IMPROVING THE LARCAN AMPLIFIER AT 50.0 MHz
By David Olean K1WHS

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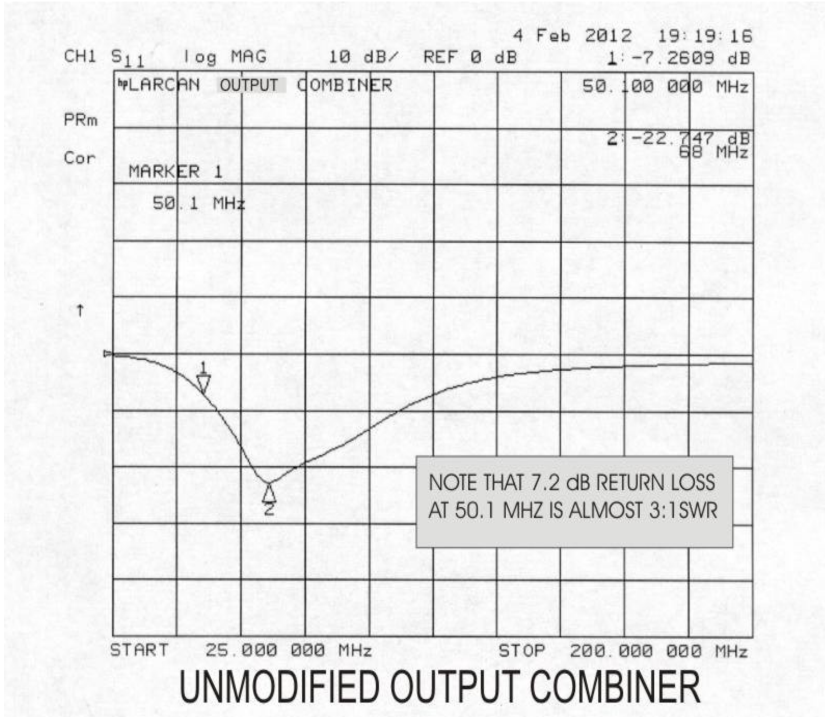
I purchased one of the LO-HI Larcan television amplifiers from the MMRA group a while back, and have finally gotten around to actually implementing it into my station. As advertised, these CH 5&6 TV amplifiers will provide 300 watts on the FM part of six meters when not converted, and will make 600 watts output in CW and 1000 watts PEP in SSB if component changes are made to convert a LO-HI amp down to a LO-LO amp. My interest was in using the amplifier at 50.1 MHz for SSB and CW service, not FM, and the additional excursion to the bottom of the band resulted in poor efficiency and lower gain. Surely there must be a way to squeeze a few more watts out of the circuit.

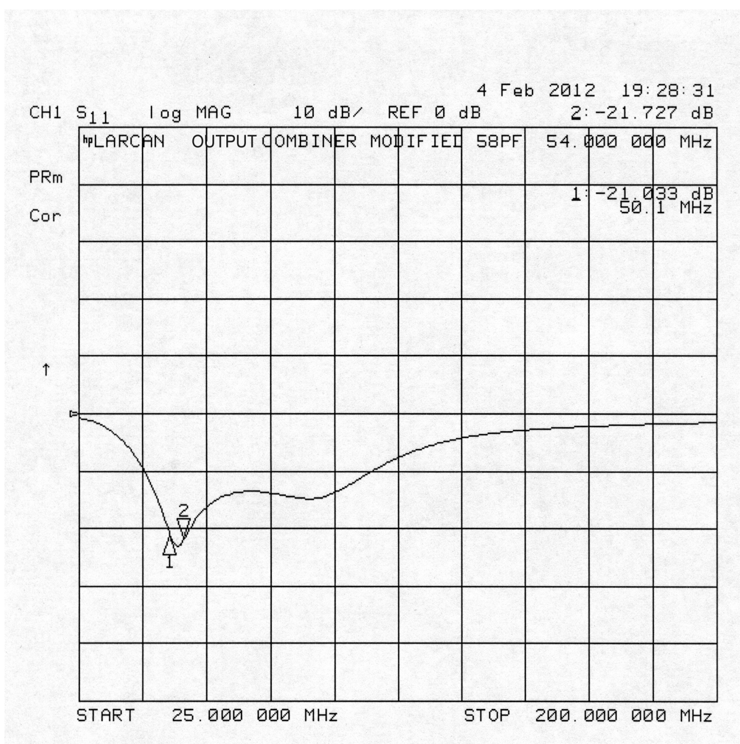
My first attempt involved tweaking an individual MRF151G stage on the amplifier chassis for better performance at 50.0 MHz. The input side seemed to be pretty optimum and no improvements were noted, but I was able to increase the performance by modifying the output circuit. I experimented with changing values of C-14 and C-16. C-13 seemed OK as is, but I was able to improve the gain by increasing the value of C-16 from the 51 pf specified by Larcan, to 75 pf. You could piggy back a 24 pf capacitor there, or just install a single 75 pf capacitor in place of the original 51 pf. I also found that increasing C-14 and C-15 from the Larcan value of 180 pf to 225 pf increased the performance as well.

