HMY2K8 - A MULTI BAND HF TRANSCEIVER

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TECHNICAL SPECIFICATIONS:

Frequency coverage: Ham Bands

3.500 - 3.600 M.Hz (80 M)
7.000 - 7.100M.Hz (40 M)
14.000 – 14.350 M.Hz (20 M)
21.000 - 21.350 M.Hz (15 M)
28.000 – 28.350 M.Hz (10 M)

Frequency control:

Ver. 1: Direct Digital Synthesizer (DDS) with 1 Hz step continuously variable vfo with 20 memory channels. 2 line LCD display. Dual VFO, Split , RIT, Key pad / rotary encoder for frequency entry.

Ver. 2: 5 Band Heterodyne VFO with PIC frequency counter to reduce cost of the project.

Receiver:

Single conversion receiver with 10.000 M.Hz Cohn filter.
Low noise figure, 2.2 K.Hz SSB band width, 1.5 W audio O/P.

Transmitter:

RF O/P - SSB - 90 W (DC PWR I/P)
CW - 60 W (DC PWR I/P)
Built in CW side tone, CW delay, pwr meter, MOS FET Push Pull PA.

Dimensions: 8.5 X 7 X 4.5 inches

Genesis:

Being a home brewer I hesitated to buy a commercial HF transceiver soon after getting my ticket in1988. Even my teacher, late T.K.Seshandam VU2WC did not allowed me to do so. But he was kind enough to give me a set of pcb's of VWN QRP TX . I was successful to come on air with VWN QRP effectively along with L board RX on 40M. Those days were really good for HF communication. With low band noise, excellent propagation conditions we could work hours together daily on 40 M with 7 W AM signals. After that I had homebrewed RM96 and ATS1 and came on air effectively with SSB signals on 40 M. Even though there is a feeling of missing a lot of activity on other HF bands Viz 20 M, because all the above rigs are mono banders. If I want come on other band I have to construct another rig of same circuit! Then I could get a used ICOM - IC720 commercial TRX. It worked well for about 6 months and gone QRT. I just sent it to few service centers and was not able to get it repaired due to the non availability of spares for PLL & Logic boards. Then I secured one BEL524 in dead condition and able to repair it and came on air on all HAM bands with a home made out board DDS VFO. But servicing such surplus equipment was not that easy due to their concealed and modular construction. Then I thought of home brewing a multi-band SSB/CW TRX using indigenous components freely available in VU land . I searched for the circuit schematics even on the internet. But ….in vain! Then I could download and made simple 40 M band SSB TRX circuits using bilateral switching technique using switching IC 74HS4053 by KD1JV using NE602 and PY2OHH using TA7358. Both performed well and gave me good results on air. But the cost of NE602/SA612 is around Rs.300/- ++ and its rare availability in VU land, whereas the cost of TA7358 is Rs.15/- and freely available.

Finally, I decided to design a multi band SSB/CW TRX using Toshiba IC TA7358 with band switching using diode switching arrangement which can give 90 W DC PWR input from 80 to 10 Mtr bands. I incorporated CW delay and side tone for easy CW operation. I designed pcb (measures 7 X 3.5 inches) lay out using EXP PCB design soft ware and printed the board which accommodates all stages Viz Bal. Modulator/ demodulator, RX/TX mixer, 5 band band pass filter, 6 pole cohn filter, Tone circuit for CW, CW side tone, mike amp, audio amplifier, transmitter driver and TRX change over. I used home made DDS VFO using up-conversion to cover 80 – 10 M bands. In other version a pre mixed heterodyne VFO has been used to minimize the cost of the rig. I hope this tiny rig shall meet all the demands of an average VU ham with all its sophistication at reasonable cost.

The circuit:

The circuit is simple and strait forward. IC1 TA7358 is used as RX/TX mixer, IC2 TA7358 is used as Product detector / Bal. modulator and IC3 as a bi-lateral switch to switch both the ICs, IC1 and IC2 to particular inputs / outputs in transceive operation by applying DC voltage in Key down / press of PTT condition.

