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Predelava 2m FM TRX Motorola RADIUS M110

Turn a professional 2m VHF FM PMR transceiver Motorola Radius M110 into an amateur radio

OPOZORILO - Modifikacije, opisane v tem prispevku, naj izvaja le za to usposobljen in tehnično ustrezno opremljen strokovnjak. Avtor prispevka ne prevzema nikakršne odgovornosti za morebitne okvare ter kakršnokoli drugo škodo, ki bi nastala kot posledica implementacije opisane predelave.

WARNING - All modifications described in this article are performed to your own risk. Author can not overtake any responsibility of any sort of the possible damages that would result from unskilfully performed modifications, described here.

V zadnjem času so nekateri profesionalni uporabniki VHF mobilnih komunikacij dali v odpis pomembno število FM radijskih postaj Motorola Radius M110 (v nadaljevanju besedila M110). S kolegom Benom S56KZN sva sklenila poiskati način, kako to simpatično, 9 kanalno profesionalno radijsko postajo predelati v napravo, ki bo pokrila celotno 2m frekvenčno področje in bo prilagojena amaterskemu načinu dela.

M110 je mobilna FM radijska postaja proizvedena v Evropi (Motorola GmbH) in tako na stari celini dokaj razširjena. Dobavljiva je bila v več različicah. V tem prispevku bo govora o 10W različici predvideni za delo na VHF območju 136 do 174 MHz.

The PMR VHF transceiver Motorola Radius M110 (in further text referred as M110) was manufactured by Motorola GmbH therefore being an European radio. Since many professional PMR radio service users has replaced this transceiver with newer gear, a considerable number of M110 has appeared on HAM flea markets. M110 is a simple yet fine transceiver with pretty good receiving performance and it would be a waste to throw it away or to use it just as a source of electronic components instead of giving it a new life in the HAM shack.

V svoji izvorni (profesionalni) izvedbi je M110 predvidena za delo na do 9 simpleksnih ali dupleksnih kanalih. Nihajni krogi VCOjev in LC sit se ne nastavljajo programsko, tako da je pri preprogramiranju frekvence, ki pripada posameznemu kanalu, skoraj vedno potrebna tudi hardverska nastavitev oz. uglasitev le-teh. Razlika med najvišjo in najnižjo frekvenco, na kateri RTX lahko deluje, je tako vsega nekaj MHz, kar pa za pokrivanje amaterskega 2m frekvenčnega obsega ne predstavlja ovire.

Po predelavi v amaterski radio podpira M110 naslednjo funkcionalnost:

- pokrivanje frekvenčnega območja 144,000.0 MHz do 145,987.5 MHz
- korak nastavitve frekvence 12,5 kHz, 25 kHz ali 100 kHz
- dupleksni (-600 kHz) in inverzni dupleksni (+600 kHz) repetitorski način dela
- generator tona 1750 Hz
- avtomatski vklop / izklop repetitorskega odmika pri spremembi frekvence, kasneje možen ročni preklop
- prikaz delovne frekvence s sedmimi ciframi (v obliki npr. 145.787.5)
- pomnenje zadnje nastavljene delovne frekvence in koraka po izklopu napajalne napetosti
- nadomestitev originalnih sluh-uničujočih "klikov" pri pritisku na tipke z ušesom prijaznejšimi
- meritev in prikaz napetosti napajanja z ločljivostjo 0,1V

Radiofrekvenčne značilnosti predelane M110 glede na izvorno izvedbo so po predelavi nespremenjene, poraba TRX se poveča za približno 20mA.

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The modification described in this article is not just a reprogramming of the existing 9 channels of the M110 to HAM frequencies. It is a hardware upgrade that will turn the PMR transceiver into a full-featured HAM transceiver. After the modification has been performed the transceiver supports following functionality:

- Coverage of the complete European 2m HAM band 144.000,0 kHz ... 145.987,5 kHz
- Available tuning steps: 12,5kHz, 25kHz and 100 kHz
- Repeater (-600) kHz and inverse repeater (+600 kHz) operation
- 1750 Hz repeater tone
- Automatic setting of the repeater offset when the frequency is changed, later it can be manually switched to the inverse repeater, repeater or simplex mode
- Display of the operating frequency in a 7 digit mode, for example 145.787.5
- Memorising of the latest set frequency and tuning step during power down
- Replacement of the "ears-breaking" key-clicks with a more gentle click tones and elimination of the "strokes" when squelch opens /closes
- Measurement and display of the supply voltage with the resolution of 0,1V
- RF characteristics of the transceiver are kept unchanged

Zasnova predelave

Vodilo pri načrtovanju predelave je bilo uporabiti čim več že obstoječih podsklopov M110. S stališča predelave v amaterski radio so najpomembnejši naslednji podsklopi:

- centralna krmilna enota, ki nadzira delovanje celotne naprave in je zgrajena okoli 8 bitnega mikrokontrolerja HD63A01
- PLL krmilje, s centralno enoto je povezano s sinhronim vodilom SPI
- snemljiva prikazna enota s tipkovnico

Snemljiva prikazna enota ima lasten mikrokontroler. Njegova naloga je krmiljenje 7 segmentnih LCD prikazov, signalnih lučk (LED) ter branje tipk. Z mikrokontrolerjem centralne krmilne enote komunicira po asihronem serijskem vodilu UART s 7 bitno besedo, enim paritetnim bitom, po enim stop in start bitom ter hitrostjo 1200 bit/s.

Najelegantnejši način pristopa k predelavi bi gotovo bila modifikacija obstoječe programske kode mikrokontrolerja 6301 ali izdelava nove programske kode v celoti. V tem primeru poseg v samo električno vezje ne bi bil potreben, pogoj pa bi seveda bil razpoložljivost izvorne programske kode ter razpoložljivost popolnega načrta električnega vezja, kajti mikrokontroler centralne enote krmilni poleg v prejšnjem odstavku naštetih še celo množico drugih analognih in digitalnih podsklopov M110. Nič od navedenega z Benom žal nisva imela na razpolago. Poleg tega je 6301 relativno star mikrokontroler s programom zapečenim v internem (P)ROM in bi bilo za razvoj programa bržkone potrebno imeti razmeroma drag emulator. Kolikor mi je znano, ti mikrokontrolerji ne obstajajo v bolj sodobnih različicah z EEPROM ali FLASH programskim spominom, tako da razvoj programske kode s cenenimi sredstvi ni možen.

Po krajšem premisleku je tako padla odločitev za manj elegantno a zato z razumnimi sredstvi izvedljivo predelavo. Ta je obsegala analizo komunikacije med mikrokontrolerjema centralne krmilne enote in prikazne enote, prekinitev komunikacije ter vstavitev dodatnega modula, ki opravlja sledeče naloge:

- sprejema iz mikrokontrolerja centralne krmilne enote ukaze za krmiljenje prikaza ter ga hkrati preslepi, da ta še vedno "misli", da komunicira z mikrokontrolerjem prikazne enote
- sprejema ukaze uporabnika (tipke, PTT)
- izpisuje na obstoječi 7 segmentni LCD prikaz delovno frekvenco in prižiga signalne lučke
- krmili PLL VCOja
- opravlja še nekatere druge za razumevanje

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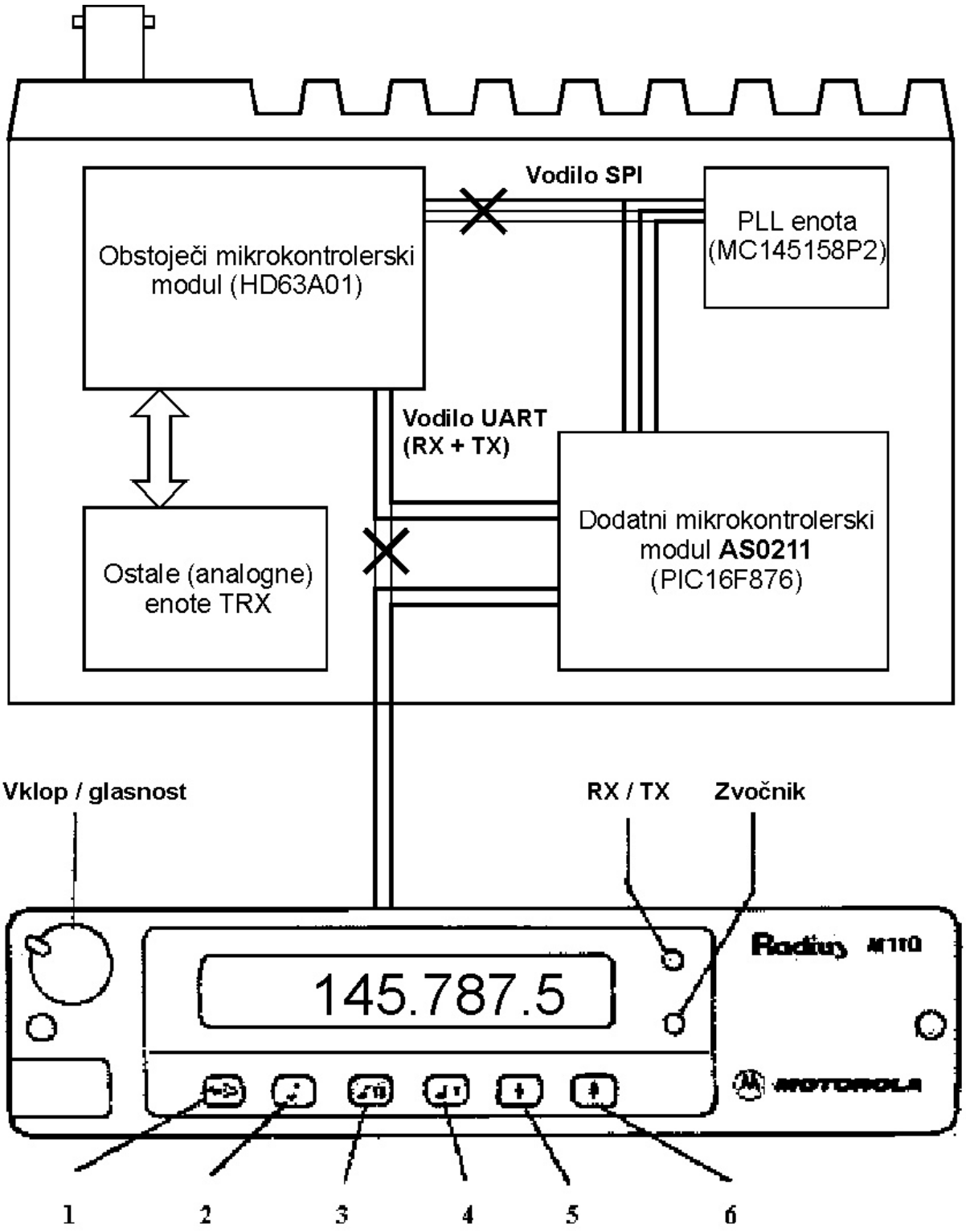