I next attacked the output combiner. My changes to each individual amplifier had improved things, but there was still a huge discrepancy between 50.0 MHz and higher frequencies. Max power was still up beyond 70 MHz. I had only marginally improved the performance. Don, W1FKF had also converted a Larcan unit to 50 MHz SSB previously, and had complained about poor efficiency there. He was seeing efficiency values in the order of 24%. He also mentioned that you could increase the gain by increasing the idle current, but my concern was that the amplifier was just not optimized for the low end of the band. All of my efforts were done with 500 ma Id per stage. Total current was 4 amps. I thought that the problem had to lie in the output combiner as well as the output section of the amplifier. I disconnected all of the MRF151G stages and substituted small 50 ohm resistors at the amplifier output. Then I connected a network analyzer there on the output connector. My feeling was that I should see 50 ohms if everything was working properly. I was greeted by a very poor match at 50 MHz with a return loss of about 7 dB, or almost 3:1! Instead of the normal 6 dB of coupling loss, I was seeing 3.5 dB on one port. That meant another port would have had almost 9 dB! I also looked at the output combiner by measuring the return loss at the individual amplifier output with the output connector terminated. With the other three stages inactive, the return loss was pretty bad at 50.0 and much better at 55 to 77 MHz. Clearly the combiner was not working well where it needed to be. I then started experimenting with the combiner cap values, and ended up changing the values of C-4 & C-5 and also C-1 & C-8. C-4 & C-5 were originally 47 pf and I increased that to about 86 pf by adding a 39 pf capacitor piggyback style on each one. C-1 & C-8 had an added 12 pf for a total of about 27 pf there. Those changes altered the output combiner more to my liking.

