

CMOS Crystal Frequency Multiplier

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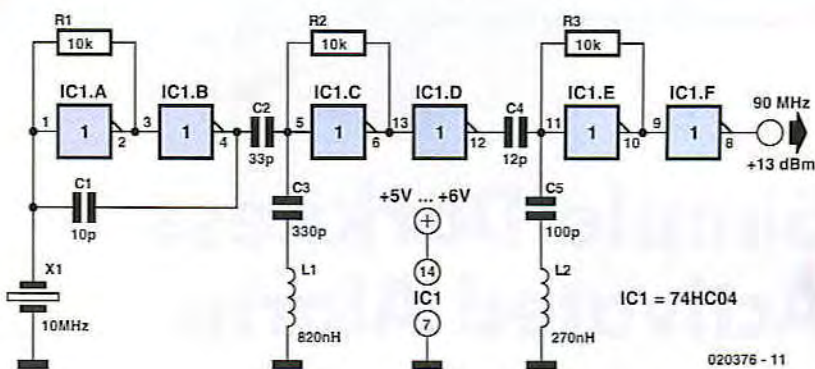
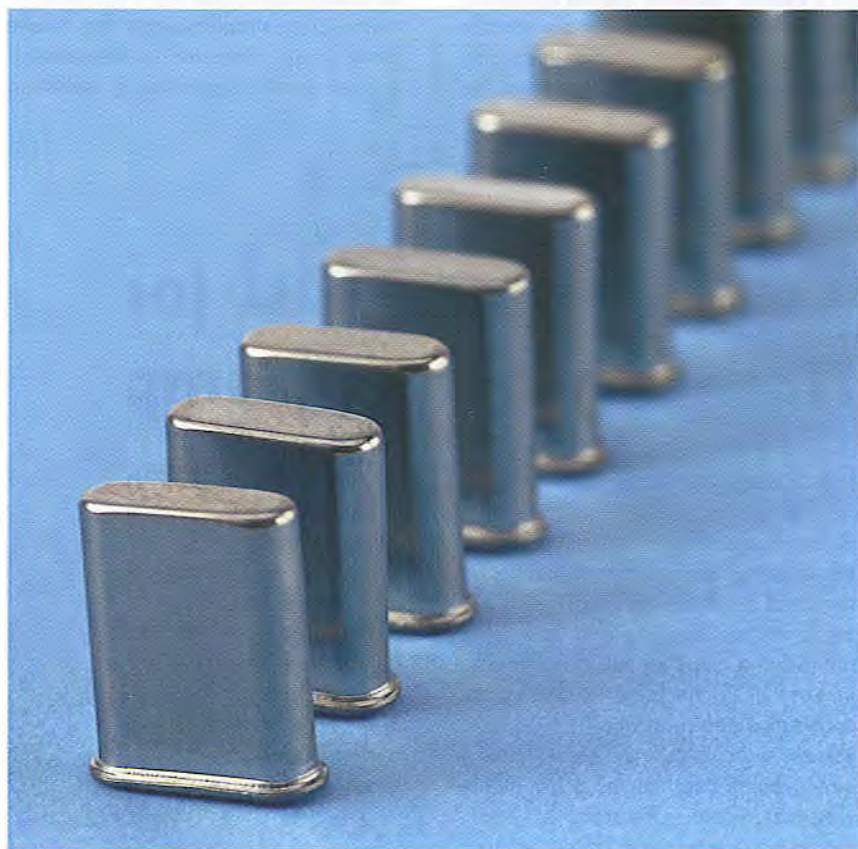
Crystals usually operate at fundamental frequencies up to about 15 MHz. Whenever higher frequencies are required a frequency multiplier is placed after the crystal oscillator. The resulting output signal is then a whole multiple of the crystal frequency. Other frequency multipliers often use transistors, which produce harmonics due to their non-linearity. These are subsequently filtered from the signal. One way of doing this is to put a parallel LC filter in the collector arm. This filter could then be tuned to three times the input frequency. A disadvantage is that such a circuit would quickly become quite substantial. This circuit contains only a single IC and a handful of passive components, and has a complete oscillator and two frequency triplers. The output is therefore a signal with a frequency that is 9 times as much as that of the crystal.

Two gates from IC1, which contains six high-speed CMOS inverters, are used as an oscillator in combination with X1. This works at the fundamental frequency of the crystal and has a square wave at its output. A square wave can be considered as the sum of a fundamental sine wave plus an infinite number of odd multiples of that wave. The second stage has been tuned to the first odd multiple (3 x).

We know that some of our readers will have noticed that the filter used here is a band-rejection (series LC) type. Worse still, when you calculate the rejection frequency you'll find that it is equal to the fundamental crystal frequency! The fundamental frequency is therefore attenuated, which is good. But how is the third harmonic boosted? That is done by the smaller capacitor of 33 pF in combination with the inductor. Together they form the required band-pass filter. (The same applies to the 12 pF capacitor in the next stage.) Through the careful selection of components, this filter is therefore capable of rejecting the fundamental and boosting the third harmonic! Clever, isn't it?

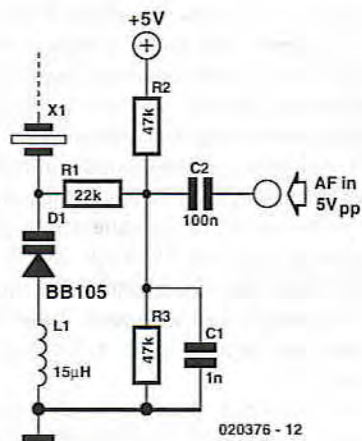
The output in this example is a signal of 30 MHz. The inverter following this stage heavily amplifies this signal and turns it into a square wave. The same trick is used again to create the final output signal of 3 times 30 MHz = 90 MHz.

At 5 V this circuit delivers about 20 milliwatt into 50 Ω . This corresponds to +13 dBm and is in theory enough to



drive a diode-ring balanced mixer directly. The circuit can be used for any output frequency up to about 100 MHz by varying the component values. When, for example, an 8 MHz crystal is used to obtain an output frequency of 72 MHz ($9 \times 8 = 72$), the frequency determining inductors and capacitors have to be adjusted by a factor of 10/8. You should round the values to the nearest value from the E12 series.

Another application is for use in an FM transmitter; if you connect a varicap in series with the crystal, you can make an FM modulator. An added bonus here is that the relatively small modulation level



is also increased by a factor of 9. Crystals with frequencies near 10 MHz are relatively easy to find and inexpensive, so you should always be able to find a suitable frequency within the FM band. A

crystal of 10.245 MHz for instance would give you a frequency of 92.205 MHz and 10.700 MHz results in an output of 96.300 MHz. You may find that the circuit operates on

the border of the HC specifications. If this causes any problems you should increase the supply voltage a little to 6 V.

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