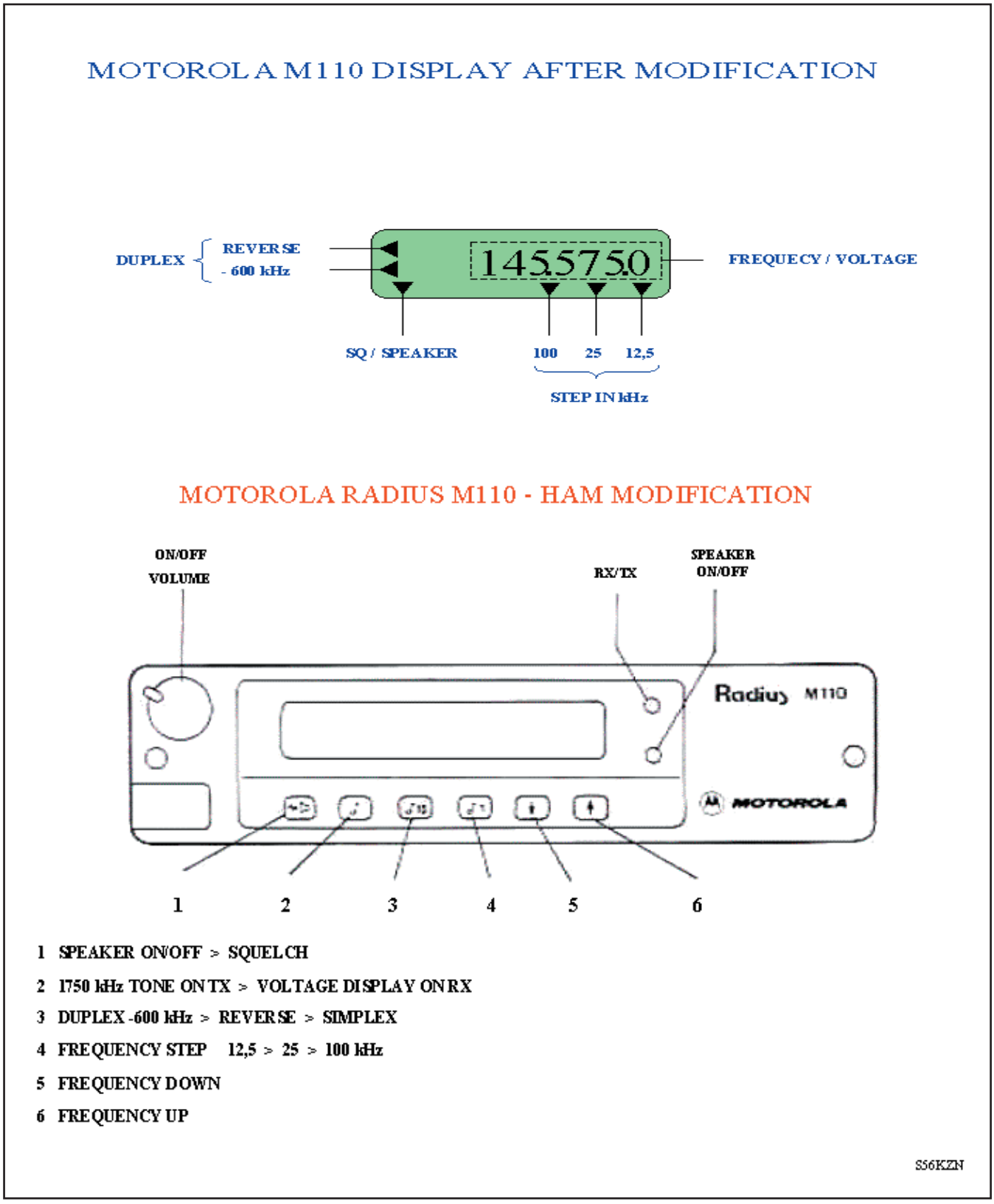
Nova funkcionalnost tipk

1 ..... Squelch, vklop zvočnika / izklop zvočnika
2 ..... Prikaz napajalne napetosti (RX), oddaja 1750Hz tona (TX)
3 ..... Preklop simplex / dupleks (-600kHz) / inverzno (+600kHz)
4 ..... Izbira koraka nastavljanja frekvence (12,5kHZ / 25kHz / 100kHz)
5,6 ...Nastavitev frekvence (dol / gor)

Slika 1a – Zasnova predelave

delovanja manj pomembne funkcije

Koncept predelave je ilustriran na sliki 1, s križcem (X) sta označeni za potrebe predelave prekinjeni izvorni serijski podatkovni vodili.



Slika 1b – Zasnova predelave, nova funkcionalnost tipk in prikaza

The idea of the modification was to use as much of the existing hardware as possible. Three modification concepts were examined. Probably the most elegant way to "improve" the radio would be to obtain and modify the source code of the main board microcontroller MC63A01 firmware which takes care over the functionality of the M110. Another although more time consuming method would be to write a completely new firmware. Unfortunately both concepts would require an access to at least an emulator of the 6301 single chip microcontroller plus availability of the firmware in first case and complete detailed schematics of the circuits in the second case. Neither of this was available to me. The 6301 is a pretty old microcontroller which (as far as I know) doesn't exist in a FLASH program memory version that would allow a development of the firmware with reasonably simple and cheap tools.

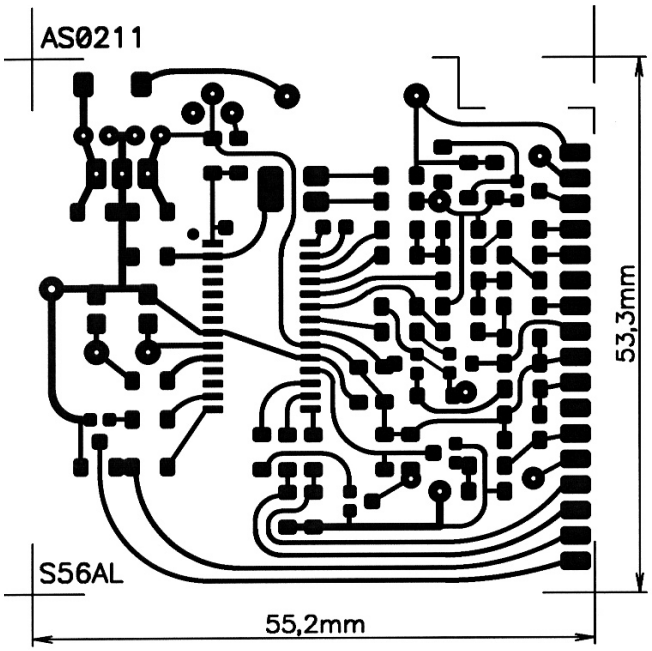
The only way found to be realisable was to analyse the communication between the M110 main and display unit micro controller, break this communication and insert an additional hardware module that would use existing display /keyboard unit as a man-machine interface, outwit the main processor and control the PLL chip.

The chosen modification concept as well as the new functionality of the keyboard and display unit is illustrated on the picture 1.

The new hardware unit, inserted in the communication path between main and display unit, should therefore provide two UART interfaces, one serial synchronous peripheral interface (SPI) to control the PLL chip and some additional stuff to produce man-machine interface tones (key-clicks) and 1750 repeater tone. The new developed unit is based on a single chip PIC16F876 microcontroller. This controller has only one hardware UART interface so the 2nd one is implemented in software. PIC16F876 supports also only one interrupt priority level. That is why a pretty high system clock oscillator frequency of 19,66 MHz was chosen to keep the generated 1750Hz repeater tone fairly clean. Otherwise the module could operate at much lower oscillator frequency (like 4,9152MHz).

The module is built on a double sided PCB (figure 3, 4), one side of the board serves as a ground. Most of the implemented components are SMD. This allows the installation of the module in the bottom compartment inside of the M110 housing.