Receiving chain:

The incoming rf signal is amplified in broad band RF amplifier and fed to the band pass filter by applying appropriate switching voltage from the band switch from front panel. The strong local signals can be attenuated by VR1 from front panel. Here the signal is filtered in the band pass filter and fed to IC1 TA7358, RX mixer through the switching IC, (IC3 sec A). Here the incoming signal is mixed with local oscillator signal (VFO) and converted to 10 M.Hz IF frequency and fed to the SSB filter (6 pole 10 M.Hz cohn filter) through switching IC (IC3 sec B) and fed to IC2 Product detector through switching IC (IC3 sec C). In the product detector the signal is beat with Carrier oscillator signal to get resultant audio signal which is further amplified by transistors Q2 and Q3 and sent to audio amplifier IC4 LM380 to deliver sufficient audio from speaker. The AF gain can be adjusted by the potentiometer VR3 (VOL) from front panel.

Transmitting chain:

Voice received by the condenser microphone is amplified by transistor Q4 and sent to IC2 Bal. modulator. Here carrier frequency is modulated and 10 M.Hz DSB signal is produced and further amplified by Q2 and fed to the SSB filter through switching IC (IC3sec C) to eliminate unwanted side band. The mike gain can be set by the preset VR2 and appropriate side band X-Tal is selected by the mode switch SW 2 from the front panel. The 10 M.Hz SSB signal from filter is fed to the TX mixer IC1 through switching IC (IC3 sec B) and mixed with Local oscillator signal (VFO) to get required transmitted frequency. The signal is further amplified by 2 stage broad band RF amplifier and sent to band pass filter through switching IC (IC3 sec A).

Appropriate band pass filter is selected by applying +12V to the switching diodes from the 5 way band switch SW3 from front panel or from logic out put from DDS VFO in case of using DDS VFO. Few milli volts of RF of TX signal from band pass filter is further amplified by 3stage broad band HF driver amplifier for about 1 – 1.5 W. The driver amplifier is having good linearity through 80 – 10 mts and the gain of the amplifier can be adjusted by changing the value of damping resistors R53, R54, and R57 to get adequate drive level to the final amplifier. Initially one can come on air with this 1W power and can work few stations to get reports and to align the transceiver.

VFO:

I used DDS VFO using AD9851 along with PIC16F628 in up conversion mode to cover 80 to 10 Mtrs bands in one set and in another set a pre mixed heterodyne VFO is used to reduce the cost of the transceiver. If one wishes to operate on single band, can use simple colpits oscillator such as RM96 VFO which is very stable in operation. I don't want to describe more about VFO, because one can choose his VFO according to his taste and requirement. There are variety of VFO circuits available in hand books or on the internet.

CW operation:

Sine wave tone around 900 K.C from an oscillator consisting of Q13 and Q14 is fed to mike amplifier through SW1, SSB/CW switch in key down condition. At the same time the side tone is amplified by IC 6 LM386 and heard in speaker LS 2. CW delay circuit provides sufficient delay for proper CW operation. The delay time can be adjusted by the preset VR7 in the base circuit of Q 12.

SSB filter:

Six x-tal cohn filter is used for selective band width of around 2.5 K.C. Select all the six x-tals with in 100 Hz tolerance to each other to achieve proper band width and audio quality. Select carrier oscillator x-tals with + and - 1.5K.C of filter frequency for LSB and USB operation.

Final MOS FET push pull broad band amplifier:

Circuit of popular IRF 510 push pull amplifier is used for final RF amplifier which is capable of delivering of 90 W DC power input over the frequencies between 3.5 to 30 M.Hz with 1 – 1.5 W of drive. Double side glass epoxy PCB has to be used for proper operation and to achieve stability especially at higher frequencies. A large heat sink (6 X 3. 5 inches) with fins should be used. The amplifier draws 3 – 3.5 A for the maximum voice peak with 25V of operation. The O/P of the PA is connected to the SO239 antenna socket through change over relay contacts with a peace of 50 ohms thin coax. The O/P of the PA is sampled and the PWR level is indicated by VU meter mounted on front panel.

