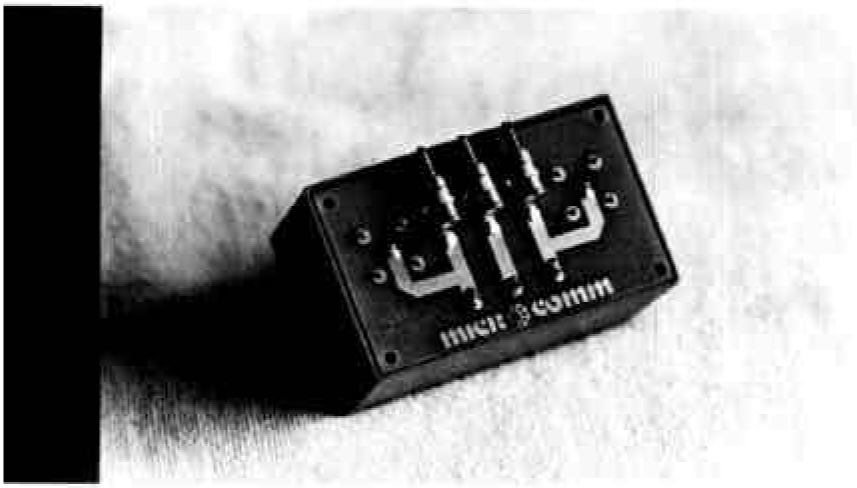

improved grounding for the 1296-MHz microstrip filter

Construction techniques for improving the performance of the three-pole 1296-MHz bandpass microstripline filter

The 1296-MHz microstripline bandpass filter I discussed in a previous article has allowed dozens of uhf experimenters to "clean up their act" on the 23-cm band.[1] As shown in **fig. 1**, the filter consisted of three top-coupled parallel-resonant circuits with grounded microstripline inductors. The filter is easy to assemble and tune, but several amateurs who have built it experienced difficulties caused by erratic stripline grounding. The new design presented here eliminates those difficulties and provides lower insertion loss and steeper skirts that will not tend to degrade as the filter is used.

The grounding of the microstriplines in the original design was accomplished by wrapping a thin brass or copper strap around the edge of the PC board, soldering it to the stripline on one side of the board and the groundplane on the other. Although this method of grounding worked well in the prototypes, the stripline inductance is a function of the placement of the grounding strap. Furthermore, the strap's placement on the edge of the board makes it extremely susceptible to physical damage, especially when installing or removing the filter board from its box. A third difficulty with wraparound grounding is that it forces the end of the microstripline inductor to extend to the edge of the board, where stray coupling can cause the tuning of the filter to change when the unit is placed inside an enclosure.

All of these difficulties can be easily eliminated by placing the grounded end of the microstripline inductors somewhat away from the edge of the board and drilling through the board for the installation of a grounding wire or post. With the ground connection running through (rather than around) the board, its mechanical integrity is assured, and the groundstrap inductance is more nearly constant from one filter to the next, especially if the diameter of the grounding wire or post is specified.

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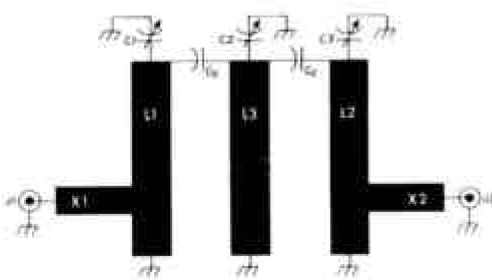
Although a short length of number 18 (1.0 mm) tinned copper wire makes an acceptable through-board ground connection, maximum grounding effectiveness and mechanical integrity, I have found, can be achieved by installing small electronic eyelets through the board, setting them with a press, and soldering both sides. The eyelets I use are made of thin brass, measuring 0.47 inch (1.2 mm) diameter by 0.093 inch (2.5 mm) long. They look something like tiny rivets. The eyelets are available from a number of vendors* and can be easily set using a center-punch (or sharp nail) and hammer.

grounding the trimmer capacitors

Another area of difficulty encountered by several readers is the grounding of the piston trimmer capacitors. The capacitors I originally used were designed for chassis mounting, so it was necessary to modify them for circuit-board use by adding a bus-wire loop around the terminal nearest the adjusting screw (see **fig. 4** of reference 1). It would have been better to use a trimmer specifically designed for PC use, with legs installed for grounding the rotor end through the circuit board. One such capacitor is the R-Triko 202-08M, a German ceramic piston trimmer available in the required 1-to-5-pF range.* I find filters using this capacitor easier to tune up, although I caution the builder against repeated adjustments because the tuning mechanism loses spring tension and becomes erratic after a couple dozen adjustments. The best procedure is to set the filter on frequency *once*, and then place a dot of nail polish, epoxy paint, or *Loctite* on the tuning screw as a reminder to leave it alone!



