MHW1815 / MHW1915 Modifications for 23cm Amateur Use

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Original MHW1915 page in Italian : http://www.ik8uif.it/mhw1915.htm (http://www.ik8uif.it/mhw1915.htm)

Extracted as an English version from http://www.geocities.com/vk3rtv/ampmod.html (http://www.geocities.com/vk3rtv/ampmod.html)

When I tried to print the English web page from VK3RTV, it gave me extra pages broken up into the frames with 'sort-of strange' page ejects...

If you can't print that page successfully to get a hard copy of these details, print the original page below as it has been re-formatted - as well as a few typo's fixed - to make it more suitable for printing .....

OVERALL PROJECT COMMENTS : There is no real bandpass filtering included within the amplifier project so provides no reduction of device-in-bandwidth spurious emissions - other than by the internal frequency response of the modified power block. While a "narrow-band" antenna will provide an additional band-pass effect, it may not significantly reduce any 3rd harmonic energy or close-in spurious. Realistically the amplifier should be fed via a BPF and out via another one rated for the power level.

Data sheets : MHW1815 (/~vk4adc/web/images/UserFiles/File/23cminfo/MHW1815.pdf) MHW1915 (/~vk4adc/web/images/UserFiles/File/23cminfo/MHW1915.pdf) :

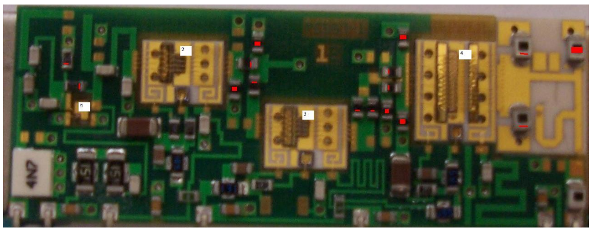
Motorola Microwave Bipolar Power Amplifier
• Specified 26 Volt Characteristics:
RF Output Power: 15 Watts
RF Power Gain: 31 dB Typ
Efficiency: 25% Min
• 50 Ohm Input/Output System

Expect *.... 20 watts with +26-28V power supply or 5 - 7 watts with +13.8V supply*

Any added comments are in blue, original in black.

IMPORTANT NOTES FOR MHW1815 USERS

On my module, which was an MHW1815 rather than a 1915, there were extra SMD caps installed as below as and marked as a bright red block. One has to wonder whether any of the other interstage capacitors have different values (as marked with a single red line (versus a red block).



My camera doesn't do good close-ups but this is the original MHW1815 - square red block = capacitors not on the 1915 layout photos.
Red line = are they the same value in both versions ???
The small white text boxes are the transistors in the device...

Mosue over the image for a larger view

On initial power up, with about +10dBm input, the amplifier was producing about 300mW / +23dBm at 1296. The quiescent current of the MHW1815 plus the 7805 regulator was 240mA with a 13.8V supply, and rose to 650mA with the RF drive. I was expecting watts rather than milliwatts so obviously the interstage tuning on the 1815 has different values to the 1915.

On searching, I realised that the interstage capacitor network between the 2nd and 3rd transistors was different too so I started to investigate them.... and, oops, the SMD cap wouldn't come off the board, the tweezers slipped and broke a few collector wires !!!! Junk now...

Stay tuned for the final modifications after I get another 1815 !

NOTE : 7 Aug 09 - A pair of 1815's arrived last week but other domestic work has kept me busy. If they don't get mod'd this week (unlikely), it won't be until the end of August now.

One thing I should mention about those persons intending to undertake this modification : you need quite a lot of heat to remove the original 4N7 input capacitor and the output network capacitor (replaced by the 2.7pF ATC). Putting in the solder bridges near the 2.7pF is tough simply because the substrate is such a terrific heatsink. *In comparison*, the installation of the bridging and extra caps is easy. I did not have an 8.2pF for the input so I paralleled a 4.7pF + 3.3pF = 8.0pF - if anything this might help move the input tuning up from 1240 to 1300 MHz.

All parts added are 0603 SMD NPO capacitors.