Tiskanina je dobavljiva pri *avtorju - S56AL*

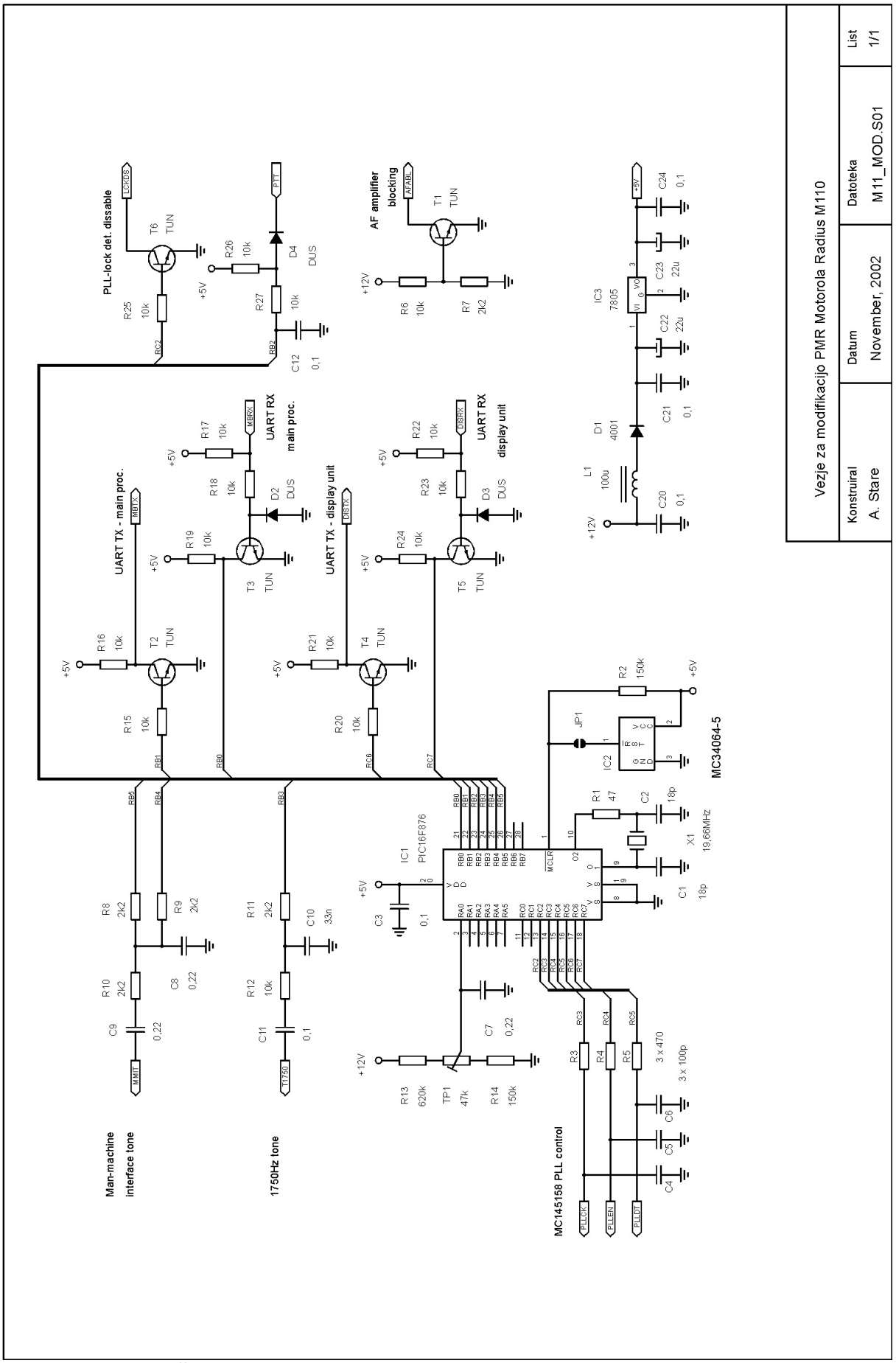


Slika 3 - Izgled tiskanega vezja

Gradnja modula

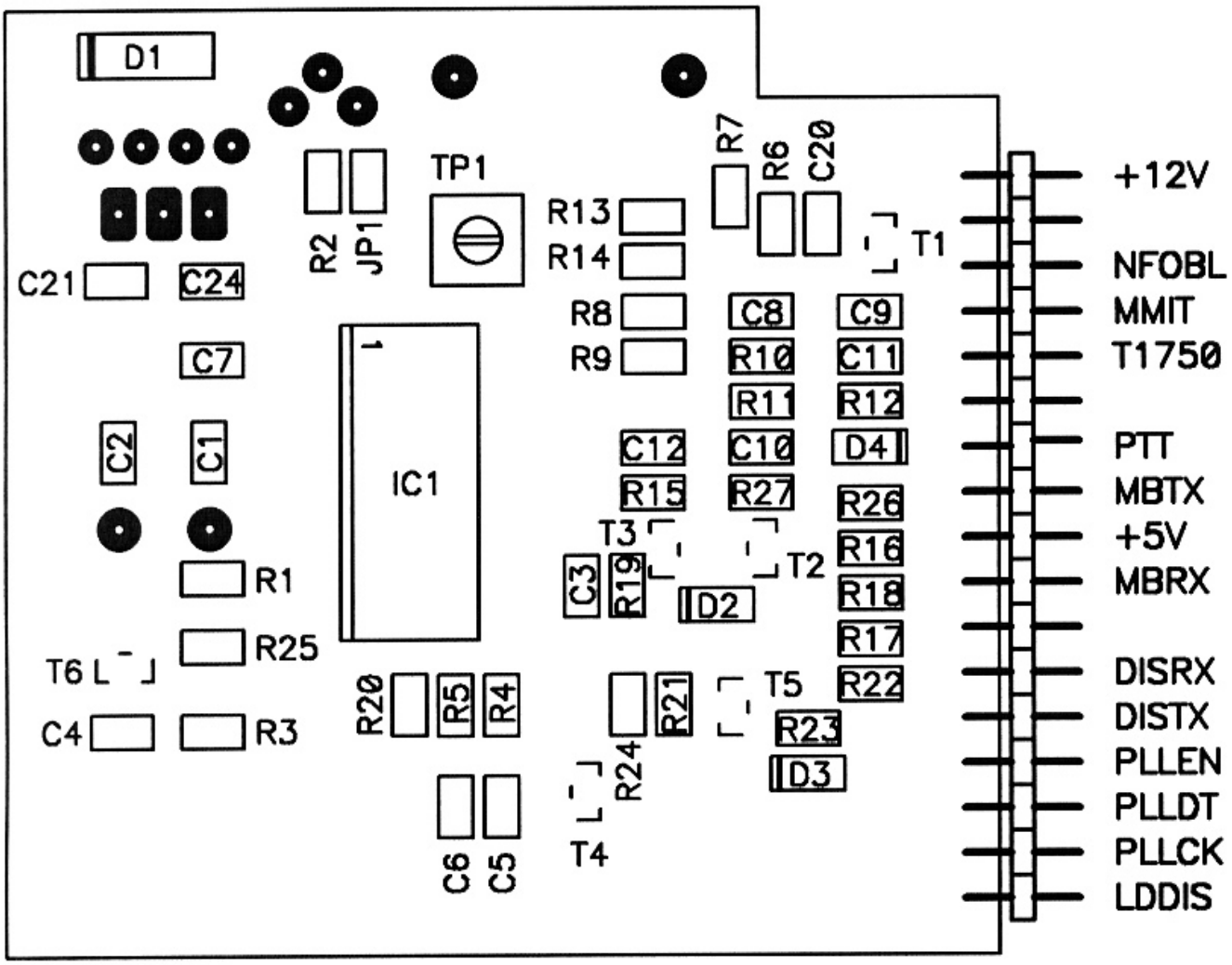
Električno vezje dodatnega modula, potrebnega za predelavo, je zasnovano na mikrokontrolerju PIC16F876. Vezalni načrt je prikazan na sliki 2. Vezje je zgrajeno na dvostranskem tiskanem vezju (slika 3), kjer je ena stran tiskanine v celoti masa, na drugi strani pa so povezave in spajkalne blazinice za SMD elemente. Elementov s klasičnimi ožičenimi priključki je malo, vsi pa se nahajajo na tiskanini na strani mase.

Montažni načrt je razviden s slike 4. Tiskano vezje je izdelano v domači delavnici, zato ni metalizirano. Tiste luknjice, skozi katere



Slika 2 - Vezalni načrt modula

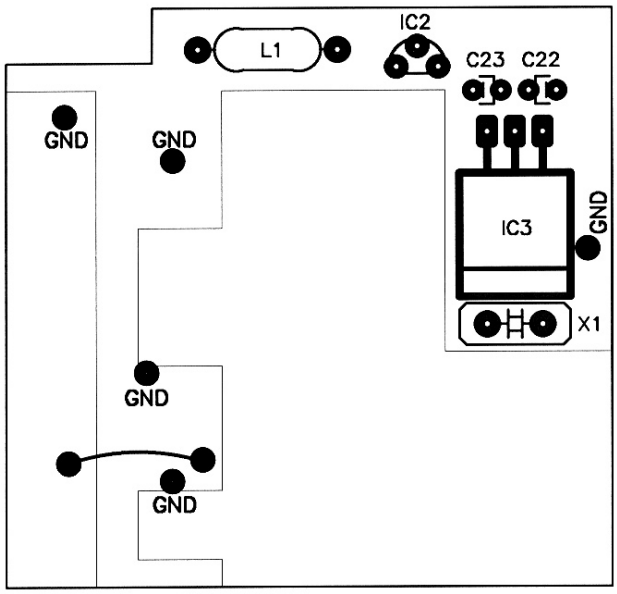
gredo nogice elementov, ki niso povezane z maso, je potrebno na strani mase rahlo povrtati s svedrom premera 5mm do 8mm (odstraniti bakreno površino), da nogice ne pridejo v stik s površino mase. Nogice elementov, ki so priključene na maso, se spajkajo z obeh strani vezja. Prostora za višje elemente je v ohišju M110 malo, zato je pred montažo napetostnega regulatorja 7805 le temu potrebno z žagico za nekaj mm skrajšati pritrdilni del ohišja TO220 (tam kjer ima luknjo). Regulator se montira v ležečem položaju, na tiskanino ga najlažje učvrstimo tako, da gornji rob ohišja na mestu, kjer smo ga odrezali, prispajkamo na površino mase tiskanine. Kvarc kristal je prispajkan leže nad napetostnim regulatorjem 7805. Ohišje kvarca je smiselno električno povezati z maso tiskanine.



