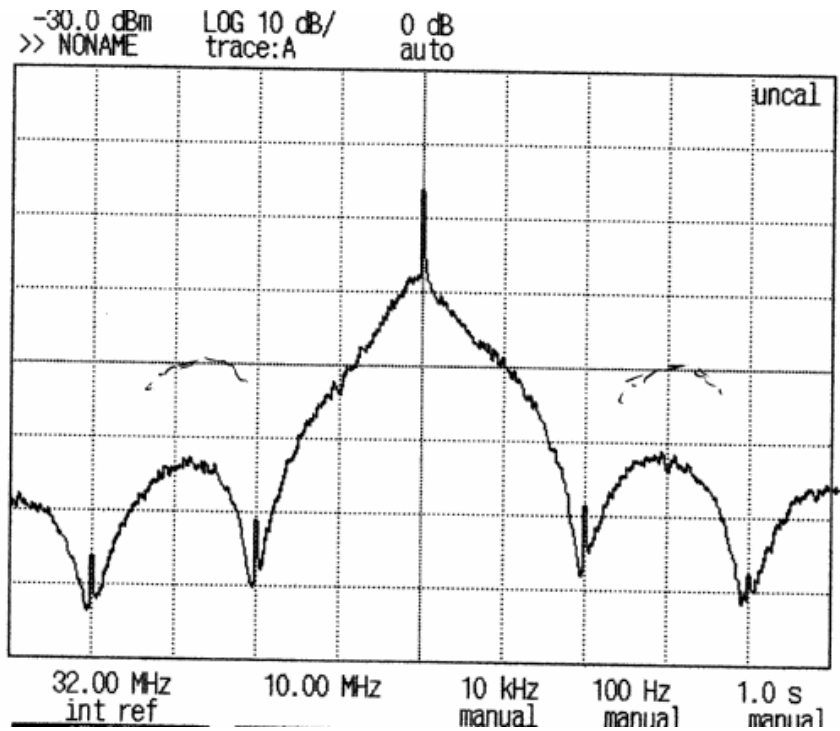


Figure 4. The Spectrum of the 2 Mb/s data after ZQM filter. The shoulders after ± 2 MHz are down 12dB.

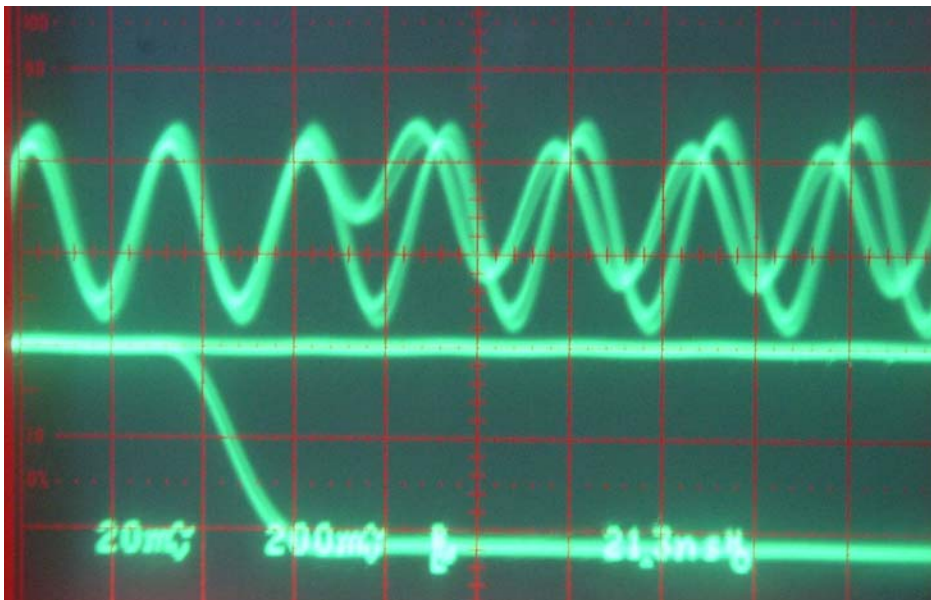


Figure 5. Modulated signal after filter at 2 Mb/s showing the phase slew rate using random data with 90 degree phase shift using NRZ-MSB modulation. The slew rate does

not conform to a group delay of 400 nanoseconds.