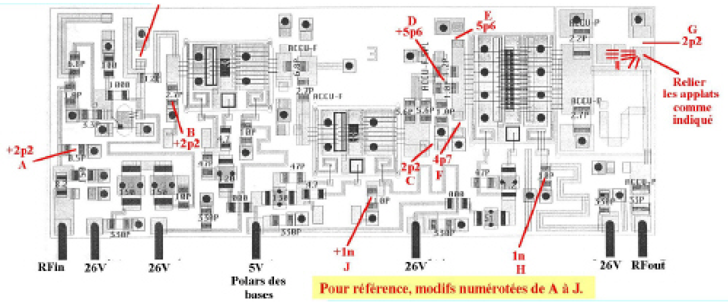
The soldered areas were washed down with Isopropyl alcohol to remove flux on completion.

Before starting to even pull the cover off it, I used a bit of wire to join all protruding external pins together to prevent any ESD during the initial modification process. I also used a multimeter to check that the hair-like transistor connections had not been caused damage (and were thus S/C) during the modification process.

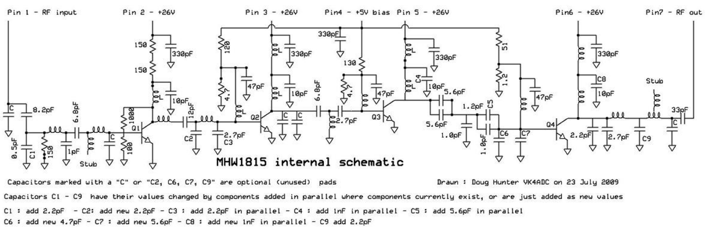
Suggestion : don't even think to undertake it if the hands shake, the vision is not good, you don't have suitable tools......

To add to the murky waters surrounding the required modifications, I subsequently found an article attributed to F1RHR called PA1G2MOD.PDF (/~vk4adc/web/../23cminfo/PA1G2mod%201815%20Page%201.pdf) which contained a front sheet plus a repeat of the MHW 1815 series data sheet. I extracted just the front modification sheet to make the file above.

That page contains this graphic overlay of the module :



[Mouse over image for a larger view]



[Mouse over image for a larger view]

I have 'decoded' the above physical layout to derive the internal schematic of the 1815 as shown here. I won't comment as to the accuracy of the values shown as against the actual values on a 1815 - I just noted what was shown above...! For instance, the input coupling capacitor is shown as 8.2pF (8P2) yet my module had a 4N7 there ! The F1RHR "PA1G2MOD info" is included as the text underneath the schematic drawing.

It is interesting to note that some of the added values are different from the previous mods ... and it still does NOT show the extra capacitors { red blocks in my photo above } on the MHW1815 version. Whether they intend that you remove the extra capacitors is uncertain to me as my french is basically non-existent. The diagram does show the component values on the modules - the SMD resistors and capacitors - so that helps understand the workings.

I have emailed Heino Schübbe, DJ6JJ, who did a presentation at a conference in Germany during 2007 on the modifications to these devices for 1296 MHz use and am awaiting a response. Maybe his information will help unravel the mysteries. NO reply at all to my email - how rude !!

Someone, somewhere, must have a complete / definitive modification detail sheet specifically for the MHW1815 !!!!

Comments found 22/7 on the web by Alan Devlin VK3XPD :

- And finally... MHW1815 Hybrid Modules by Motorola.... these are intended for 1800 Mhz @ 15 Watts but they can be modified to work on 1260/1296 Mhz. This is the Module used in the High Gain Amp above. Once modified.. it delivers 10 Watts of Drive & more on 1260/1296. It's a fiddly processs because you need to work (fit 5-6 Caps) on

the ceramic substrate but it is possible.. I've done many.. I have found a URL on the Web for this Mod... Interested ?.. Just ask..

I have emailed Alan re the info.... and had a response. I have yet to put the information supplied into the form of a "mod sheet" but as soon as the 'replacement' 1815 appears (and I have time), I will get that done. Interestingly, Alan has used the small "grey plate capacitors" in his mod - rather than SMDs....