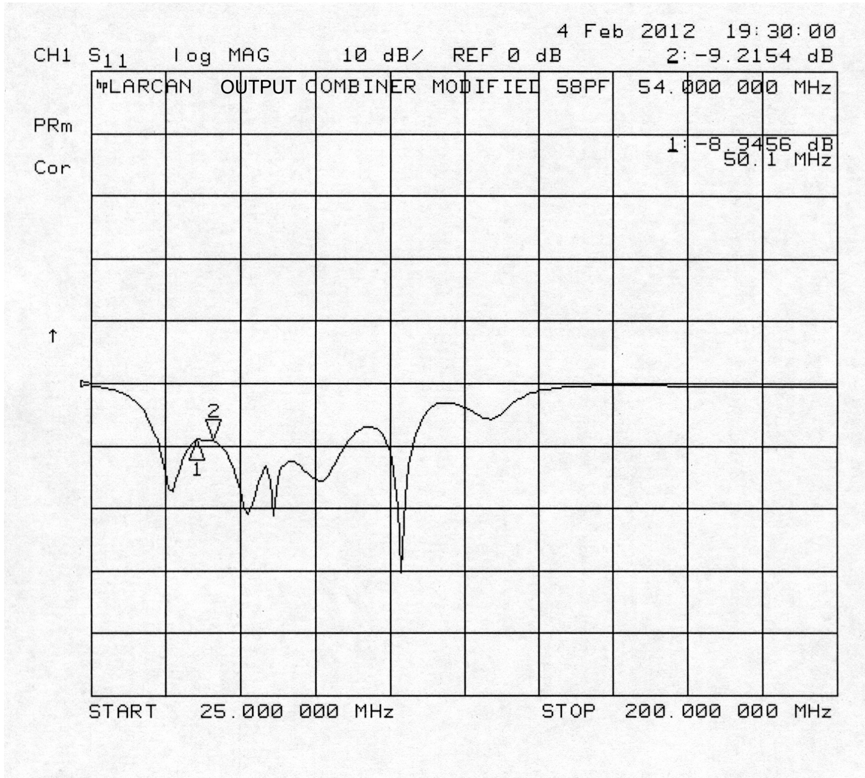
I could see that the input splitter was very similar in construction to the output combiner, so I figured it needed help as well. I tried the same trick on the input by putting 50 ohm resistors at each amplifier input and measuring the input return loss to the splitter. C-5 & C-6 needed more capacitance and I piggybacked another 30 pf across the 39 pf ones for a total of 68 or 69 pf. I left C-3 & C-4 alone. Changes there did not have much effect. The input splitter sems to have much less bandwidth than the output combiner. In addition it is skewed slightly below 50 MHz, but the return loss was more than acceptable, so I did not pursue things any further. I felt a little better knowing that the amplifiers were now running into a more reasonable load.



This plot was taken from measurements made at the output connector with each 50 ohm FET amplifier output point disconnected and a non inductive 50 ohm resistor substituted in its' place.



Converted OUTPUT Combiner. Each FET amplifier is replaced by a 50 ohm load, and the return loss is measured from the output connector. Return loss is better than 20 dB between 50 and 54 MHz.



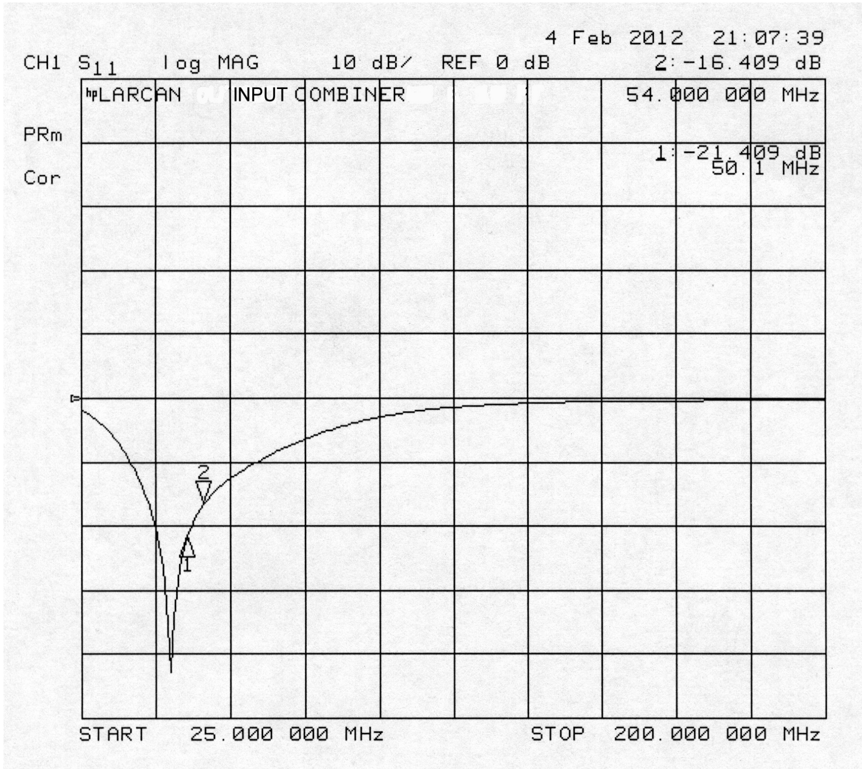
Return loss plot of Larcan output combiner with 50 ohm loads removed and FET drains re-attached. The FETs are not drawing any idle current, but are cut off.

