Chapter 2

Frequency Multipliers

A Universal Multiplier for Microwaves

F6BVA

Translated by G3PHO from the French microwave newsletter "Hyper" July 2000 issue

Building equipment for 76GHz has made us review our ideas on local oscillators. In effect, until then, we had been very happy to use the DB6NT kits, which gave us every satisfaction but then, the helical and printed circuit filters are very nice and very effective. The other side of the coin, however, is that that type of circuitry is relatively narrow in bandwidth and does not lend itself to retuning to other frequencies other than those for which it was designed. The specification for my oscillator is quite straightforward:

- Output frequency adjustable from 9.5GHz to 12.8GHz
- • Output power +10dBm (enough for our requirements) with clean spectral characteristics as far as possible (the first spurious is -25dBm

The Local oscillator is made in two separate modules:
The first is a 1250MHz generator, a modified version of one published by F6DER in Hyper some years ago. The frequency s maintained at the correct frequency by using an ovened crystal at around 50 degrees C. Five to ten milliwatts from this stage are sufficient to drive the multiplier.

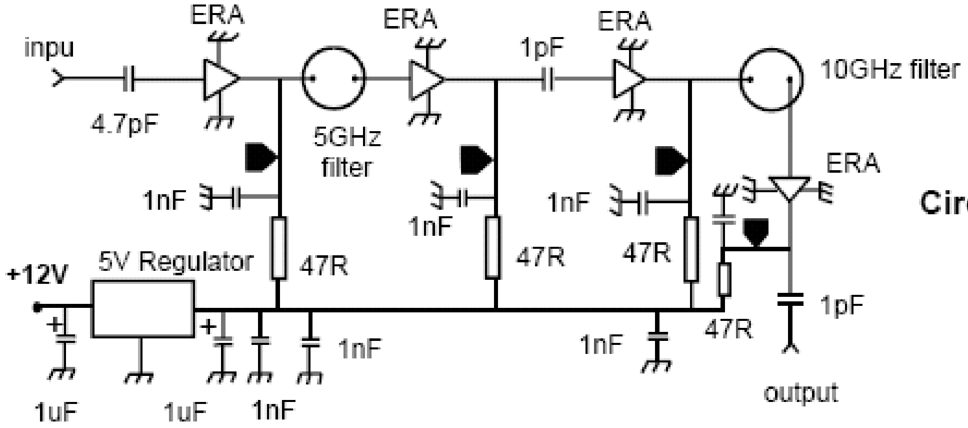
The multiplier forms the second module. An ERA3 is used as a x4 multiplier from 1.250GHz, and produces 5GHz after the first filter. A second ERA3 amplifies the 5GHz and drives an ERA1 which doubles to 10GHz, which in turn is filtered and then amplified by another ERA1. Several examples of the multiplier have been built using the filter dimensions provided in this article and used to produce output between 9.5GHz and 12.6GHz without further modification, other than tuning the filters.

The circuit was etched on double sided 0.8mm Teflon board (Er = 2.35). The filter cavities are soldered to the ground plane side. Prior to this, the copper around the holes for the filter probes is cleared with a 3.5mm drill bit, as are those for the input and output pins of the 5V voltage regulator.

The ground pins of each ERA device are passed through very thin slots (carefully cut with a sharp scalpel) from the strip line side to the ground plane side of the board and soldered on both sides. (editor's note: an alternative method to this would be to use flat head veropins (as in G3WDG and DB6NT modules) pushed through holes drilled from one side of the board to the other. This would then allow minimum ERA ground lead length.)

The filters are made from standard copper pipe fittings ('stop ends' … editor) found widely in DIY stores. The filter pipe caps are then drilled and tapped to take M2.5 tuning screws and locknuts.