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13th September 2009 : Finally getting back to the MHW1815 amplifier, spurred a little by a recent email from Colin G4KLB :

> Hi Doug
>
> How are you getting on with your MHW1815 mods? I have done a few of them and had the same results as you have on your website.
>
> I wanted to get 2-3W at 12v to use as a driver, but so far I don't really get any power out until around 20v. after about 28v the ones I have done destroy themselves (well they are rated at 26v) None of the ones I have done with 0603 size caps have lasted but that is probably due to the make I am using.The 0805 caps I have, seem to work but are a pain to fit. I have been using one done with the French values for over a year now (10dbm in 3W out at 26V) to drive my ATV PA, but it is producing more heat than the PA!!!! So I would like to have another go at improving this, and also mod one for portable use.(12V) Made a real neat job of one, then damaged the gold wires cleaning off the flux!
> With the right mods I expect they should work better than the MHW1915s.
>
> Kind regards
>
> Colin G4KLB

My response :

Colin

I was hoping to get back to the MHW1815's last week but have been otherwise occupied with family issues.

I have 2 "new" one's sitting on the workbench awaiting attention but I hope to see more than your 3W out at 1296 for +10dBm in, even with the +12V supply.

If you have a look at the schematic I traced out, you will see that there is a very simply resistive bias arrangement in place for the first stage - one not off the regulated +5V pin and with the range of supply voltages being applied, it could be that any/all of the stages have moved into an excessive collector current mode with the +28v applied. It may be worthwhile measuring the quiescent current drawn by each stage with +24 to +26v applied (no drive) and then adding another lower bias resistor in parallel to all stages to achieve the same current at +28 to +30v. If it still blows up then when RF is applied then it is probably ineffective heatsinking and/or thermal runaway. Your comment "more heat than the PA " may simply mean that the stages may not be tuned to 1300 MHz properly (and thus drawing higher-than-normal current) - or - as the data sheet says : a total quiescent current of 300mA for all pins (no drive) { thus about 8 watts of heat } and that the efficiency is 25% (at +26v ??) so for the 15w out, that means 45w is dissipated as heat. Around typical Class AB efficiency, from memory.

To run at +12V in linear mode, the upper bias resistor may need to be paralleled for each stage so that it does in fact work "linearly". I will have to get around to doing a current measurement run on all individual collector supply leads with around +26V applied (but without RF drive) and try to emulate those currents with the resistors for a +12 to +13v supply. The initial 'work' is being done here without biasing changes but that will probably change once I get the interstage tuning capacitor values correct.

I find it hard to comprehend that there isn't a real set of definitive mods for these MHW1815's somewhere on the web already. Maybe my changes will become that set.

73
Doug Hunter

Doug

Thanks for your reply, I agree with all the points you have made.

Your schematic will be most useful as I have not had much experience at these frequencies, but that is why I am having a go!

I transmit on 1248 1255 and 1280MHz and have to adjust the voltage each time I change frequency, I suspect this is due to the output from my comtech TX varying, but I don't have a power meter that can read that low. The TX should give 17dbm and after a early failure it was assumed I was overdriving the front end of the 1815, so now I always use a 7db attenuator on the input, but this may not be the case.

As you say, someone must have already done this, but I have not found them!!
I have just had some more modules from Alan VK3XPD so was looking on the net to see if there was any more info,as I last looked a year ago, then a came across your website. Probably won't have chance to play this week, so I understand your position.

If I do find any more info, I will let you know.

Kind regards

Colin G4KLB

Hope you didn't mind being quoted Colin but it goes to show that I am not the only one with issues with getting these going properly. By the number of visitors to this web page, many others are interested in the outcome too.

I started off with the two "new" used modules and did what I suggested to Colin : measure the currents on each pin at around 24 to 25V supply then again around 12 - 13V. I marked each module with a couple of permanent marker spots on the metal flag so that as I progressed, I could be sure of which module I was using.