Construction:

Soon after finishing soldering all the components, check for shorts and solder bridges between the tracks. I selected a cabinet of FLD (front loaded) tape deck available from electronic shops which measures 8.5 X 7 X 4.5 inches (Almost the size of commercial TRX). On front panel volume controller, Tuning knob, Attenuator controller, mode switch, band switch, key pad, on/off switch, jack sockets for PTT/MIC, Phones, Key and VU meter are fixed. The main board is fixed on the chassis and on the back panel the PA, SO239 antenna socket, relay and two fuse holders are fixed. Inter connections are done with multi strand hookup wire. 25 V line to PA has to be wired with thick wire used for car wiring capable of carrying 5A. All audio connections should be made with 1+2 shield cable and the RF interconnections are done with thin coax cables RG174 and RG58C/U. Shields with thin ms sheet should be provided for SSB filter, VFO and to the PA. PTT switch and microphone are housed in a small plastic box such as cell phone charger case. Condenser microphone is wrapped with few layers of soft cloth or sponge to avoid unwanted low frequencies entering into mike such as breath. 1 + 2 thick shield cable which is used for public address system should be used for microphone.

Alignment:

To align the receiver, the RF signal from signal generator or the incoming signal from antenna should be used. Both the coils for each band in the band pass filter are peaked by teflon alignment tool for maximum signal strength. Then adjust the carrier frequencies of LSB and USB X-Tals for exact beat note. This completes the receiver alignment. To align transmitter, connect a 6 V low current bulb to the O/P of driver amplifier and apply power to TX line by pressing PTT or in key down condition. As you shout into the microphone or depressing the key, you will observe glow in the bulb. By observing brilliance of the bulb set the mike gain preset VR2 to adequate level. If necessary alter the values of damping resistors R53 , R54 , and R57 in driver amplifier to get adequate drive. Keep this level 20 % low in CW mode to protect the finals from thermal run away by adjusting CW level preset VR8 . Now disconnect the bulb and connect the driver amplifier O/P to relay, with this one can work (QRPP) few stations and get reports initially.

Connect a milli ammeter in series with PA and apply 25 V than adjust idling current of MOSFETS to draw 40 mA (20 mA each) by adjusting potentiometers VR4 and VR5 . Then disconnect milli ammeter and connect 5A FSD ammeter and connect the driver amplifier O/P to the I/P of the PA. Now connect a 50 ohms / 100W dummy load or an external antenna to the rig. By shouting into the microphone, check the current drawn by the PA. It should be 3 – 3.5 A at 25V of drain supply. If not, re-adjust the mike gain preset VR2. Too much mike gain leads to distortion of transmitted signal and shift in operating frequency.

Things to remember:

1. All the resistors should be of 1 % tolerance and capacitor C6, C8, C11, C13, C16, C18, C21, C23, C26, C28, C56, C57 are styroflex to obtain stability and to avoid drift in operation. Use only 74HC4053 high speed switching IC to achieve good results especially in higher bands.
2. SSB filter should be shielded with a metal case and grounded.
3. Use 1 + 2 shield wire for audio and RG174 & RG58C/U for RF inter connections.
4. Good quality heat sinks should be used for Q8 , Q9 , IC5 and a large (6 X 3.5 inches) heat sink for FETs. use heat sink compound applied both the sides of mica washers.
5. Shield VFO and the PA with small boxes made with soft ms sheet.
6. Beware of static damage while handling FETs, microcontrollers etc. Ground your soldering equipment and unplug from mains while soldering such devices.
7. Use 50 ohms/100W dummy load and carry your initial testing of your rig. Don't shout haaaalo--- haaaalo---- halo on air and create QRM to others. Identify yourself on band to get critical reports and certainly these reports shall help you to improve the performance of the rig.