The 5GHz filter is 25mm o.d. and



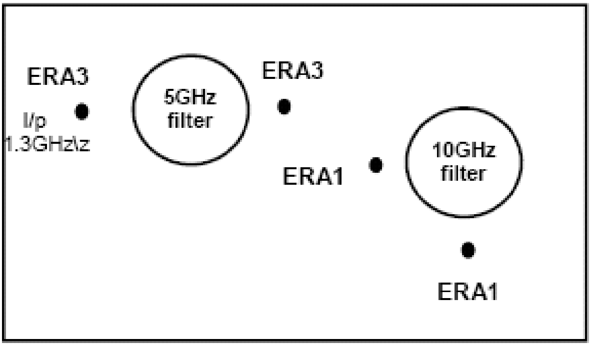
Circuit diagram

17 mm internal height (assuming 1mm wall thickness for the fitting …. editor). The probes for this filter extend 3mm into the cavity, i.e. above the ground plane surface). The 10GHz filter is 20mm o.d. and 10mm inside height. The 10GHz probes extend
2mm into the cavity. (editor's note: to accurately cut probes to length it is suggested they be first cut slightly long and checked with a micrometer. Don't forget to add 0.8mm to their length to account for the thickness of the pcb they pass through.)

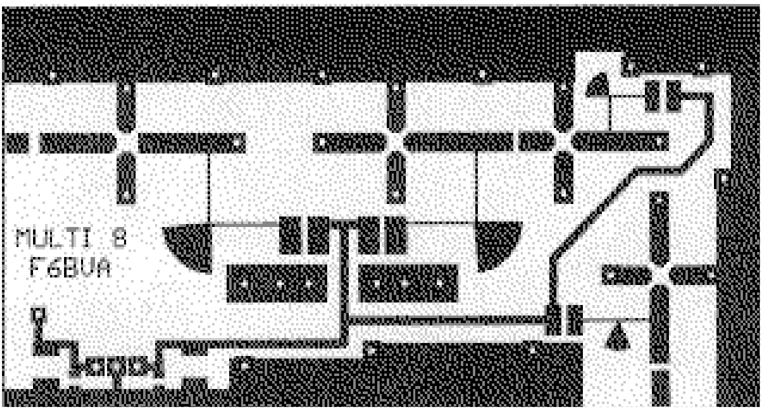
The printed circuit board is mounted in a standard tinplate box measuring 55mm wide x 110mm length x 30mm depth. The ground plane is carefully soldered all the way round at its interface with the sides of the box, 8mm above the bottom of the box.

The construction presented no particular difficulties … just don't forget to make the through connections for the ERA devices. Pre-adjustment of the filters can carried out with the aid of a signal generator if you do not have access to a spectrum analyser. After this adjustment you should see an output of around 5mW. Depending on the chosen output frequency, it may be necessary to "snowflake" the lines with two or three stubs to obtain the +10dBm required. Lossy rubber or foam may be needed in the lid of the box if any instability is found to be present.

This Local Oscillator/multiplier has been fitted into equipment for 47, 76 and 145GHz with entirely satisfactory results.



Physical layout



PCB layout

F6BVA Multi 8 'New Look' Frequency Multiplier

From a translation by John Jaminet, W3HMS

Editor's comments:
The original F6BVA multiplier is described in the previous article. Michel, F6BVA, has now produced this most interesting version, based on cheap and easily obtainable double-sided epoxy PC material. Surprisingly it appears to work as well as, if not better than, the Duroid version!

Introduction
Faced with the difficulties of getting Duroid PCB material, I have redesigned the tracks for double sided epoxy board 0.8 mm thick. Surprisingly ... (it's good that the quality of the substrate is not there for nothing!) … this new design is much more stable than version # 1.

Measured results:
F input 1.0-1.6 GHz at 10dBm
F out from 8.0-13 GHz = 10dBm, minimum and without tuning stubs.
F in 2.0-2.3 GHz . P in = 0 to +3dBm for P out max.

To obtain the total tuning range, the size of the pipe cap resonators have been modified from the previous design.

5GHz Resonator: Interior diameter is 22 mm and the internal height is 7 mm. Probes are 3 mm long.

10GHz Resonator: Internal diameter is 18 mm and internal height is 5 mm.. Probes are 2.2 mm long.