I tried firing up the amplifier and driving it with a laboratory signal generator and instrument amplifier. With 4.0 watts of drive I had the following results:

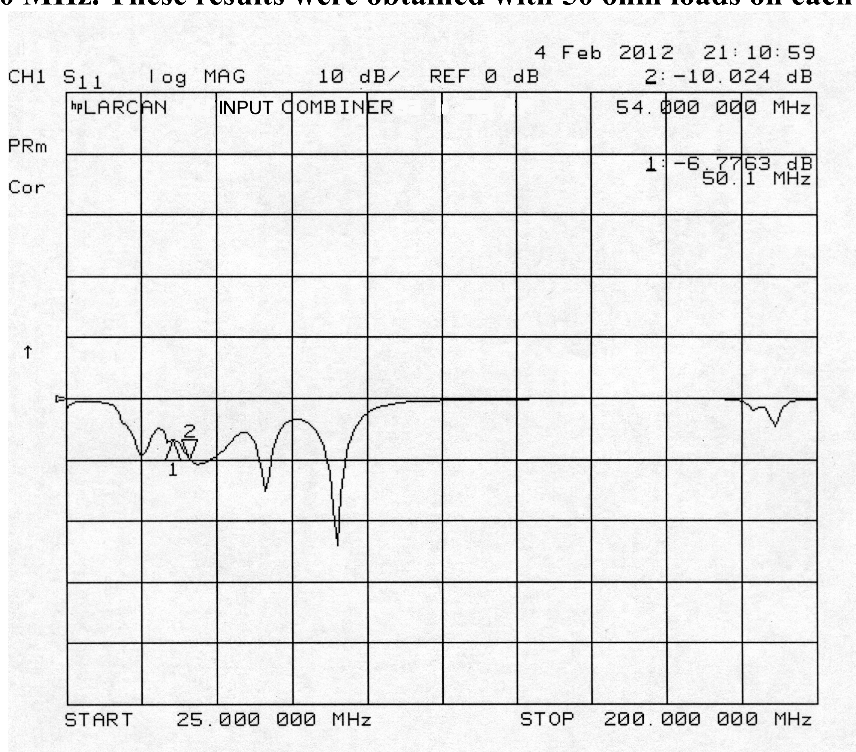
FREQUENCY	VOLTS DC	AMPS	POWER OUT	EFFICIENCY
50	51	30	540	35.30%
52	51	31	580	36.70%
54	51	32	630	39.20%

I tried running the converted amplifier at 70 MHz at full power, but was greeted by a blue flash from one of the FETs and a blown fuse. Scratch one $110 LDMOS! (It failed as an open circuit) With the changes I made to the output stage, the maximum RF output of an individual amplifier driven through the input splitter is reached at about 60 MHz. I guess full power at 70 MHz into the modified output combiner was a bad idea. Note to self: Operate only between 50 and 54 MHz after making these changes!! I ran the drive up at 54 MHz to a bit over 5 watts to obtain 900 watts of carrier. Current drain was 38 amps for an efficiency of 46.94%. There is one caveat with this test. I used a 1000 watt 100-250 MHz Bird slug which is not rated for 50 MHz. I suspect the power accuracy is pretty close though, as it is a high power element with light coupling. (You would think that K1WHS would have his act together and possess a 1000 watt Bird element for 50 MHz. If you did think that, you would be WRONG!) This gain is drastically better than the unmodified LO-LO module will do, so I feel that my efforts were effective and make a good amplifier even better. I did not have a peak reading watt meter in my shop at the time, but a scope did show PEP values significantly higher than the CW carrier levels when SSB is employed.

The input combiner still favors higher frequencies and you can see the input power to the FET rising as you raise the frequency. I reasoned that reworking the etched lines was not worth the effort in an attempt to correct this. After all, you need only increase the drive a bit to overcome the roll off in the input combiner. Gain ranges from 21+ dB at 50 MHz to well over 22 dB at 54 MHz.