Slika 4a - Montažni načrt, SMD komopnente

Za povezavo z obstoječim vezjem M110 je uporabljena priključna letvica. Na tiskanino zgrajenega modula prispajkamo njen moški del, ženski del pa s priključnimi žicami ustrezno povežemo z električnim vezjem M110. Modul tako lahko po potrebi hitro zamenjamo ali odstranimo. Fotografija izdelanega modula je prikazana na sliki 5.

Pred vgradnjo modula v radijsko postajo je potrebno le-to ustrezno pripraviti. Najbolje, da nepredelanemu TRX vprogramiramo v razpoložljivih 9 kanalov 9 radioamaterskih frekvenc, čim bolj enakomerno razporejenih



Slika 4b - Montažni načrt, ožičene komponente

med 144 MHz in 146 MHz. Zatem poglasimo vsa LC sita sprejemnika, nihajne kroge oddajnika ter nastavimo območje pokrivanja TX in RX VCO. Pri tem si pomagamo s servisnim priročnikom, ali pa prepustimo ta del predelave kateremu od za to usposobljenih serviserjev. Koncentrirana navodila za uglasitev se nahajajo tudi v prilogi 1 tega prispevka. Ko TRX v svoji originalni izvedbi lepo deluje na vseh devetih kanalih znotraj amaterskega 2m obsega, ga preprogramiramo na nastavitve, s katerimi bo postaja delovala po predelavi (priloga 2). Izpis nastavitev je v izpis iz programa za PC, ki služi programiranju TRX.

Preparation for the hardvare upgrade

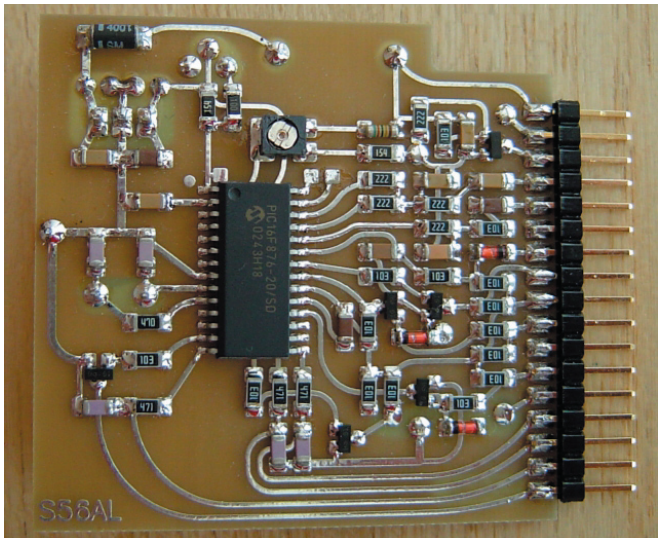
Before the modification is performed it is strongly recommended to program the 9 existing channels of the original M110 to amateur frequencies, equally spread over the complete 2m HAM band and carefully tune the RX VCO, TX VCO as well as RX and TX resonant circuits as described in the service manual. At the end of this article there are also concentrated alignment instructions prepared by Beno S56KZN (attachment 1). After this is being done and transceiver is being radically tested (specially with the frequencies at the both band edges), reprogram the transceiver with the parameters needed to run the modified radio (see attachment 2).

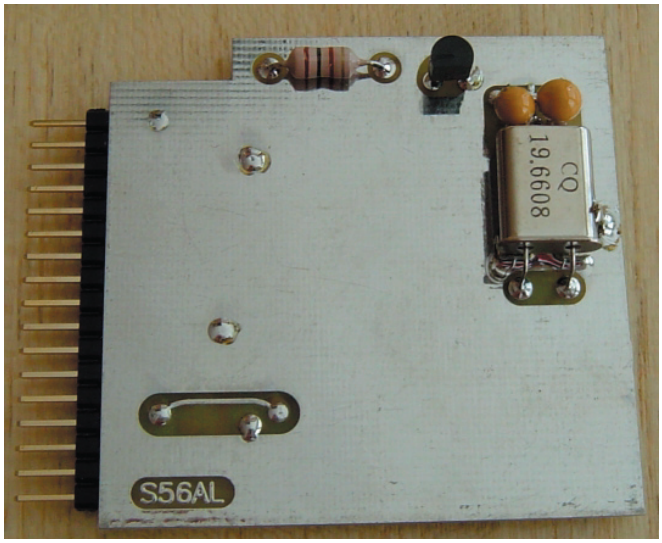
Namestitev modula v TRX

Ko je M110 ustrezno pripravljen, lahko pristopimo k modifikacijam električnega vezja ter vgradnji dodatnega modula. Postopek modifikacije je sestavljen iz korakov opisanih v točkah 1 do 15.

1. Odvijemo vijaka, ki držita prikazno enoto M110 pritrjeno na ohišje in jo odstranimo. Snamemo tudi aluminijasti pokrov ohišja TRX.

2. Odstranimo plastični pokrov s hrbtne strani prikazne enote. Pokrov je učvrščen v ležišču z gumijastim tesnilom.



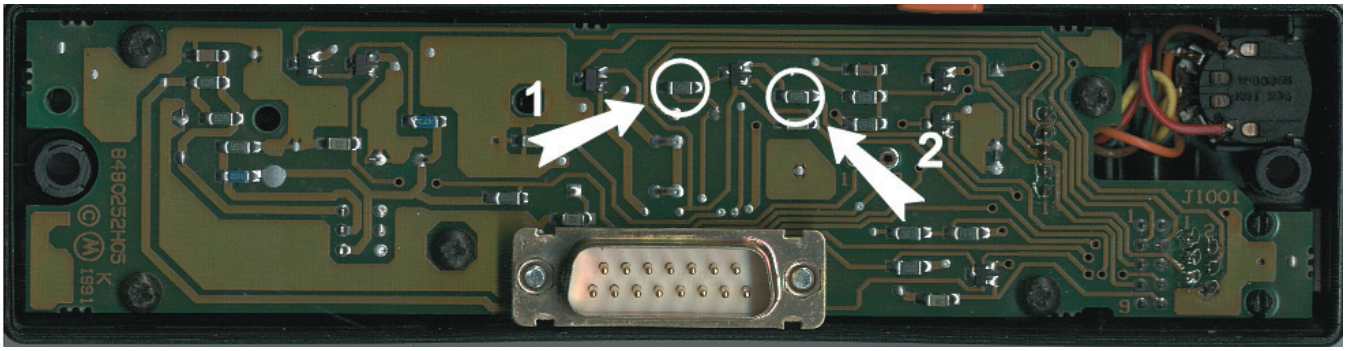


Slika 5 - Fotografiji izdelanega modula

3. Na tiskanini prikazne enote poiščemo upor 820 Ohm (slika 6, puščica 1) in ga odstranimo. S tem izključimo preglasne klike ob pritisku na tipko, ki jih generira procesor prikaze enote.

4. Na tiskanini prikazne enote poiščemo upor 10 Ohm (slika 6, puščica 2) in ga premostimo z žičko ali nadomestimo z uporom vrednosti 1 Ohm ali manj. S tem omogočimo regulacijo glasnosti sprejemanega signala v zvočniku "do ničle ".

različne dolžine, zato si označimo, kje je bil kateri privit. Popustimo tudi dva vijaka, s katerima je izhodna stopnja TX pritrjena na hrbtno stran šasije. Odklopimo konektor, ki povezuje izhodno stopnjo TX z glavno kontrolersko ploščo. Kontrolersko ploščo snamemo. Kontrolerska plošča je s tiskanino na drugi strani šasije povezana prek močnejše priključne letvice z 11 kontakti. Najlažje jo snamemo tako, da porinemo med tiskano vezje kontrolerske ploče in šasijo primerno trdo leseno ali plastično letvico. Z njeno pomočjo v neposredni bližini priključne letvice



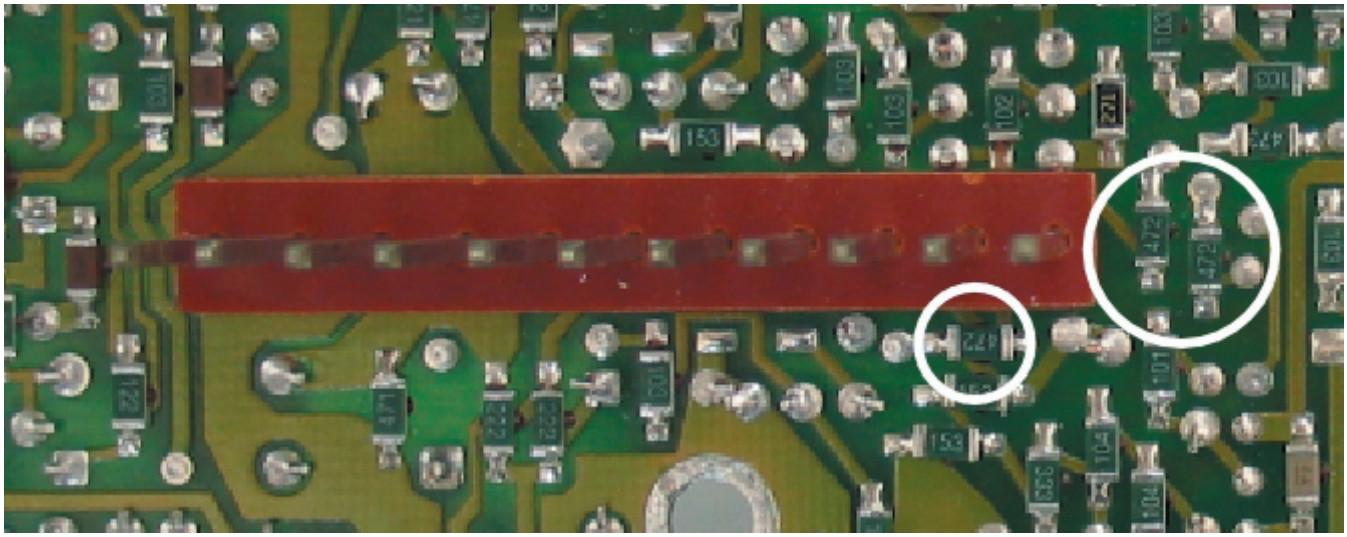
Slika 6 - Tiskano vezje prikazne enote

5. Plastični pokrov prikazne enote vrnemo na svoje mesto.

6. Na glavni kontrolerski plošči odvijemo 9 vijakov, ki držijo ploščo pritrjeno na šasijo. Dva se nahajata na stranici šasije. Z njima je pritrjeno hladilo močnostnih tranzistorjev NF ojačevalnika. Vijaki so

tiskanino previdno odmaknemo od šasije, da se priključna letvica iztakne iz ležišča na tiskanini na nasprotni strani šasije.