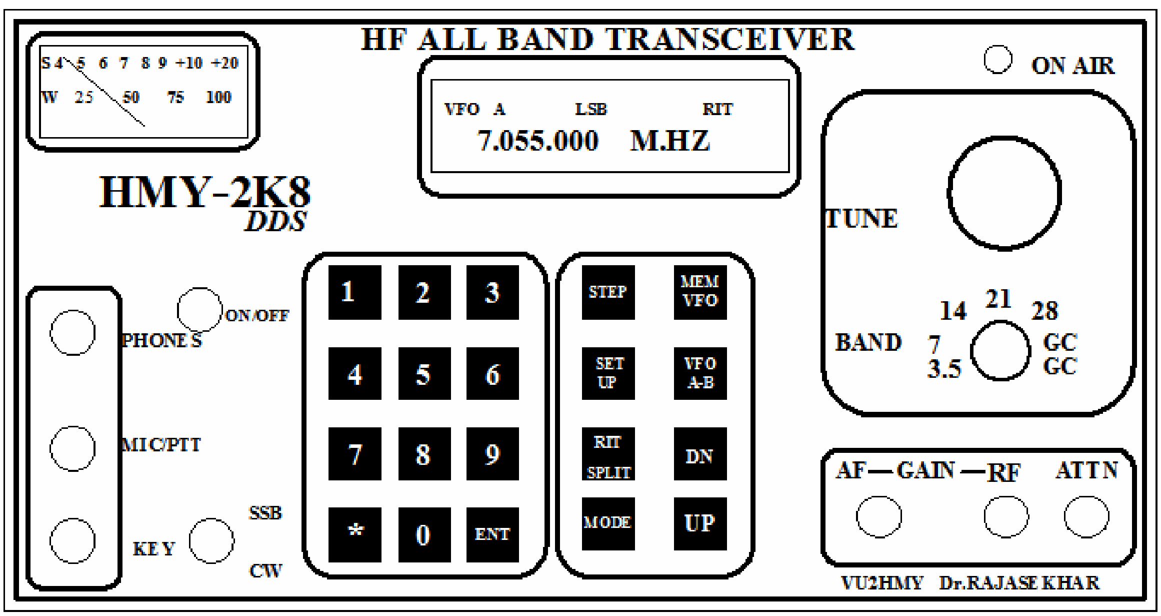


Fig1: The front panel layout used for the multi band transceiver (8.5 X 4.5 inches).