The test setup was simple : unmodified / unopened module screwed down to a heatsink, a 5V regulator to pin 4 with bypass capacitors on input & output pins, power supply (either +24 or +12v) via a current meter to a the pin via the meter's test (wander) lead. No RF drive. Apart from the bias pin (4) and the pin under test, no other pin had voltage applied at any one time.

Module # / Supply volts	Pin 2 mA	Pin 3 mA	Pin 5 mA	Pin 6 mA	Comment
1 / 24.7V	52	25	40	112	
1 / 12.3V	12.5	16	34	88	
2 / 24.7V	52	0	2.8	1.0	Bad !
2 / 12.3V	12.6	11	3.5	1.0	Bad !

Well that was interesting !!!! It looks to me like module #2 is actually faulty - before I even open up the case and do any mods. The currents for module #1 are much as I would expect so that will be the first one to be mod'd. If I can see a simplistic reason for the issues in #2 after I pop off the cover I will try that one - otherwise it will either go back or be binned. In one way, having checked the quiescent currents, it means that I am not going to waste too much time trying to get a probably-faulty module running !

As you have probably noted, the collector currents at 12.3V are down to 64, 85 and 78% on stages 2,3 & 4 respectively but the main concern would be the first stage - it is down to around 25%. I see this as fixed by one of 2 possible mod's for 12v operation : either (1) drop out one of the 150 ohm collector resistors by strapping across it; and/or (2) place a parallel resistor across the 1K collector to base bias resistor - select on test (SOT). Stage 2 bias is set by the 120 ohm, stage 3 by the 130 ohm and stage 4 by the 51 ohm top bias resistors so if circumstances permit, it might be possible to spend some time getting the 12V currents close-ish to the 24V-supply collector values. Probably not super-critical for module #1 at 12V except for maybe the 1st stage.

You need to remember that a device like this does use LC tuning networks for impedance matching inside from collector to next stage base so if you hope to get the maximum gain from the module, you need to approximate the original impedances. Halving the supply voltage means that you need to double the current to get the same impedances so that the matching networks can achieve maximum power transfer.

It is now time to put all of the ferrite beads and bypass caps back in place and start to feed some RF into it - but not today, maybe tomorrow, now that I have started on the project again.

Update 19 Sep 09 : During the week I found a window to have a closer look at module #2 and started by re-checking the currents to each stage pin and, yes, they were the same as tabled above. I then started out by measuring the +5V bias voltage - no, it wasn't 5.0V, it was down at +1.8V. I put the current meter in line to the 7805, 68mA and still 1.8V. I disconnected the lead and the current dropped to about 3mA (the internal regulator power usage) and the voltage rose to +5.02V. Was the regulator in protective fold-back mode ???

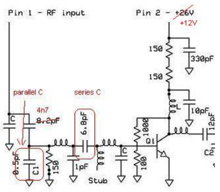
I quickly exchanged #1 for #2 and measured the 5V bias voltage : +5.02V, supply current to the 7805 about 105mA. I checked the schematic and did a quick sum on the calculator as to the total resistance of the parallel bias networks for stages 2,3 &4. At a composite value of 35 ohms, the current could be as high as 140mA so 105mA was possibly correct. Ok, swap #2 back in place of #1, measure - still +1.8V & 68mA. Weird !

My 7805 has stabilising caps on the input & output leads back to the centre common but what if the values aren't high enough ? I delved in the parts on the table and came up with a 33uF 35V electrolytic and put it across the input cap - no change. Discharged it and put it across the output lead - voila, +5.02V and around 110mA. It just goes to show that while it was all ok with #1, #2 module must have placed a complex load on the regulator such that it was unstable. I thought the regulator should have been inherently stable with the capacitors initially installed across it but it goes to show that you just can't tell. If driving the module with RF of varying level (eg SSB), it could have generated a partially stable / partially unstable mode of operation - and that means it would have generated up to watts of spurious !!

The currents to each terminal were again measured with the 12V supply :

2 / 12.3V	12.7	15.5	35.8	102.2	Much better...

Ok, it was time to do some RF work - or at least start it. I powered up the EME72B transverter in transmit mode with 0dBm in at the 145.1 MHz IF, output to the MHW1815, the module itself powered off a 12V supply. Without any modification, the first stage current was 12.7mA no drive, about 18mA with the 1300MHz drive.