Procedure for Mounting.

- Cut the PCB to fit your tin plate box dimensions. Smooth one cut side edge.
- Drill 0.6mm diameter probe holes through to the ground plane.
- Using a 3mm drill, held in the fingers, cut away the copper on the ground plane side of the board around the holes for the in and out pins of the regulator.
- Drill a 2.2 mm hole for the ERA placement in a way that lets the pins make a good ground contact without being bent.
- From the ground plane side, determine the axis for the pipe cap probes, then use a pair of compasses to mark the mounting position for the pipe caps.
- Solder in the probes and then cut them to 2.2 mm for 10GHz and 3 mm for 5GHz.
- After the pipe caps have been cut to the right height, drill and tap them for the tuning screw, preheat, position them as precisely as possible at the mounting location on the PCB and then solder.
- Solder the PCB into its box. (assume open at bottom for testing)
- With the aid of a fine wire (0.3 to 0.5mm diam.), pull each wire going through the 0.6 mm holes from the component side of the PCB to the ground plane side via the 0.6 mm holes and solder it on each side. Solder the ground wires on the PCB side when soldering the rest of the components.
- Solder all components, MMICs last of all.

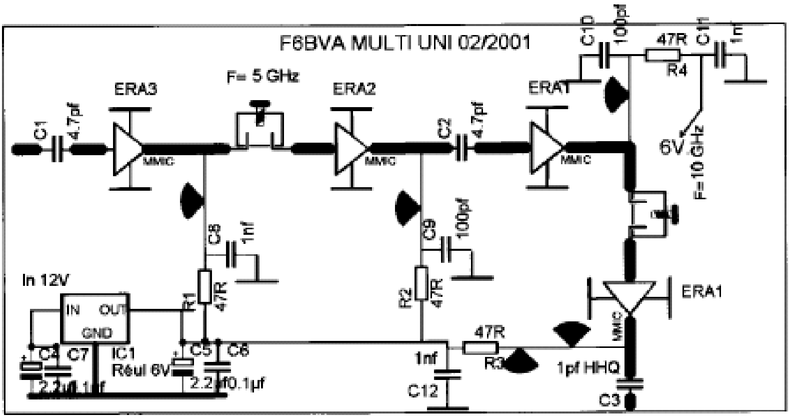
Remember:

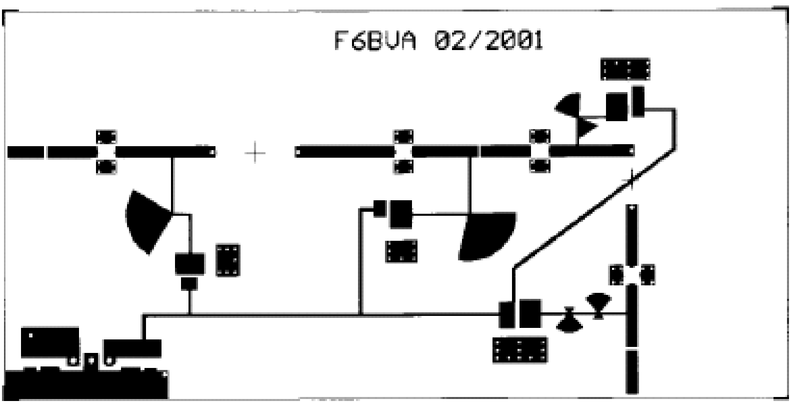
- Pipe caps from 4 – 6.5 GHz =

internal diameter of 22 mm and height of 7 mm with internal probe height of 3 mm.

- Pipe caps from 8 -13 GHz = internal diameter of 18 mm and inside height of 5 mm with probes 2.2 mm.
- Input capacitors at pins 1 and 2 = 4.7 pF. Output capacitors are 1 pF high quality capacitors for use at 10 GHz (e.g.: ATC chip caps ...editor)
- Regulated voltage = 6 VDC and current drain = 200 ma.
- The MMICs as used on the last prototype are, in order from input to output, ERA3, ERA2, ERA1 and ERA1.
- Don't exceed 10 dBm input. Reduce same to +3dBm if you go on 2.xxx GHz.
- Be particularly careful with the MMICs' grounding.