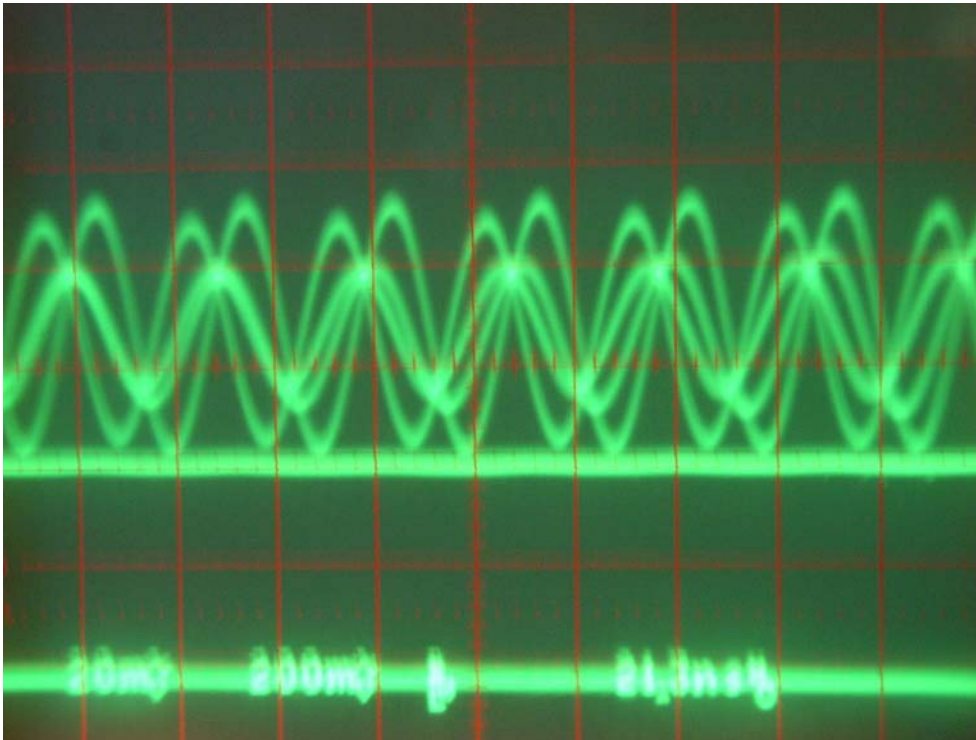


Figure 6. The Modulation Pattern for Random Data after many bit periods. Some phase slew rate slowing is seen as well as some amplitude change. The phase slew is apparently completed in 4 IF cycles. There are 16 cycles per bit period (32 MHz IF, 2 Mb/s modulation. Tuning causes this to vary. This may not be optimum tuning.

This would indicate a worst case T_g of 100-120 ns. (not 400+ nanoseconds.). Tuning and Q adjustment (gain) can cause this to vary.

Unfortunately the ZQM filter is often level sensitive. The phase loss depends on the drive level.

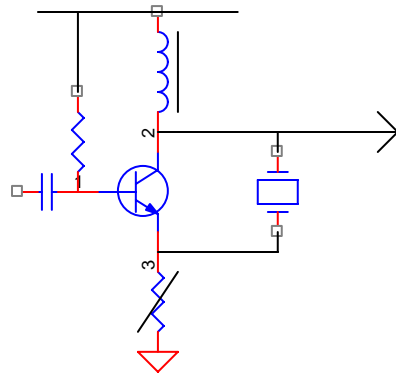


Fig. 7. Another example of a Q multiplier circuit. If the gain is too high, the circuit will oscillate. It can be used as a filter for the UNB methods.