Plot of converted input splitter after the component changes were made. You can see some low frequency skewing apparent. I left it AS-IS since it looked "good enough"! The markers are at 50.1 and 54.0 MHz. These results were obtained with 50 ohm loads on each FET input.



Input Splitter plot with 50 ohm resistors removed and FET gates reconnected. The FETs are not drawing any current. Input VSWR is OK under normal drive conditions, although this plot shows well over 2:1 "static" VSWR. It gets better when the FETs are turned on and operating!

So here are the changes required for better performance at 50-54 MHz:

INPUT SPLITTER:
C-5, C-6 39 pf to 68 pf ATC100B (You could also use a silver mica cap as the drive level is low)

AMPLIFIER OUTPUT :
C-16 51 pf to 75 pf ATC100B chip cap.
C-14, C-15 180 pf to 230 pf ATC100B chip cap.

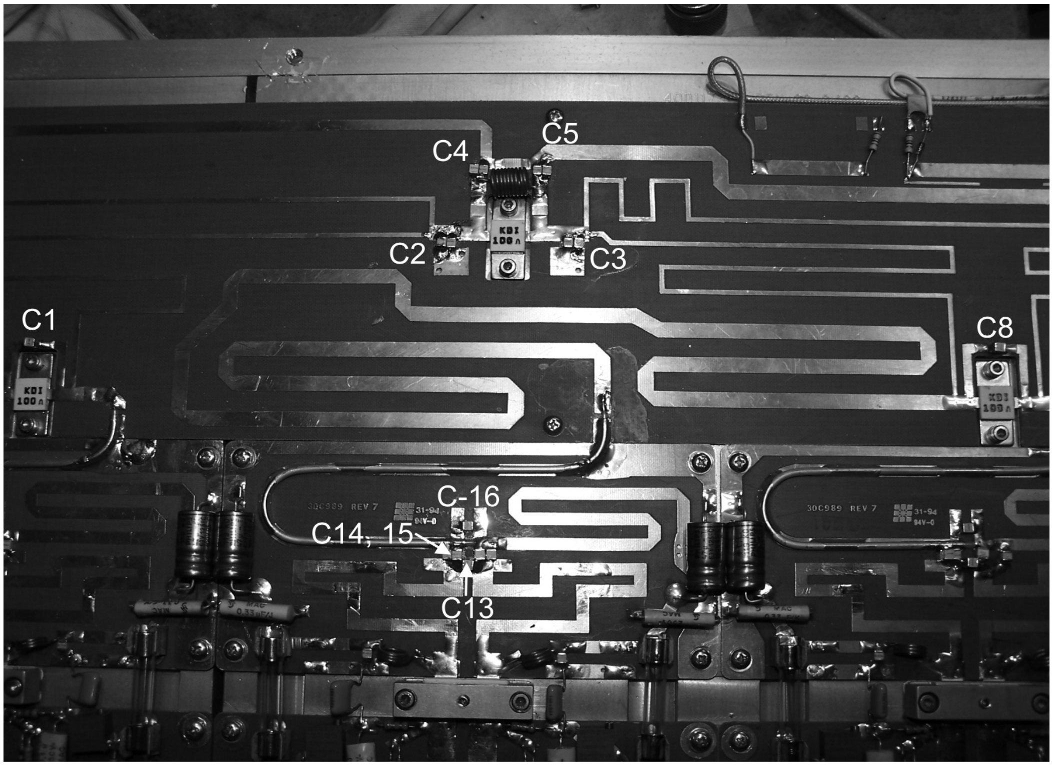
COMBINER OUTPUT:
C-4, C-5 39 pf to 86 pf ATC100B chip cap.
C-2, C-3 24 pf to 68 pf ATC100B chip cap.
C-1, C-8 15 pf to 27 pf ATC100B chip cap.

The capacitor reference numbers are the ones specified in the Larcan schematic diagrams as posted on the MMRA website. (See http://www.mmra.org/larcan/) This website has a wealth of data on the Larcan amplifiers. I have included pictures that show the capacitor locations in both combiners.