C1 - C3	1.5-pF ceramic piston trimmer (Triko 202-08M or equivalent)
C_c	Stray coupling capacitance between stator ends of trimmer capacitors
J1, J2	SMA or equivalent microstripline launchers (E.F. Johnson 142-0298-001 or similar)
L1, L2, L3	Microstripline inductor, 0.5" (13 mm) long, 0.1" (2.5 mm) wide, spaced 0.3" (7.5 mm) center to center. Bottom ends strapped to ground plane with thin copper strap
X1, X2	50-ohm microstripline, 0.1" (2.5 mm) wide, any length. Centerline tapped to L1 and L2 0.2" (5 mm) from grounded end

fig. 1. Three-pole microstripline bandpass filter, which will tune the range from 1100 to 1500 MHz. Full-size printed-circuit layout for this filter is shown in fig. 2.

fig. 2. Full-size printed-circuit layout for the three-pole 1296-MHz bandpass filter. Etched on double-clad 1/16" (1.5 mm) fiberglass-epoxy circuit board; the unetched side serves as a ground plane.

assembling the modified filter

Fig. 2 is a full-size printed circuit layout for the 3-pole bandpass filter, modified for through-board grounding. The board should be etched from double-clad 1/16-inch (1.5-mm) fiberglass-epoxy printed-circuit stock, with one side left unetched to serve as a ground plane. The board should be drilled in the same manner as the template in **fig. 3** and the three eyelets installed at the bottom end of the microstriplines.‡ Don't forget to remove a bit of ground plane

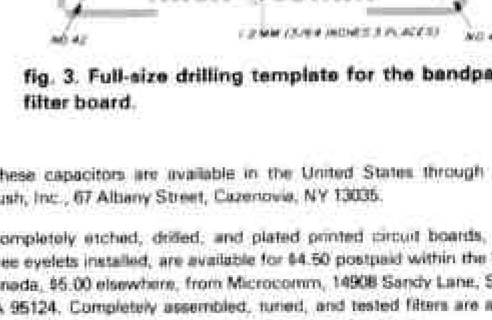


fig. 3. Full-size drilling template for the bandpass filter board.

*One acceptable eyelet is part number F-4793-B, available from International Eyelets, Inc., 528 Santa Barbara Street, Santa Barbara, CA 93101.

*These capacitors are available in the United States through Stettner-Trush, Inc., 67 Albany Street, Cazenovia, NY 13035.

‡Completely etched, drilled, and plated printed circuit boards, with the three eyelets installed, are available for $4.50 postpaid within the U.S. and Canada, $5.00 elsewhere, from Microcomm, 14908 Sandy Lane, San Jose, CA 95124. Completely assembled, tuned, and tested filters are also available. Send a stamped, self-addressed envelope for details.

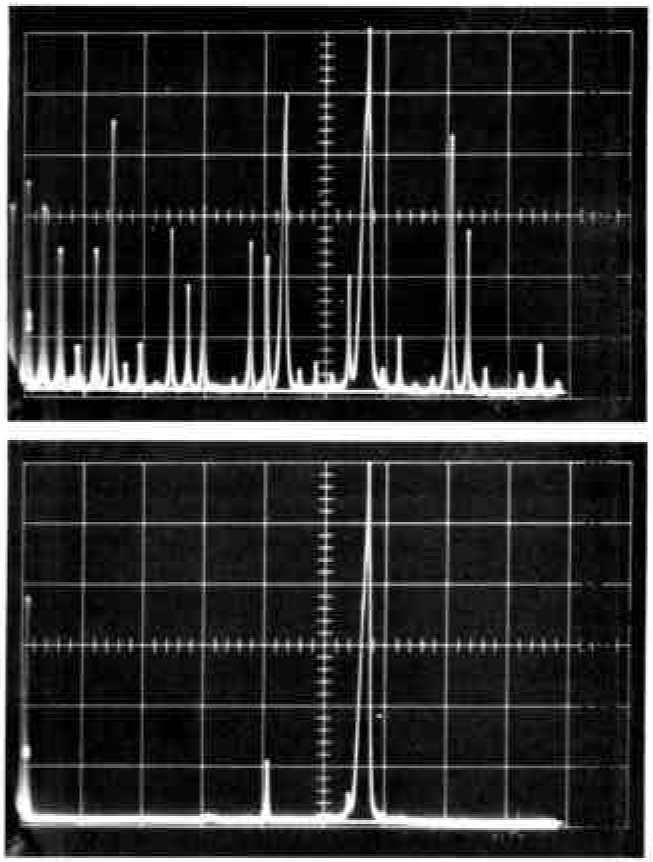


fig. 4. Effect of the bandpass filter on a 1296-MHz local oscillator chain. Spectrum display at top shows the various spurious outputs of a poorly designed LO. Spectrum at bottom is the result of passing the LO signal through a three-pole bandpass filter of fig. 1. The worst remaining spurious component is suppressed 25 dB. (Both displays: dc - 1.8 GHz sweep; horizontal scale, 200 MHz/division; vertical scale, 5 dB/division.)

metallization from around the center-pin holes for the input and output coaxial connectors so the signal isn't grounded out. A 1/8-inch (3-mm) twist drill, used as a deburring tool, works well for this operation.