I tried a number of small capacitor values around the input stage, mainly across the 0.5pF and across the series 6.8pF, watching only the collector current (Pin 2). The capacitance across the 0.5pF seemed somewhat critical and even fingers holding parts was causing side effects. I soldered a small ceramic 2-7pF trimmer across the spare pads at the input (parallel C) and adjusting its value peaked the collector current at about 35mA. I then tried several small caps in place of the trimmer but failed to find the same peak in current. I then left the input pads unused and started with a series of caps across the 6.8pF. The final peak was with a 5.6pF across it with a collector current around 30mA. Obviously it was a case of both parallel and series capacitance required to move the input matching down to 1300MHz. I re-soldered the trimmer across the input pad, adjusted it's value and saw the current rise to over 45mA. Unfortunately that was the end of my available time so nothing further was accomplished - BUT - it left my mind wondering why the other mod sheets paid so little attention to re-tuning the input stage properly, particularly the series C. It might explain the low power insensitivity !

Update 21 Oct 09 : Well it's been a while getting back to this project but finally, it is under way again. I ignored the other modification sheets and just continued my own modifications by adding small capacitor values across the lumped constants to see what effect they would have on the drive to the next stage. The capacitors used were the small flat plate ceramic style in 2.7pF (2p7), 3.3pF (3p3), 5.6pF (5p6) as I had a few of each value in this format and it was considered much quicker/easier to handle and add these than the SMT style.

The "long and the short of it" was that by adding caps at various points, I was able to get up to about 3.5 watts of RF out at 1296 with a 13.6V power supply - but note that my capacitor values and placings do not match up with either the F1RHR or the VK3XPD mods. Another thing that was done once I started to get a bit of output power to to see the effect of shorting out one of the 150 ohm collector resistances (as mentioned above) since I was only interested in operation at a nominal 13V supply. The output power almost doubled with this mod so a permanent strap was soldered across the one closest to the Pin 2 power pin. Realistically, once I got to the 3.5 watt mark, nothing I did with the inter-stage coupling seemed to increase the output power significantly so I decided to try optimise the output network section. Wrong move !!! In doing so, I managed to break the two very fine wires between the end of the series L and the output DC block and was greeted by a small sizzle near the 4th section as the output transistor went short-circuit and fused the fine wire power bridge to the collector series L / RFC. Of course the device had to be powered up and under RF drive for me to see any tuning / de-tuning effects so in some ways was unavoidable as I didn't remember that the links were there - or - that they were so fine. That 'sizzle' sounded the death knell for one of the two RF power modules so I powered it all off, marked the final C values on my schematic then walked away in disgust.

Essentially I will do these same mods to the other 1815 module (hopefully) later today or tomorrow - but will avoid touching the fine wire links !!! If it all works much the same then I will present those mods on this web page for others to try.

Update 31 Oct 2009 : I have had a few attempts this last week at getting the first module (#1) to produce power at 1296 and even though the quiescent currents more-or-less match up with #2, the output power is minimal (< 0.3W). The drive level to the MHW1815 is about +10dBm so even allowing for the reduced gain at a 13V supply, I would have expected something greater than the 23dB gain that I managed to achieve with module #2 - and that was using sub-miniature trimmers to fine-tune the thing for maximum gain. Those trimmers cannot exist in other than a test-lab environment as they would always be a temptation for fiddly-fingers. The final form for #2 MODS was the small thin square-ish grey-plate ceramic capacitors as listed in the positions below.

Across C1 / 0.5pF pads : sub-miniature 2-7pF ceramic trimmer - tune initially for rise in Pin 2 current with RF drive, finally for max output. Final value not determined so not replaced by a plate disc.
Across 6.8pF in series to stage 1 base (Q1) : 5p6
Across C3 /2.7pF -: 2p7
At Q2 collector : the capacitors marked C are now 3p3 and 2p7 - i.e. are added.
Interstage Q2 to base Q3 : 2p7 added in parallel with the existing series 2p7
Interstage Q3 to base Q4 : 2p7 added in parallel with the existing series 1p0/1p2 combination
Output of Q4 : the extra pads are solder bridged on the output coupling substrate (as per other mods) but no extra caps are fitted.