7. Na kontrolerski plošči na strani s SMD elementi poiščemo tri upore 4,7 kOhm (slika 7) ter jih odstranimo. Upori povezujejo žebljičke 2, 3 in 4 priključne letvice s procesorskim krmiljem. Z



Slika 7 - Kontrolerska plosča TRX, stran s SMD elementi

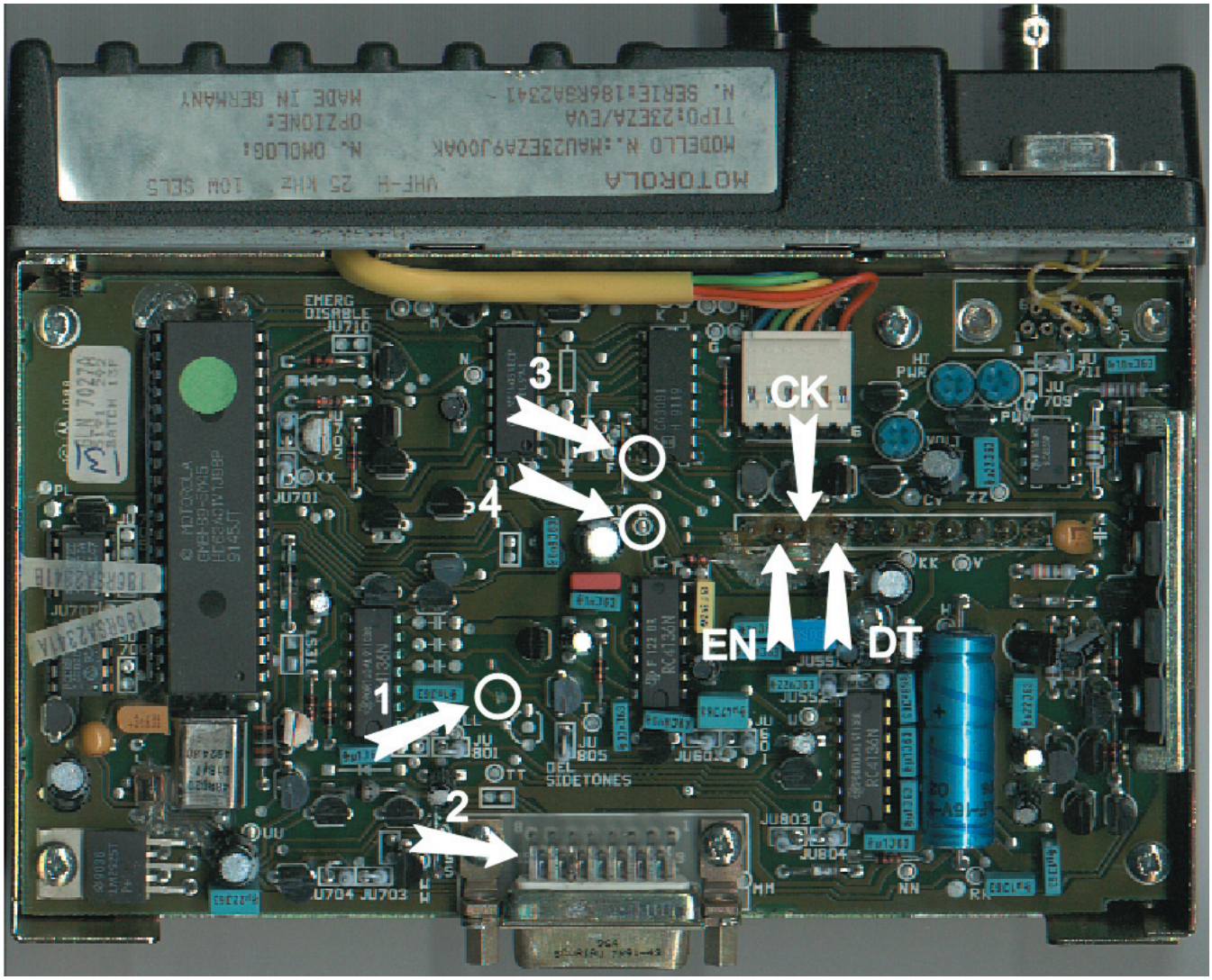
odstranitvijo uporov smo od glavnega mikrokontrolerja odklopili PLL vezje, ki se nahaja na tiskanini na nasprotni strani šasije. Kontrolersko ploščo namestimo in privijemo nazaj na šasijo M110.

8. Na gornji strani kontrolerske plošče poiščemo vezico do kratkostičnika JU805 ter jo prekinemo (slika 8, puščica 1). To storimo tako, da bakreno vezico s skalpelom ali drugim ostrim rezilom dvakrat prečno prerežemo na razdalji ca. 1mm in pogrejemo s spajkalnikom, da 1mm dolgi košček vezice odstopi.

9. Komunikacijsko vodilo UART, ki povezuje glavni procesor ter procesor snemljive prikazne enote, poteka prek DB15 konektorja (priključka 8 in 15). Obe povezavi (8 in 15) DB15 konektorja s tiskanino s primernimi ščipalkami prerežemo približno na sredini (slika 8, puščica 2 in slika 9). Kasneje bomo na vsakega od tako dobljenih 4 štrcljev prispajkali priključno žico za povezavo z našim modulom.

10. Zgrajen dodatni modul za modifikacijo M110 namestimo na svoje mesto v ohišju (slika 10) ter ga povežemo z ustreznimi priključnimi točkami električnega vezja M110, kot je to opisano v tabeli.

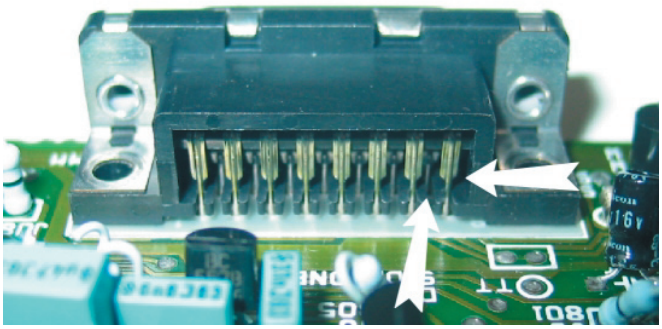
11. Pokrov ohišja M110 oblepimo z notranje strani na mestu, kjer se nahaja naš dodatni modul, s tankim kartonom ali primerno debelo folijo iz umetne mase, da modul ne pride v stik s pokrovom. Modula ni potrebno pritrjevati, ker je prostora v ohišju ravno toliko, da modul



Slika 8 - Kontrolerska plosča TRX, gornja stran

lepo sedi na svojem mestu. Bolj dosledni pa ga lahko s kapljico silikonskega kita ali dvostranskim selotejpom prilepijo na hrbet mikrokontrolerja.