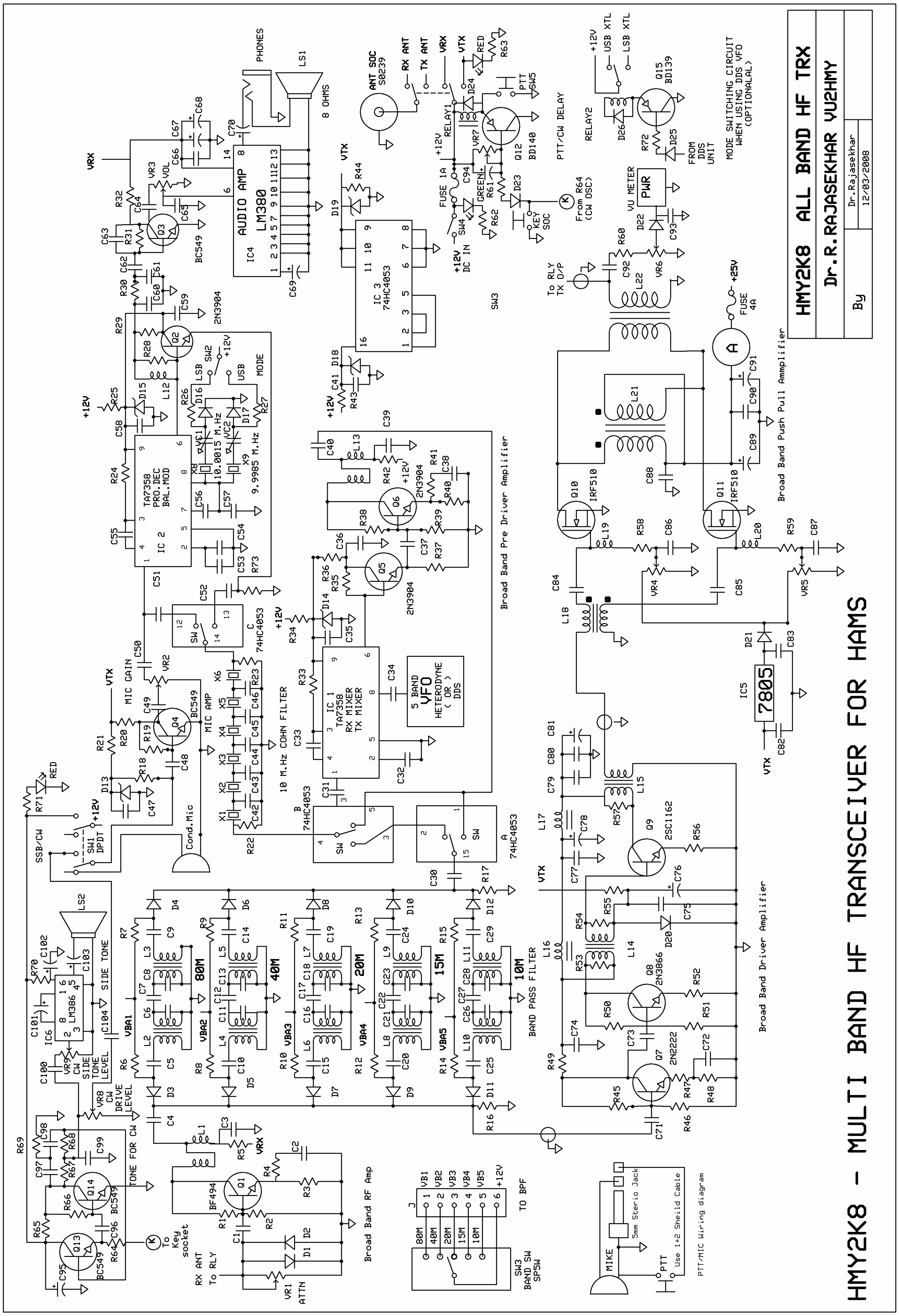


Fig 2: The schematic circuit diagram of multi band HF transceiver HMY2K8

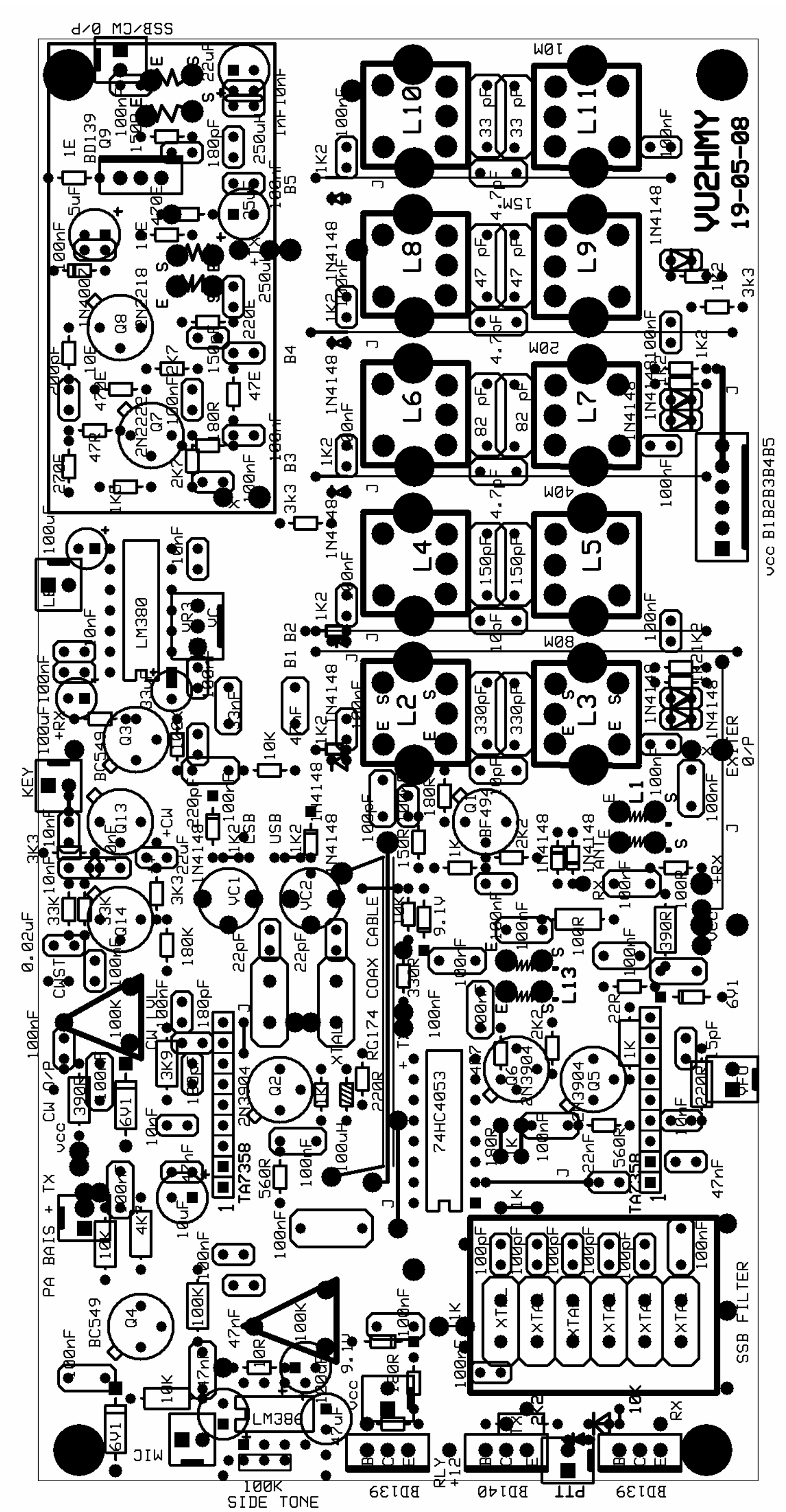


Fig 3: Component layout of HMY2K8 multi band transceiver (7 X 3.5 inches).

List of components:

Resistors:

R1, R38	2K2	R52	10R
R2, R22, R23, R35, R39, R61	1K	R53	220R* Adj
R3, R40, R43	180 R	R54	10R* Adj
R4	150 R	R55	470R
R5, R42, R70	100 R	R56	10R ½ W
R6 – R15, R26, R27, R46	1K5	R57	220R* Adj
R16, R17, R65, R69	3 K3	R58, R59	33R
R18, R21, R30	10K	R60	47K
R19, R31	100K	R62, R63	1K5
R20, R28, R32, R64	4K7	R66	180K
R24	3K9	R67, R68	33K
R25, R34	390R	R72	15K
R29	220R	VR1	1K Lin Pot
R33	220R * Adj	VR2, VR6 – VR9	100K Preset
R36	22R	VR3	100K Log Pot
R37, R73	560R	VR4, VR5	4K7 Preset
R41	4R7	Note: All are ¼ W Unless otherwise specified	
R44	330R		
R45, R50	2K7		
R47, R49	47R		
R48	270R		
R51	470R		

Capacitors:

C1 – C5, C9, C10, C14, C15, C19, C20, C24, C25, C29, C35 – C41, C47 – C52, C58, C59, C62, C64, C66, C71, C73 – C75, C77, C82 – C88, C100, C104 -	0.1 uF	C32, C54, C60	0.047uF
		C34	10pF
		C42 – C46	82pF
		C53	10uF
		C56, C57	- 180PF Styroflex
C7, C12, C17, C22, C27, C92 -	10Pf	C61	0.033uF
C6,C8	330pF styroflex	C63, C72	220pF
C11, C13	150pF Styroflex	C76	4.7uF