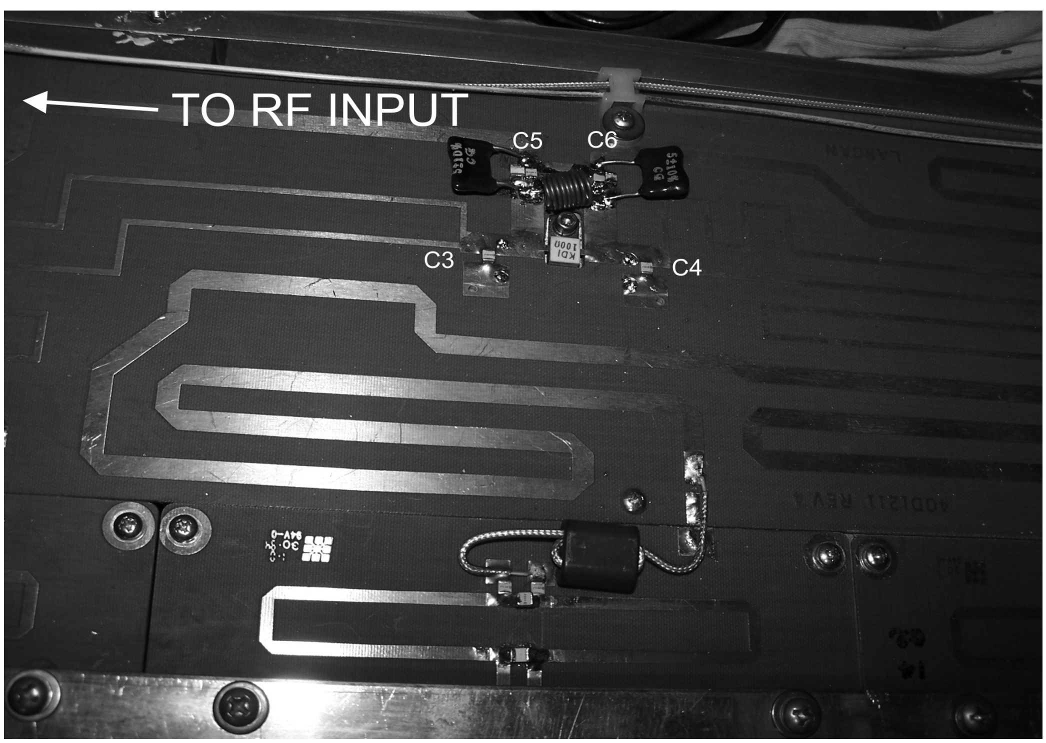
I am sure there is more that can be squeezed out of this unit. In my testing, I was disturbed to see that the isolation between stages, provided by the output combiner was not very good at 50 MHz. I originally tried running a single amplifier stage with the other three terminated in low power 50 ohm resistors, in an effort to match into the combiner. There was too much power being absorbed in the resistors. I did not measure the isolation, but I think that it is much less than the typical 20 dB obtained with Wilkinson dividers. As a result, I abandoned that plan of matching into the terminated combiner in favor of my "bucket of worms " approach! What I ended up with is still quite nice and well worth the effort. This amplifier will make a nice addition to the shack. I can drive this amplifier easily with rigs such as the FT-817 at 5 watts, or my low power (7.5 watt) Elecraft K3 on 50 MHz.

As a side note, I obtained a single MRF151G Larcan PC board (¼ of the full amplifier) from W1FKF, and built that up on a new heat sink. This single stage has no input and output combiners. After performing the amplifier mods listed above, I saw pretty constant output from 50 MHz up to about 68 MHz. The FET really took off with drive and I had no trouble getting 300 watts out of a single transistor. In fact I drove it to 400 watts CW output with much less than 5 watts of drive. DC Current at 50 volts was about 11.5 amps! This is pushing the rating for the MRF151G. You should keep the current under 12 amps per device at the 50 volt level to provide a safety margin so as not to exceed the safe area of operation. At 300 watts it runs beautifully. The efficiency is way up there too at 68% at the 400 watt level. I noticed that my Larcan amplifier came from the TV station with 7 amp fuses for each FET. The Larcan schematic calls for 5 amp fuses. It would be a good idea to err on the low side with your fuse selection. I am using 6 amp fuses now. Incidentally, all of my testing was done with the Larcan recommended 0.50 amps idling current per FET.