12. Namestimo pokrov ohišja in snemljivo prikazno enoto nazaj na svoje mesto ter privijemo z vijakoma.

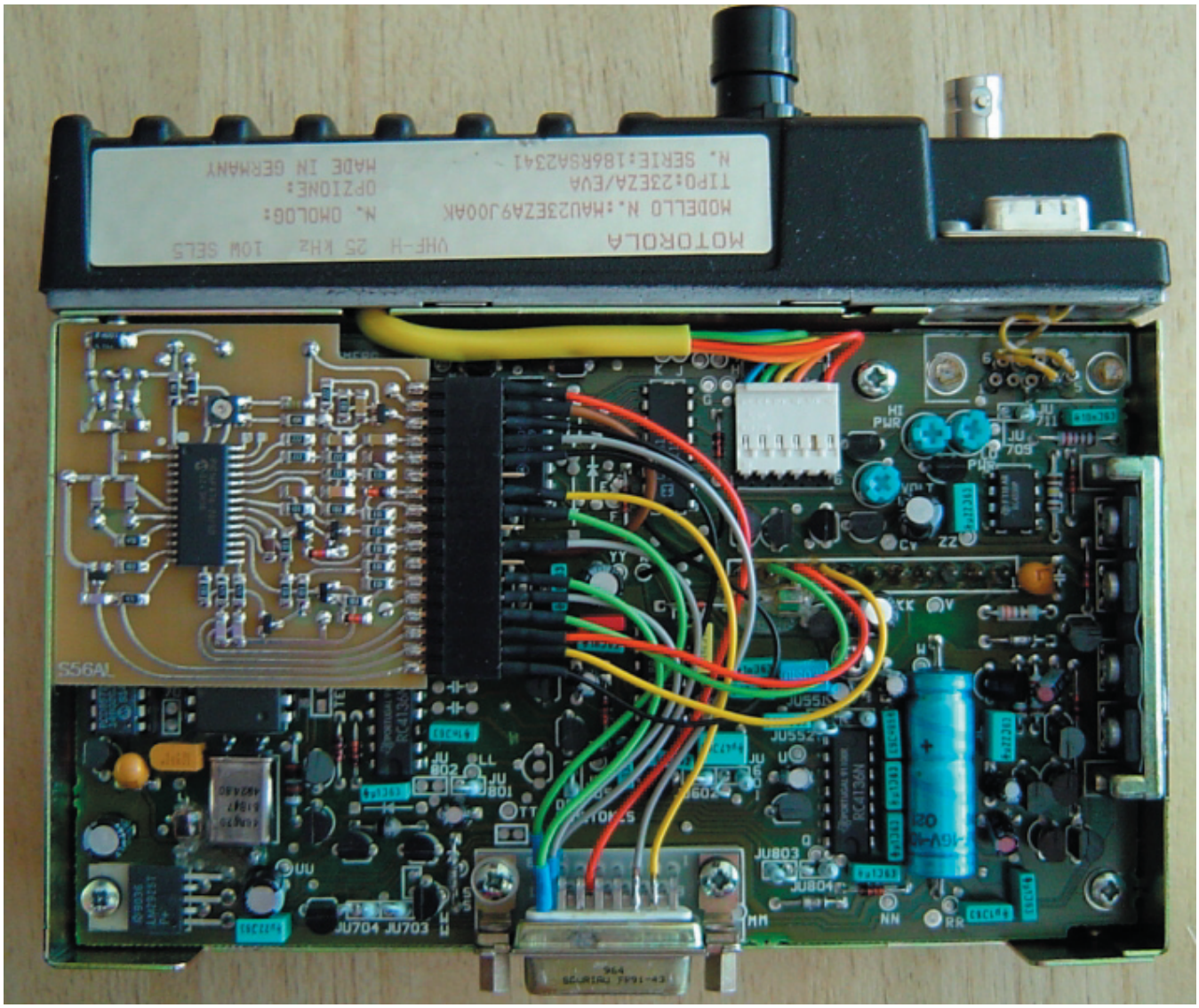


Slika 9 - Konektor DB15

13. Povežemo TRX z napajanjem, priključimo anteno (ali umetno breme), mikrofon ter zvočnik.

14. Po vklopu se mora na prikazu izpisati delovna frekvenca, prižge se rumena signalna lučka (LED). Če se TRX odziva tudi na pritiske na tipke, izberemo prosto delovno frekvenco ter aktiviramo stikalo PTT. Prižgati se mora rdeča signalna lučka. Če imamo kontrolni sprejemnik, preverimo modulacijo.

15. Radijska postaja je pripravljena za prvo zvezo (slika 11).



Slika 10 - Namestitev dodatnega modula

Hardware upgrade

1. Remove the display unit and aluminium top cover from the transceiver body.

2. Remove the plastic cover from the display unit (no screws, only rubber holds it in place :).

3. Locate the 820 Ohm resistor (see figure 6 - arrow 1) and desolder it. This turns off the horrible key-click tones generated by the display unit processor.

4. Locate the 10 Ohm resistor (see figure 6 - arrow 2) and replace it with short circuit or another resistor with value <1 Ohm. This would allow you to control the speaker audio level with the potentiometer down to zero.

5. Put the plastic cover back to it's place on the display unit.

6. On the main processor board locate and unscrew 9 screws that hold this board in place. Two are at the side of the housing (chassis), holding the power transistors heat sink attached to the chassis. The screws are of different lengths so remember which one was where. Unplug the connector that connects the TX power amplifier to the board. The board removes easier if the two screws that hold TX power amplifier at the back of

Slika 11a - Radius M110 po predelavi

Kontakt priključne letvice	**Povezati na kontrolerski plošči**
+12V	s priključkom 13 konektorja DB15
GND	z maso glavne kontrolerske plošče; poiskati primerno, dovolj veliko površino mase na tiskanini in povezati s čim krajšo žičko
NFOBL	s skozno povezavo (via) označeno z "R" (slika 8, puščica 4)
MMIT	s priključkom 3 konektorja DB15
T1750	s kratkostičnikom JU805
PTT	s priključkom 2 konektorja DB15
MBTX	s prerezanim priključkom 8 konektorja DB15, na strani glavne kontrolerske plošče
+5V	ostane nepovezan - vir napajalne napetosti 5V za splošno uporabo
MBRX	s prerezanim priključkom 15 konektorja DB15, na strani glavne kontrolerske plošče
DISRX	s prerezanim priključkom 8 konektorja DB15, na strani konektorja (povezava s prikazno enoto)
DISTX	s prerezanim priključkom 15 konektorja DB15, na strani konektorja (povezava s prikazno enoto)
PLLEN	z žebljičkom 2 11-polne priključne letvice (slika 8, puščica EN)
PLLDT	z žebljičkom 3 11-polne priključne letvice (slika 8, puščica DT)
PLLCK	z žebljičkom 4 11-polne priključne letvice (slika 8, puščica CK)
LDDIS	z nogico 16 integriranega vezja CA3081 (slika 8, puščica 3)

Tabela - povezava vgrajenega modula z električnim vezjem M110

the transceiver are slightly untightened. The main processor board is connected to the PLL / RF board at the other chassis side with a fairly strong header. GENTLY pull the board together with the header from its place with the help of a wider screwdriver (without sharp edges) or better with a suitable wooden or plastic tool inserted between the board and metal chassis as close to the header as possible.

7. On the bottom side of the main processor board locate three 4,7 kOhm resistors (connected to the 2nd, 3rd and 4th pin of the header) and remove them (see figure 7). This disconnects the PLL chip from the main board microcontroller. Put the main processor board back to its place and screw it down.

8. On the top side of the main processor board locate the trace from JU805 and cut it (figure 8 - arrow 1).

9. The UART (communication) connection between the main and display unit microcontrollers leads through the pins 8 and 15 of the 15-pin (DB15) connector. Cut this two pins approx. at the middle (figure 8 - arrow 8, figure 9). Later four wires will be soldered to this two pins at both - display and main board sides.

10. Insert the built module to its place (figure 10). Connect the header at the module PCB to the main board with 14 wires as specified in the table.

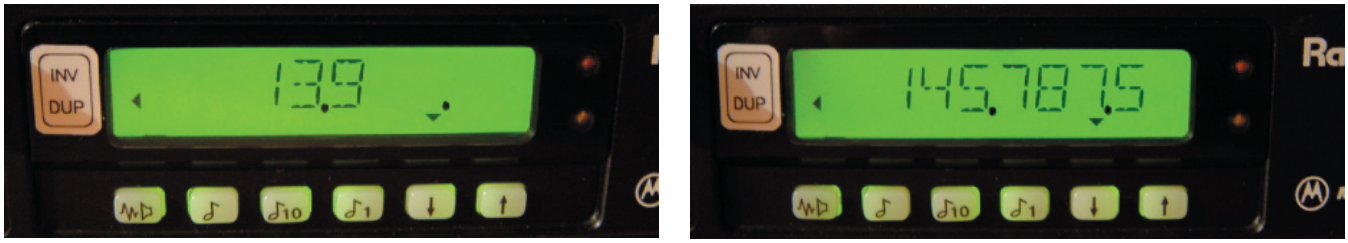
11. Isolate the inner side of the aluminium housing top cover at the place where the module is inserted with a paper or similar isolating means (Scotch tape).

12. Put the housing cover and the display unit back to their place, connect the transceiver to the antenna (or dummy load) and to the power supply. Connect the loudspeaker and the microphone.

13. Turn the transceiver on. The operating frequency should be displayed and the yellow LED should light. If the transceiver responds when the keys are pressed, try to press the mic. PTT key. The red LED should come on and the transmitter

HEADER	Connection to the main board
+12V	Parallel to the pin 13 of the 15-pin DB15 connector
GND	To the ground of the main board PCB - find a strong suitable ground area somewhere on the main board close to the module header and connect with the shortest possible wire
NFOBL	Parallel to the via marked with "R" (figure 8 - arrow 4)
MMIT	Parallel to the pin 3 of the 15-pin DB15 connector
T1750	Parallel to JU805
PTT	Parallel to the pin 2 of the 15-pin DB15 connector
MBTX	To the pin 8 at the main board side of the 15-pin DB15 connector
+5V	Requires no connection, this is just a spare source of the regulated 5V supply voltage, may be used for other purposes
MBRX	To the pin 15 at the main board side of the 15-pin DB15 connector
DISRX	To the pin 8 at the display side of the 15-pin DB15 connector
DISTX	To the pin 15 at the display side of the 15-pin DB15 connector
PLLEN	Parallel to the pin 2 of the header that connects the main board with the PLL board (figure 8 - arrow "EN")
PLLDT	Parallel to the pin 3 of the header that connects the main board with the PLL board (figure 8 - arrow "DT")
PLLCK	Parallel to the pin 4 of the header that connects the main board with the PLL board (figure 8 - arrow "CK")
LDDIS	Parallel to the pin 16 of the CA3081 (figure 8 - arrow 3)

Connection of the module to the M110's PCB



Slika 11b - Fotografiji predelanega TRX, prikaz napetosti napajanja in frekvence

should transmit.

14. The modified transceiver is ready for it's first QSO (figure 11).

Za konec

Kot sem omenil že v uvodu, sva projekt predelave izpeljala skupaj z Benom, S56KZN. Beno je prevzel aktivnosti programiranja in uglaševanja M110, moja naloga pa je bila razvoj, izdelava in programiranje mikrokontrolerskega modula. Benu hvala tudi za pomoč pri pripravi slikovnega gradiva in navodil za uglaševanje

Priloge

1. Koncentrirana navodila za uglasitev Motorola Radius M110 (avtor Beno, S56KZN)

2. Programski parametri za predelavo

Koncentrirana navodila za uglasitev Motorola Radius M110 Beno S56KZN

Concentrated instructions for Alignment of Motorola M110/MC micro (VHF) by Beno, S56KZN

W A R N I N G - This is a transcript from service manual, there might be some typo errors in the text, so the author can not overtake any responsibility of any sort of the possible damages to your radio.

