

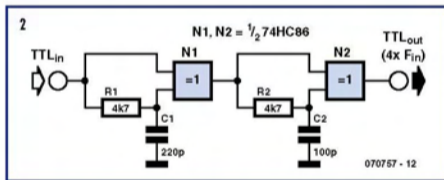
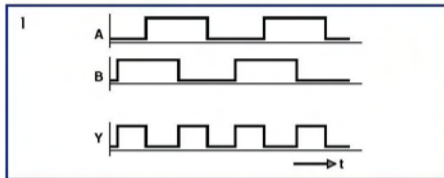
XOR frequency multiplier

Gert Baars

Frequency multiplication is often used in RF designs, for example to increase the frequency from a crystal. This is often implemented using a non-linear transistor amplifier, where the output is tuned to a multiple of the input frequency. A PLL (phase locked loop) can also be used as a frequency multiplier. The multiplication factor is then determined by the divisor in the feedback loop. But there is an even simpler method. And more importantly, it operates over a wider bandwidth than the previous two methods. The truth table for an XOR gate is as follows:

Y	A	B
0	0	0
1	0	1
1	1	0
0	1	1

When A and B are TTL signals with the same frequency, but with a phase difference between them, the truth table shows that



the output signal has twice the frequency of the input signal, as shown in **Figure 1**. In this example the phase difference between the signals is exactly 90°. This ensures that signal Y has a duty cycle of exactly 50%. When the

phase difference is less than 90° (but more than 0°) or more than 90° (but less than 180°), the duty cycle changes, but the frequency remains the same.

We then tried out the circuit shown in **Figure 2**. The phase

shift is created using a simple R-C network, and the duty cycle of each output varies with the frequency. When the phase shift becomes very small, the following stage won't work very well. In theory you could have four stages, but then the frequency range becomes restricted.

With an input signal ranging from 0.1 to 1.5 MHz fed to the circuit from **Figure 2** the output signal was measured as 0.4 to 6 MHz, as expected. The duty cycle of the output signal was irregular, since there are two multiplication stages. For frequency synthesis in RF circuits, you would need a filter after the output to remove the higher harmonics from the signal. When the circuit is used to drive an input to a TTL flipflop or counter, for example, the higher harmonics aren't a problem. For these types of input the number of pulses is important and the duty cycle doesn't matter.