For 12V operation, solder a link across the 150 ohm SMD resistor { marked 151 } near pin 2.

Maybe I will come back to these devices in the future- maybe not !!!

SUMMARY :The MHW1815 mods have to be straight-forward and repeatable and I don't think that this is readily achievable. Carefully doing the addition of extra capacitors to a miniature PCB with SMD parts requires fine eye and hand skills and appropriate hand tools and soldering iron is possibly beyond most amateurs these days.

When you consider that many (/ most ?) would also typically lack 1300 MHz test gear, that makes the modification process almost impossible.

My plan was to have this part of the project incorporated into the box with the 1296 transverter before the VK 2009 Spring Field Day (28/29 Nov 2009) and with less than 30 days to go, it won't happen if I continue with the MHW1815's - not if I hope to get a worthwhile power level (> 5 watts) at 1296 with a 13V DC supply.

I am giving in and taking the easy way out : the Mitsubishi RA18H1213G RF power block (260KB PDF (/~vk4adc/web/images/UserFiles/File/23cminfo/RA18H1213G.pdf) **) does NOT require any internal modifications and is rated as 23dB gain at 12.5V DC, about the same as the above #2. To achieve the device's absolute maximum rated power of 30 watts, it requires about +23dBm input - but to operate linearly, the drive level would have to be in the order of 2-5dB below that (i.e. about +20dBm). Obviously there is a 10dB discrepancy of drive level between the EME72B transverter output level and what the RA18H1213G requires and this will be achieved with an ATF50189 HEMT (15.5dB gain, max output level +29dBm { @ 1dB compression }) (360KB PDF** (/~vk4adc/web/images/UserFiles/File/23cminfo/ATF50189.pdf) **) gain stage preceded by a 5 dB RF attenuator.**

My expectation is to have > 15W of RF out at 1296 when running on a nominal 13.8V DC supply. What power I actually end up with will be quite interesting.....

My only problem has been getting my hands on one of the RA18H1213G modules in a timely manner. I hope that is solved within a few days so I can still make my deadline !!!

THE END

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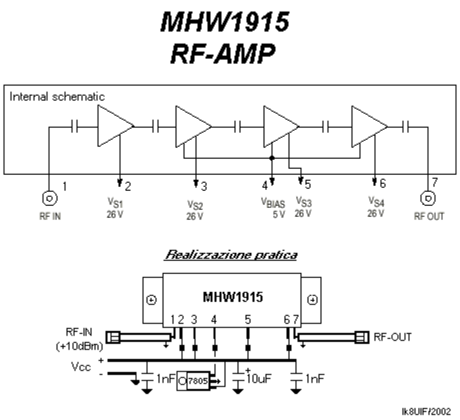
THE ORIGINAL ARTICLE USED AS A REFERENCE :

1.2GHz (23cm) 20Watt RF AMPLIFIER

With modified Motorola MHW1915 / MHW1918 Hybrid Module

Original Modification by IK8UIF with English translation by VK3JDG

BLOCK DIAGRAM OF MODULE AND PRACTICAL APPLICATION CIRCUIT

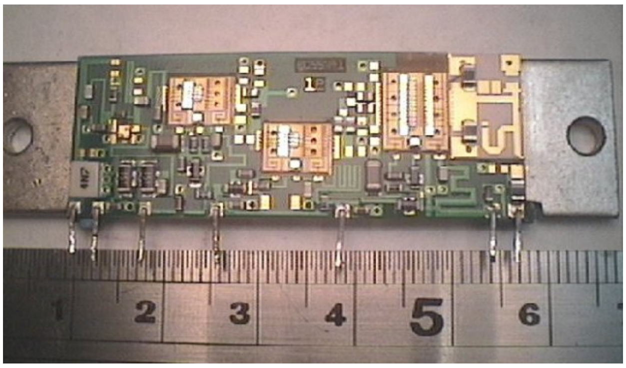


Mouse over to view

THE MODIFICATION

The first part of the operation is to take the module apart. You should have already removed the module from its original circuit. The module's blue cover is glued on each corner. The cover is removed using brute force. A screwdriver under one of the corners of the plastic corners and some leverage is all that is required to pop the case off the module. BEWARE there are TINY components inside the module that are easily destroyed so be careful. The transistors on the interior of the module are unprotected from physical damaged once you have removed the cover and are easily damaged so beware.