The PC board measures 109.5mm long and 55mm wide when full size.
If using this page to make a board please check these dimensions and adjust on your copier or scanner to suit.





The Qualcomm 2GHz to 10 or 12GHz Multiplier

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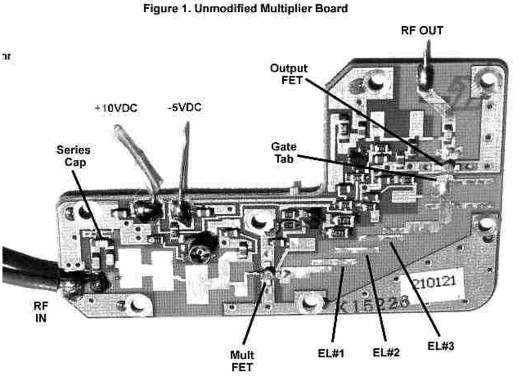
Figure 1. Unmodified Multiplier Board



The Qualcomm Multiplier is used to multiply synthesizer outputs in the 2GHz frequency range by X4 or X5 to the 10-13GHz frequency range. As-is, the multiplier's pc board was designed to multiply 2.620GHz times 5 to 13.1GHz, with a 2GHz drive level of +10dBm to provide +7dBm of output power at 13.1 GHz.

The pc board is quite small measuring 1 5/8 inch by 2 3/4 inches. The board is populated with two stages of MGF1302 FETs and two dc control transistors, one for each FET. The first stage multiplies to 13.1GHz, driving a stripline filter to the second stage output amplifier. The DC power requirements are minus 5 volts bias and plus 10 volts dc. Figure 1 shows the unmodified pc board and indicates the areas involved in this modification.

This board is a natural to drop into a 2 by 3 inch housing for frequency multiplication schemes in the 10 to 13GHz frequency ranges. Our earlier Qualcomm output filter modification schemes for 10GHz used a 1/2 inch pipe-cap filter in place of the original stripline output filter. That board was nearly 3 times larger than this newer smaller multiplier board. This means that you can have a 2.x GHz multiplier to 10 or 12GHz in a small aluminium box of 2 by 3 inches by 1/2 to 3/4 inch high. The filter approach for the new small board is to use standard stripline extensions made of copper strips the same size as the original stripline filter elements. Extending the element lengths lowers the resonant frequency from 13.1GHz to the new multiplier output frequency range.

The Modification

The new dimensions in this modification are specifically to multiply a 2.556GHz input X4 to 10.224 GHz as an LO for 10.368GHz operation. You will add a 1.5 pF chip cap to the existing input filter.

This improves the drive to the multiplier stage in the vicinity of 2.5GHz. Modifications to the multiplier circuit output filter consist of extending three stripline filter element lines by strips of copper soldered to the original stripline elements. This retunes the filter for best output at the 4th harmonic for a 10.2-10.4GHz LO. The gate tab improves the output by about 1 dB. Typical output power can be +4 to +8 dBm. This of course depends on drive and re-tune success. If you need to have a different output frequency range than the 10.224-10.368GHz described above, then the output filter element lengths and gate tab dimensions will need to be experimentally redetermined.

The multiplier pc board has a notch in one corner about .75 by 1.5 inches in size.

Although I didn't take advantage of this space in the modified unit in this article, the notch allows room for a small internal power converter in the same enclosure. The power converter could provide the 5V negative bias of 1 ma or so, and regulated +10 V, allowing the multiplier to be self-contained operating from a +12 volt dc main supply.

Again, as with all modified Qualcomm material, DO NOT CONTACT QUALCOMM for information on these devices. Please contact Chuck Houghton, WB6IGP, clhough@pacbell.net, or Kerry Banke, N6IZW, kbanke@aol.com for any information or availability. More details are on the Web at :

http://www.ham-radio.com/sbms/sd/multx4.htm