C16, C18	82pF Styroflex	C78, C81, C94, C95	22uF
C21, C23	47 pF Styroflex	C79	0.001uF
C26, C28	33pF Styroflex	C89	100 uF/63 V
C30	100Pf	C90	0.01uF /63V
C31	22nF	C91, C101	1uF/63V
C33, C55, C65, C93, C96 – C98	0.01uF	C99	0.02 uF
C67, C80	0.01uF/63V	C102, C103	47 uF
C68	100 uF/25V	VC1, VC2	22 pF Philps Trimmers
C69	33 uF /25V		
C70	100 uF		

Diodes:

D1 – D12, D16, D17, D22, D23	1N4148
D20, D21, D24, D25	1N4001
D13, D14. D15	6.1 V / ½ W Zenar
D18, D19	9.1 V / ½ WZenar

Transistors:

Q1	BF494	Q9	2SC1162 (or) BD139
Q2, Q5, Q6	2N3904	Q10, Q11	IRF510
Q3, Q4, Q13, Q14	BC549	Q12	BD140
Q7	2N2222A	Q15	BD139
Q8	2N3866		

IC'S:

IC1, IC2	TA7358	IC5	7805 Regulator
IC2	74HC 4053	IC6	LM386
IC4	LM380		

X-TALS:

X1 – X6	10.0000 M.Hz	* See text
X8	10.0015 M.Hz	* See text
X9	9.99850 M.Hz	* See text

Switches:

S1 - DPDT, S2 - SPDT, S3 - 1 Pole 5 Way, S4 - SPST

Relay1 - 12V DPDT, Relay2 - 12V SPDT Mini (If DDS VFO is used)
Condenser mike – 1, LED's Green – 1, Red - 2, Speaker - 8 Ohms/ 2W - 1
Mini speaker / Piegeo element - 1, Fuse holders – 2, Fuse 1A -1, Fuse 4A – 1
6 pin RNC connector – 1, 5 mm Stereo Sockets – 2, 5mm mono Socket -1
VU meter – 1, Heat sinks for BD139, 2N3866, 7812 and 6 X 3.5 X 1 inches for PA.