Running the modified Larcan amplifier with a real SSB CW ham rig was an eye opener. I had more drive than the 4 to 5 watts of my instrument amplifier. I used an old Yaesu FT-625RD and cranked the drive back to 8 or 9 watts, but I still see that I can seriously overdrive this amplifier. I easily whistled it up to violently pin the 1000 watt Bird slug! Current drain looked like it was over 50 amps or more! I retrieved my LP-100A peak power meter from my ham shack and utilized it to determine the actual gain of the Larcan amplifier at 50 and 54 MHz with my low power Elecraft K3 as an exciter. It delivers a nominal 8 watts on 50 MHz. I suspected that 7 or 8 watts was the proper drive level for this amplifier. At 50.0 MHz the K3 delivered 7.3 watts PEP to the Larcan amp which produced about 1200 watts PEP on SSB for a gain of 21.9 dB. At 54.0 MHz the gain is higher and the amplifier delivered 1380 watts with gain of 22.9 dB. Measured efficiencies at full power are in the 65% range with idling currents of 500 ma per side.



Photograph of the capacitor locations used in the modification of the output combiner and FET output stages. C13, 14, 15, and 16 are all changed in each of the four power modules. The other capacitors are all used in the power combiner as shown.



Input splitter photograph, showing the first Wilkinson divider area. C5 and C6 are changed. C3 & C4 are not altered and are shown for reference only. You can see some 5 pf silver mica caps. I took this picture while "fine tuning" the input. Silver micas are OK here as power levels are low

Looking at the MRF151G spec sheet, you can see that maximum safe area current drain at 50 volts is in the area of 9 amps per side or 18 amperes total per device. This is an absolute maximum, and you should not run the FET at anywhere near this level. Seeing that a single MRF151G Larcan amplifier assembly will pull 12 amps or more on 50 MHz when modified, I would guess that with four pallets in the line, you could very easily exceed the safe dissipation of these devices with heavy drive and current levels over 50 amps. They would not stand continuous levels at 50+ amps! Some form of overdrive protection is needed to protect the expensive FETs. I would limit the power on peaks to about 1100 to 1200 watts to be safe. After all, the MRF151G is rated for 300 watts output and there are four devices in this amplifier! I would also worry about the current carrying capability of the ATC100B capacitors in that output combiner. In my situation, I paralleled up two caps to spread the current between them. In a 50 ohm system, we would see well over 5 amps of current, so C4 and C5 in the output combiner are working very hard. Using two caps in parallel makes sense.

The protection circuit needed must be more bullet proof than the existing Larcan VSWR protection circuit. At high VSWR the FETs are not really shut down. The bias is reduced to 0 volts, but the amplifier will still generate power with a lot of drive applied. I have not delved into a suitable solution yet, but a simple remedy may be to disable the ASTEC 50 volt supply with a switching transistor circuit. That will be the subject of additional investigation here.

In summary, I believe that most of the added gain and increased efficiency is obtained by cleaning up both combining networks on the inputs and the outputs of this amplifier. Some added output amplifier board tweaks (C-14, 15, and 16) over those specified by Larcan for the LO TV channels (2,3 & 4) increased the gain a bit more. These mods altered the gain from barely 20 db to about 22 dB or more. This amplifier is now ready to be buttoned up and installed for some serious DX. I plan to use a 19” rack panel for the front, and stick it in a relay rack. While the amp extends a long way in the back, it will only take up a few inches of rack space. I have an array of 115 vac muffin fans that will cool the heatsink. The thought of my QRP Elecraft K3 driving this instant -on amplifier to 1200 or 1300watts on CW or SSB is pretty exciting.

CU on six this summer!