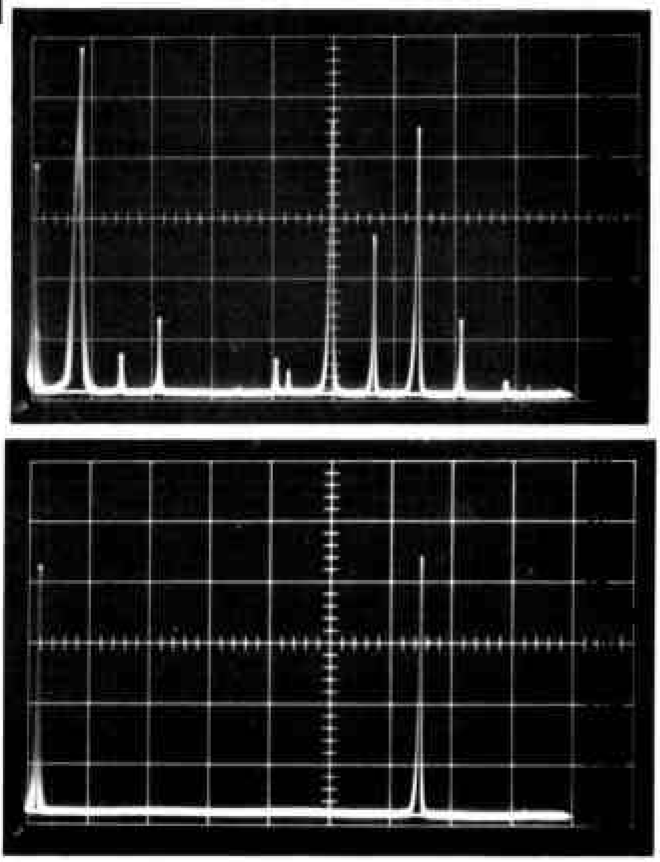
Connectors J1 and J2 are installed next, soldering the center pin to the input and output microstriplines, and running a bead of solder around the connector body on the ground-plane side of the board. The trimmer capacitors are installed last. If you use the recommended Triko trimmer, be sure to bend the two mounting legs nearest the adjusting screw down against the ground plane before soldering. The photograph of the completed filter will assist you in assembly.

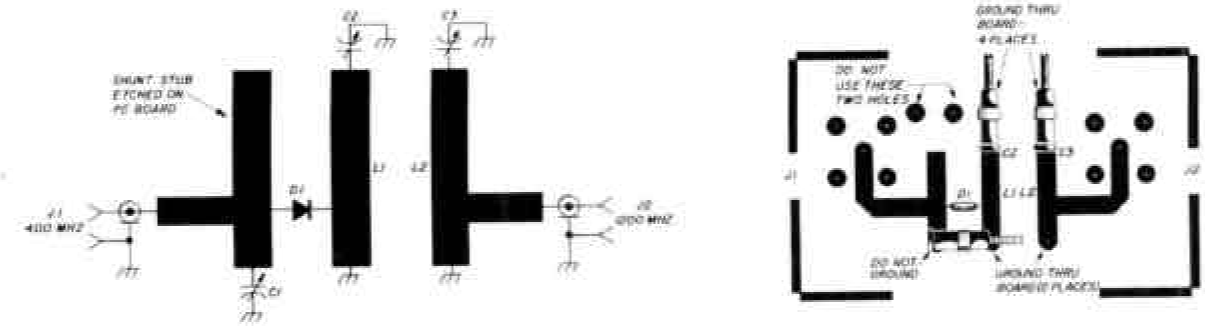
filter performance

Reference 1 included a swept response curve for the original bandpass filter, as measured on a network analyzer. The response curve for the modified filter design shows slightly reduced insertion loss (on the order of 0.5 dB) and slightly steeper skirts. Perhaps the most realistic indication of filter performance is not its swept response, but the filter's behavior in an actual system. **Fig. 4** shows the effect of installing the bandpass filter behind an extremely spurious local oscillator chain. Note that the numerous spurious components are all significantly suppressed, with the worst remaining spur reduced from −5 dB to about −25 dB, relative to the desired output.