MODULE INTERIOR WITH COVER REMOVED



Step 1

Remove the input capacitor marked 4N7

Step 2

Place chip capacitors on empty pads as shown in Yellow boxes in photo's below.

Step 3

Place chip capacitors shown in Red boxes in photo's below in parallel with existing components.

Step 4

The capacitor marked 2p7 in the yellow box placed on the right side of the module should be an ATC type due to the high temperatures that may develop inside the module.

Step 5

The Green lines in the photo's below show points on the output strip line that must be connected.

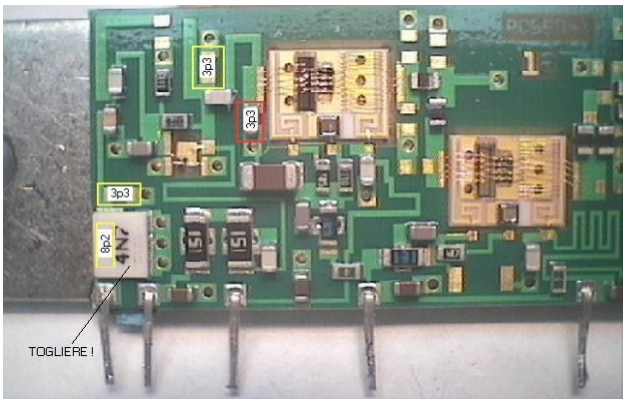
Step 6

Replace the blue cover and secure with a small amount of glue on the edge.

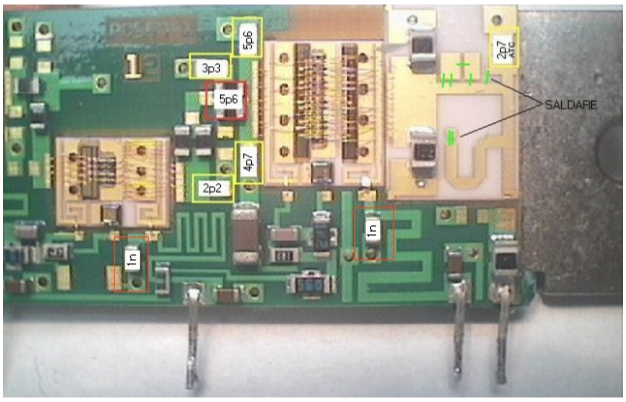
Step 7

Once the modifications are complete the module is ready for use. A practical implementation is shown at the top of this page.

MODULE INTERIOR LEFT SIDE



MODULE INTERIOR LEFT SIDE



PRACTICAL IMPLEMENTATION OF FINISHED PRODUCT

For the practical implementation the module should be bolted into a metal box with heat transfer compound to maximise heat transfer. The box will need a heat sink on the exterior. In this implementation by the author the input and output are fed by UT141 semi rigid coax with SMA connectors. The interior has a 5V regulator (7805 or similar) to supply the bias voltage to pin 4 of the module. Pins 2,3,4,5,6 should have a ferrite bead on each leg next to the module. The power supply should enter the box via a feed through capacitor with liberal use of 1nf ceramic or chip capacitors on the supply line near the module.

TESTING

Use a 13.8V supply initially for testing. Use an input signal of approximately 10dbm (10mW) and a maximum of 17dbm (50mW) at 1240MHz. The output should be 5W - 7W if all is well. A supply of up to 24V can be used with an increase in output power to approximately 15W - 20W.

Shown below are test results from the author (Module fed with supply of 13.8V)

The amplifier can be used on the entire 23cm band as demonstrated above.