ALIGNMENT

Note: Key the radio while making adjustments or measurements.

GENERAL

Perform all adjustments at a supply voltage 13.2 ~0.1 volts dc, unless the instruction call for a different voltage.

Interpret instruction to turn controls clockwise (CW) or counterclockwise (CCW) to mean "as viewed from the component side of the circuit board".

Picture A and B show the locations of the components.

When you perform any of the tune-up procedures given in sections 1.2, 1.3, 1.4 and 1.5, the radio must be completely assembled except for the chassis cover, top cover of the synthesizer compartment, and the radio sleeve. When you have completed the tune-up, install the synthesizer cover, chassis cover and sleeve before testing the radio against specifications following the procedures given in sections 1.4, 1.5, 1.6 and 1.8 .

The following test equipment is recommended for aligning and servicing the MC micro radio:

R2001D	Communication System Analyser
or	
R2200B	Service Monitor
GTF180A	Mobile test set with
GTF244A	Adapter cable for MC micro
PFT4053A	Psophometric filter
FTP3005B	Select 5 test unit (not required with R2001D)
R1001B	Power supply
or	
S1347D	Power supply (for radios with 10 watts or less power)
R1037	Digital multimeter
or	
R1024B	Digital multimeter

TO ADJUST THE TRANSMITER

Preset the following pots:

* HI PWR	R453	Fully CCW
* LO PWR	R455	Fully CCW
* VOLT LIMIT	R463	Fully CW

Adjust the radios dc supply voltage to 13.2 ~0.1 VDC (12.6 VDC for MAU1, six-watt model).

Select the channel with highest transmit frequency.

Connect the radio antenna output to an accurate RF power meter that provides a 50-ohm load.

Connect a dc voltmeter from the steering line test point (SL) to ground. Meter impedance should be 11 MegaOhms or more.

Key the radio and adjust coil L210 until the voltage reads 7.0 VDC

Select the channel with the lowest transmit frequency. Key the radio and verify that dc voltage is at least 2.5 VDC

Select any transmit channel. (If radio has the MAB889 slaved RF power option, select any high power transmit channel).

Key the radio and adjust R453 (HI PWR) for:

Model number	Power setting
MAU0	1.0 W
MAU1	6.0 W
MAU2	10.0 W
MAU3	25.0 W

Switch through all channels (all high power channels for MAB889). On each channel key the radio and note the power output. For MAU0, MAU2 and MAU3 models note that channel that gives the minimum power output; for MAU1 models note the channels that gives the maximum power output. If more than one channels gives the same maximum or minimum power, chose any one of those channels.

Switch through all transmit channels (all high power channels for MAB889). On each channel, key the radio while watching the dc voltage at Pin 4 of connector P6, or at test point CV on the command board. Record the number of the channel that gives the greatest voltage and what voltage is. (If more than one channel gives the same maximum voltage, chose any of those channels). If it is greater than 10.0 VDC, go to step 14 if not go to step 12.

On the channel that step 11 shoved to have the highest dc voltage, turn R463 fully CCW. Turn R453 fully CW.

Key the radio. Adjust the voltage limit pot R463 for a dc voltage 2.0 higher than voltage level recorded in step 11, as measured at Pin 4 of P6 or at test point CV

Set the channel selector to the channel that was noted in step 10. Key the radio and adjust R453 for:

Model number	Power setting
MAU0	1.1 W
MAU1	5.6 W
MAU2	10.7 W
MAU3	26.8 W

Verify that all channels (all high power channels in MAB889) produce at least 1.0, 10.0 or 25.0 watts as appropriate for MAU0, MAU2 and MAU3 models. Verify that no channels produces more than 6.0 watts for MAU1 models.

If the radio has option MAB889 (slaved RF power level) select any low power channel. Key the radio and adjust R455 for an output power of 1.0 watt (or other specified power setting) for MAU1 and MAU2 models. Verify that the RF power output on all low power channels is between 0.7 and 1.4 watts. Readjust R455 slightly if necessary. For MAU0 models, adjust R455 for an output power of 0.1 watt or some other specified power level. Verify that RF power output on all low power channels is between 70 and 140 mW.

TO ADJUST THE REFERENCE OSCILATOR

Connect the radio antenna output to an accurate frequency counter through a suitable attenuator.

Select any transmit channel.

Key the radio and adjust L151 (all models except those with 2 ppm stability) or R163 (models with 2 ppm stability) until the exact transmit frequency (~100 Hz) appears on the counter.

Check all transmit channels to verify that the correct transmit frequencies have been programmed.

TO ADJUST THE DEVIATION

Connect the radio antenna output to a modulation analyser or test receiver through a suitable attenuator

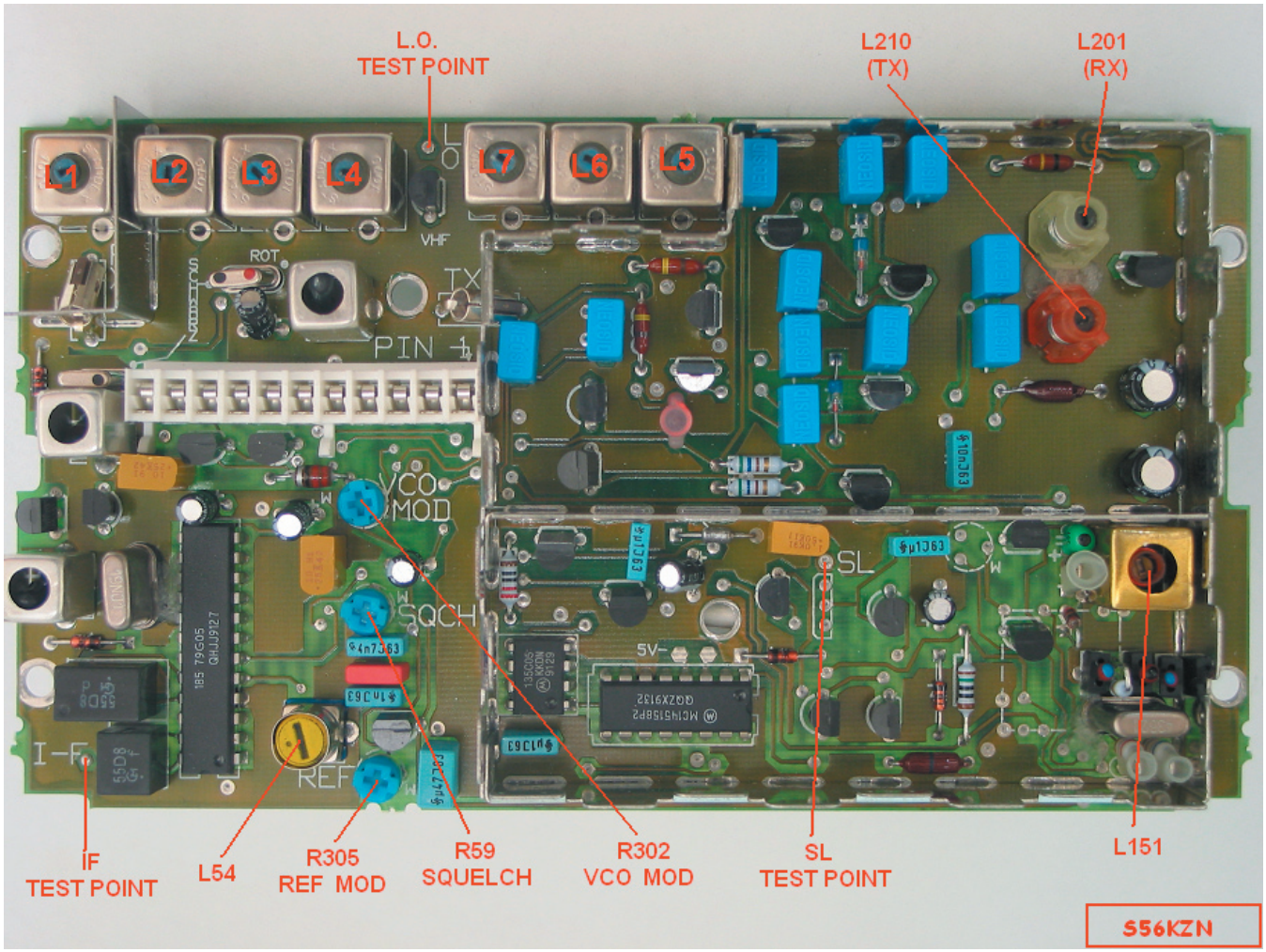


Figure A - Alignment point on RF board

Connect an audio oscillator to the microphone audio input through the circuit in figure C. Set the oscillator frequency to one kHz and the output level to 800 mV RMS.

Preset pots R302 (VCO MOD) and R305 (REF MOD) fully CCW.

Select any transmit channel. For PL models select channel that transmit PL.

Key the radio and adjust the VCO MOD pot R302 for appropriate deviation level:

Channel spacing	Deviation setting
25 kHz	~ 4.6 kHz
20 kHz	~ 3.7 kHz
12.5 kHz	~ 2.3 kHz

Note

If + and – deviation readings differ, use only the higher reading.

Change the audio oscillator frequency to 200 Hz and maintain the output level at 800 mV RMS.

Key the radio and observe the waveform on an oscilloscope connected to demodulated output of a test receiver. Test receiver should be non-deemphasized and there must be dc coupling between the test receiver and the scope. (AC coupling is suitable if the corner frequency is 2 Hz or lower.) Adjust R305 (REF MOD) for the flattest square-wave response with minimum tilt.

Return the audio oscillator frequency to one kHz, 800 mV and repeat step 5.