Fig. 5 shows the results when the filter is used to clean up the output of a previously published transmit balanced mixer.[2] Notice that the i-f feedthrough signal and its harmonics, the LO feedthrough, the

fig. 5. Effect of the three-pole bandpass filter on the output of a 1296-MHz transmit mixer. Spectrum display at top shows the output from a singly balanced diode mixer; visible spurious components include the desired signal and image, some LO feedthrough, a very strong component of the i-f injection, and its second and third harmonics, and transmit intermods (resulting from these harmonics mixing with the LO signal). With the three-pole bandpass filter installed in the system, the spectrum (bottom photo) shows that all spurious outputs have been attenuated by more than 25 dB. (Both displays: dc - 1.8 GHz sweep; horizontal scale, 200 MHz/division; vertical scale, 5 dB/division.)





C1	1-9 pF piston trimmer (Triko 203-09M or equivalent)
C2, C3	1-5 pF pistion trimmer (Triko 201-01M or equivalent)
CR1	Step recovery diode (H-P 5082-0180)
J1, J2	SMA coaxial connector (E.F. Johnson 142-0298-001 or similar)
L1, L2	Microstripline inductors (see **fig. 2**)

fig. 6. Circuit and construction details for a local-oscillator multiplier which provides 0.5 mW at 1200 MHz from a 5-mW 400-MHz drive signal. This circuit uses the same printed-circuit layout as the bandpass filter (see fig. 2). Output spectrum of this circuit is shown in fig. 7.

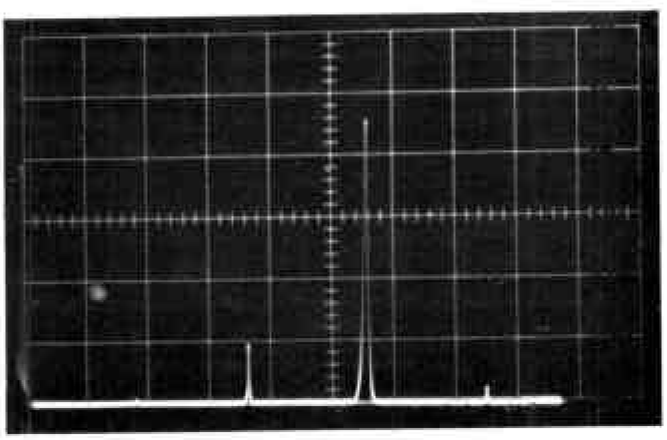
image signal, and the intermodulation products are all suppressed below the dynamic range of the spectrum analyzer.

local-oscillator multiplier

In a previous article I described a diode multiplier for developing local-oscillator injection for a 1296-MHz converter.[3] As this multiplier used a microstripline output filter, it seemed reasonable to assemble a similar multiplier on the bandpass filter PC board, thus allowing one PC artwork to do the job of two. The circuit, which makes a rather nice low-level tripler, is shown in **fig. 6**. Note that the microstripline previously associated with the first filter pole is now used to support the multiplier diode and its input matching circuit. Do *not* install a grounding eyelet on this first stripline if you are building the multiplier! The other two filtering poles help reject the many other harmonic components generated by the step-recovery diode, as shown in the spectrum analyzer display of **fig. 7**. When driven by the 5-to-10 mW signal from my uhf LO chain, this multiplier provides about 0.5 mW of third-harmonic output. This power level can be easily buffered in a 1296-MHz preamp,[4] applied to a 3-pole filter for additional spurious rejection, and used to drive the LO port of a transmit or receive balanced mixer.

I should point out that the circuit of **fig. 6** provides no dc return for the anode side of the multiplier diode. A dc return is necessary for the diode to properly develop self-bias; in my system this dc path is provided at the output of the uhf LO. If the driving stage does not offer dc continuity to ground, it will be necessary to install a dc return circuit on the multiplier board. This can be most readily accomplished by adding a small (0.33-μH) rf choke to ground at the location normally occupied by the first trimmer capacitor when this board is used as a filter.

fig. 7. Output spectrum of the 400-MHz to 1200-MHz LO multiplier. Note that the tripler circuit provides some degree of filtering of the 400-, 800-, and 1600-MHz components from the step recovery diode.



summary

The printed-circuit layout can be used to fabricate high-quality bandpass filters and diode multipliers for the amateur 23-cm band. The designs are based upon previous articles, but the addition of through-board eyelet grounding significantly improves performance and reliability. Further details on construction, tune-up and testing, and system application are discussed in reference 1.

references

1. H. Paul Shuch, WA6UAM, "Microstripline Bandpass Filters for 1296 MHz," *ham radio*, December, 1975, page 46.
2. H. Paul Shuch, WA6UAM, "Rat-race Balanced Mixer for 1296 MHz," *ham radio*, July, 1977, page 33.
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ham radio