Coil winding data:

L1, L13 – Bifilar, 10 turns on 10 mm torroid with 28 SWG
L12 – 50 turns on ferrite dumbbell with 45 SWG
L14 – Pri- 30 turns and Sec – 4 turns with 28 SWG on 10 mm torroid.
L15 - Pri – 6 and Sec 4 with 28 SWG on 10 mm torroid or on TV balun.
L16, L17 – 25 turns on 10 mm torroid with 28 SWG.
L18 – Bifilar 10 turns on 12 mm torroid with 28 SWG
L19, L20 – 9 turns 6 mm dia air core with 20 SWG
L21 – Bifilar 10 turns on 25mm torroid with 20 SWG
L22 – Pri – 2 turns and Sec – 3 turns on HF BALUN core formed by six 10 mm Torroid cores with 20 SWG teflon hook up wire (used in submersible motors)

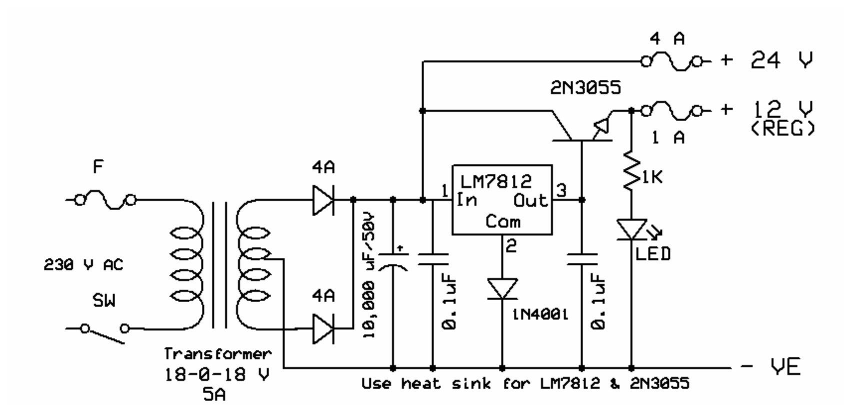
Coil winding details for Band pass filter:
Slug tuned 10 mm former (Preferably with slots for split winding and ferrite cup over former). 36 SWG or thinner enamel copper wire.

Turns

BAND	COIL	PRI	SEC	COIL	PRI	SEC
80 M	L2	3+2	8+9+9+8	L3	8+9+9+8	3+2
40M	L4	3+2	5+6+6+5	L5	5+6+6+5	3+2
20M	L6	3+2	3+5+5+3	L7	3+5+5+3	3+2
15M	L8	1+1	2+4+4+2	L9	2+4+4+2	1+1
10M	L10	1+1	2+3+3+2	L11	2+3+3+2	1+1

Power supply:

The exciter requires 12 V / 1 A depends upon the type of VFO / Display and PA needs 24 V / 4 Amp to get maximum RF O/P. I have got 35 W DC PWR I/P even with 12V car battery and had several contacts. The following circuit diagram can be used for PSU. Use rated fuses and good heat sinks for LM7812 and 2N3055.



Power supply unit for HMY2K8 - Multi band transceiver

Fig 4:

Acknowledgements:

I am thankfull to VU2RVK and VU2WMJ for their constant support especially monitoring my signal and giving reports. I thank VU2RM and VU2SV for their critical suggestions to improve the final performance of the rig especially on improving CW oscillator. I thank our UV hams VU2NR, VU2VWN, VU2RM,VU2ATN, VU2IF, VU2EM, for their great contribution in designing and publishing successful homebrew rigs and kept many hams on air.

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Guardian angel of my happy HAM home, my XYL Dr. Ashalatha and my harmonics Hannu and Minnu were more keen on my academic and research activities rather than domestic chores and kept me scintillating with vigour always and never allowed any situation that would dampen my enthusiasm for ham radio.

73. Happy home brewing. **DE VU2HMY, Sekhar.**