TO ALIGN THE RECEIVER

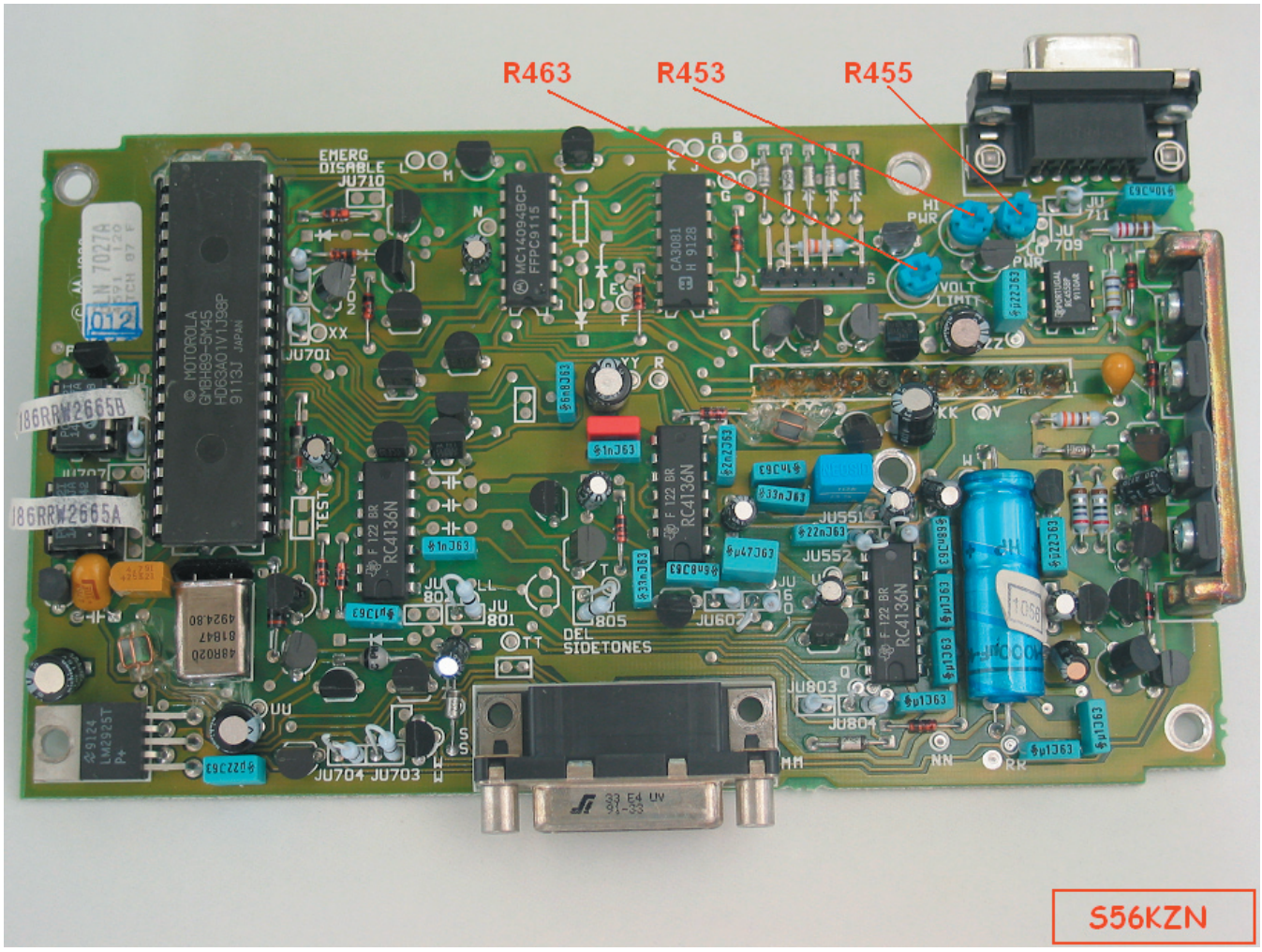


Figure b - Alignment point on RF board

Note:
Adjust the transmitter VCO and reference oscillator before aligning the receiver

1.5.1 Receiver VCO

Connect a high impedance (11 MegaOhms or greater) dc voltmeter from steering line test point (SL) to ground.

(Radios with more then one receive frequency) Select the channel with highest receive frequency.

Adjust the receiver VCO coil (L201) until the voltage meters reads 7.0 VDC.

Select the channel with the lowest receive frequency and verify that test frequency is at least 2.5 VDC.

Receiver

Find the tune-up frequency , f_{tune} as follows:

(a) On single channel radios and mult channel radios with a single receive frequency:
$f_{tune} = f_{receive}$

On multi channel radios that have a receive bandwidth of two MHz or less:

f_{tune} = frequency of highest frequency channel

On multi channel radios that have a receive bandwidth greater than two MHz but less than or equal to four MHz find f_{mid} where:
$f_{mid} = (f_{highest} + f_{lowest}) : 2$

If one of the radio channels has a frequency within 500 kHz of f_{mid} perform the tune-

up on that channel. If not you must either get a tune-up PROM programmed to f_{mid} or program the tune-up frequency f_{mid} into the radio (EZ models only). EV models contain a preprogrammed tune-up channel, accessed by temporarily shorting the TEST pins on the command board.

Set the channel selector switch to the channel of the tune-up frequency as determined in step 1 above

Connect a two ohm resistive load across Pin 4 of J5 (hot lead) and Pin 5 of J5 (ground lead). Monitor the audio output across this load resistor.

Preset the slugs of L1 through L7 for f_{tune} flush with the circuit board.

Connect a dc voltmeter from the local oscillator test point (LO) to ground.

Peak the injection filter coils L6, L5 and L7 in that order, for maximum dc voltage typically between 2.1 and 3.5 VDC. Repeat until you cannot make the dc voltage increase any farther.

Connect an RF signal generator to the antenna connector and adjust it to generate an unmodulated on channel signal strong enough to quiet receiver.

Connect an ac voltmeter with bandwidth of at least 500 Hz (an HP331A distortion analyser) from the IF test point to ground. Increase the RF generator output until the ac voltmeter indicates approximately 30 mV. Adjust the RF filter coils L1, L3, L4 and L5 until the voltmeter peaks. Reduce the generator's RF level as necessary to maintain approximately 30 mV RMS on the meter during this process. Repeat the adjustment until you can get no further increase in voltage.

Set the RF level of the generator 1 mV. Modulate it with 1 kHz at 60% of full system deviation. Full system deviation for channel spacing of 25 kHz is ~ 5 kHz; for 20 kHz ~ 4 kHz; for 12.5 kHz ~ 2.5 kHz. Adjust the volume control to get an audio level of about one volt RMS across the 2 ohm load. Slowly peak the quad coil, L54 for maximum audio output.

Adjust the squelch as follow:

Preset the squelch control R59 CCW.

Apply an on-channel RF signal at a level of one mV. Modulate with a one kHz tone at 60% of full system deviation.

Adjust the volume control for 1.7 volts RMS across the two ohm load.

Reduce the RF level until the CCITT-weighted SINAD is 10 dB.

Enable the carrier squelch mode with the front panel switch.

Slowly turn the squelch control CW until the audio is squelched (muted) then very slowly turn CCW until the radio just unsquelches (unmutes)

Reduce the generator RF level to zero slowly increase the level until the radio just unsquelches and verify that the CCITT-weighted SINAD at this RF level is between 8 and 12 dB SINAD. Readjust R59 slightly if necessary.

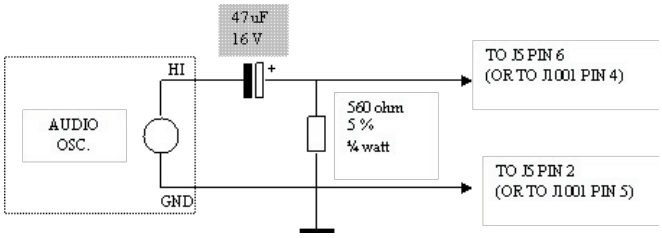


Figure c - Connecting audio oscilator to microphone

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Motorola RADIUS M110 Field Programmer Print Out                Page :  1

Date :  9.12.2002   10:12       Field Prog. Vers.: R02.00.00

USER COMMENT: PROGRAMM RADIO THIS WAY BEFORE MODIFICATION


Radio Type: VHF H 25 S5         Serial Number : 186aaa0000


Model M110 Select 5
VHF high 146 - 174 MHz
25.0 kHz channel spacing
Low power RF PA

Channel Information                  Refer to table(s) below .....
Time-out timer / Rekey timer         Timeout :    255 sec
                                     Rekey :          sec
Tone system: ZVEI                    Encoder tone duration :   70 msec
Encode sequence A - D                A:
                                     B:
                                     C:
                                     D:
Decoder code                         Decode     :  111
                                     Groupcall  :  ---
                                     Grouptone  : A
Auto reset with carrier override                    2 sec
Auto Acknowledge delay                              0 msec
Encoder Pretime                                   141 msec
Intersequence delay                               141 msec
Extended first tone duration         Encoder :    600 msec
                                     Decoder :    550 msec


RF Frequency Table:

NOTE: RF frequencies marked with '*' do NOT match the subband range.

Ch! Receive ! Transmit! Clk !  Transmit ! Monitor
No! Freq MHz! Freq MHz! Sft !   admit   ! inhibit
  !          !         !     !           !
--+----------+---------+-----+-----------+--------
 1!*145.0000!*145.0000! NO  !   MONITOR !   NO


Selective Call Table:

Ch! PL Encode ! Call button !   PTT      ! Auto Ack   ! Decoder
No!    Hz     !  sequence   ! sequence   ! sequence   ! enable
  !           !             !            !            !
--+-----------+-------------+------------+------------+----------
 1!           !             !            !            !   YES

END of RADIUS M110 Field Programmer Print Out
```