Introduction

The version 3 of sBitx circuit has moved from IRFZ24N in the power amplifier to the IRF510. This decreases the nominal output of the lower bands from 40 watts to 25 watts. This is about 1 dB of difference to the perceived signal strength on air. However, this results in some major gains in terms of resilience to heat, overdrive, etc.

Please note that the sbitxv3 software continues to work with all legacy circuits as well. The software and the circuit are independent of each other.

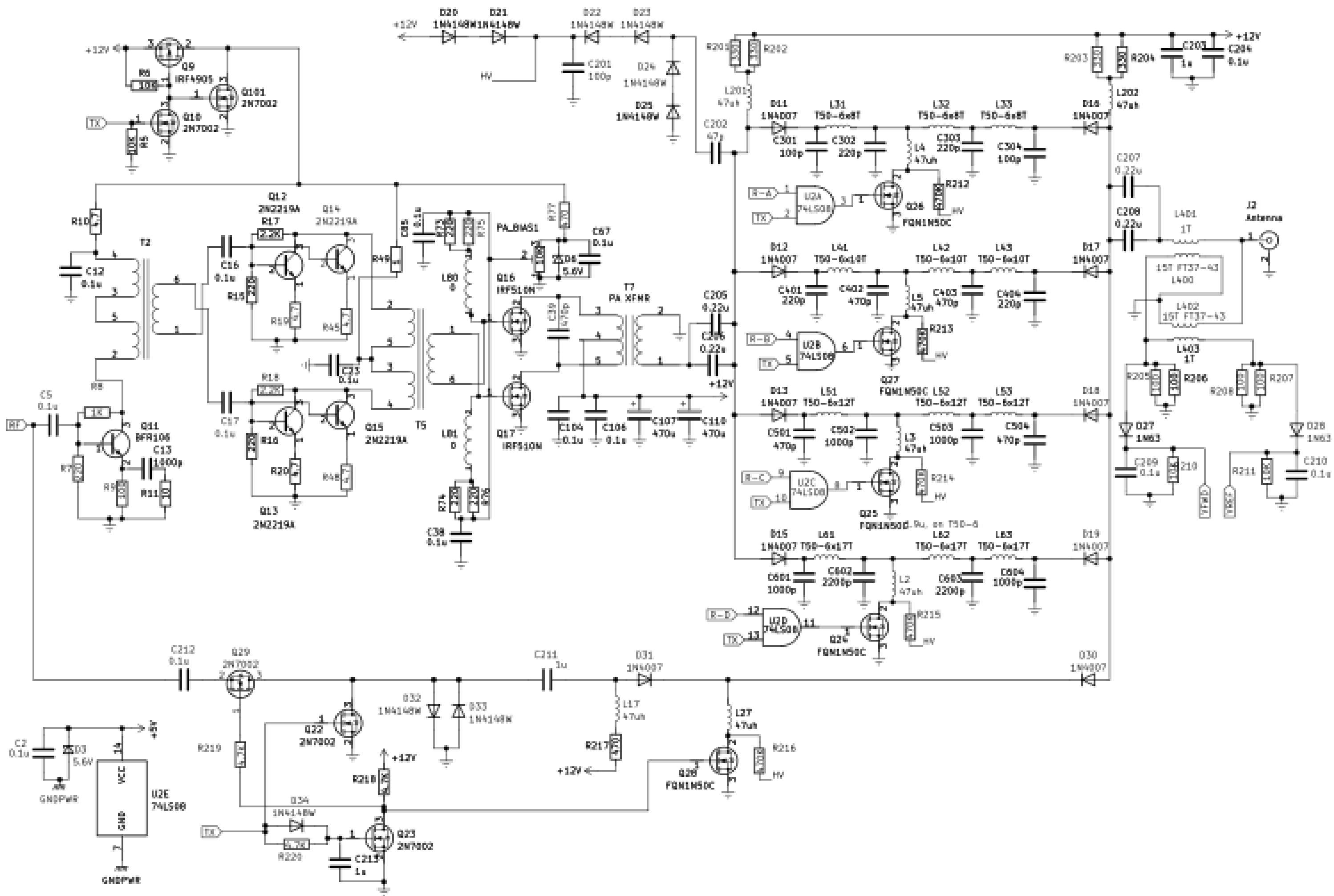
sBitx V3 changes in the circuit.

The main changes are:

1. Decreased the gain and the idling current of the predriver to limit the output to reasonable levels. This affects R8 (from 2.2k to 1K), R7(from 470 to 220), R9 (from 47 to 100), R11 (from 4.7 to 10).
2. The PA gate bias was through an inductor in series with 50 ohms resistors (formed out of two parallel 100 ohm resistors). The inductors L80 and L81 are eliminated and replaced by a short-circuit (a jumper wire). The bias resistors that also act as gate load are now 100 ohms each. Replace the R73, R74, R75 and R76 from 100 ohms to 220 ohms.
3. The standing current in the diodes that switch the LPFs was found insufficient on 3.5 MHz, hence, the resistors R201, R202, R203 and R204 are changed from 470 ohms to 330 ohms.

It is also highly recommended that you install the Transient suppressor diode CDSOD323-T08C across the gate and source of the PA transistors. These are expensive to buy in retail but they are available on Mouser.com.

The changed circuit is as follows (The updated circuit is also on the github on https://github.com/afarhan/sbitx/blob/main/sbitx_v3_production.pdf):



+12V
D20 1N4148W
D21 1N4148W
D22 1N4148W
D23 1N4148W
D24 1N4148W
D25 1N4148W
C201 100p
HV
Q9 IRF4905
Q101 2N7002
Q10 2N7002
R6 10K
R5 10K
TX
R10 4.7
C12 0.1u
T2
R8
RF
C5 0.1u
1K
Q11 BFR106
C13 1000p
R7 220
R9 100
R11 10
Q12 2N2219A
Q14 2N2219A
R17 2.2K
C16 0.1u
R15 220
R19 4.7
R45 4.7
C17 0.1u
R18 2.2K
R16 220
R20 4.7
R48 4.7
Q13 2N2219A
Q15 2N2219A
C23 0.1u
T5
R49
C85 0.1u
R73 220
R75 220
R77 470
PA_BIAS1
C67 0.1u
D8 5.6V
L80 0
L81 0
Q16 IRF510N
Q17 IRF510N
C39 470p
R74 220
R76 220
C38 0.1u
T7 PA XFMR
C104 0.1u
C106 0.1u
C107 470u
C110 470u
C205 0.22u
C206 0.22u
C202 47p
R201 330
R202 330
L201 47uh
D11 1N4007
L31 T50-6x8T
C301 100p
C302 220p
L4 47uh
L32 T50-6x8T
C303 220p
L33 T50-6x8T
C304 100p
D16 1N4007
R-A
U2A 74LS08
Q26 FQN1N50C
R212 470K
D12 1N4007
L41 T50-6x10T
C401 220p
C402 470p
L5 47uh
L42 T50-6x10T
C403 470p
L43 T50-6x10T
C404 220p
D17 1N4007
R-B
U2B 74LS08
Q27 FQN1N50C
R213 470K
D13 1N4007
L51 T50-6x12T
C501 470p
C502 1000p
L3 47uh
L52 T50-6x12T
C503 1000p
L53 T50-6x12T
C504 470p
D18 1N4007
R-C
U2C 74LS08
Q25 FQN1N50C
R214 470K
D15 1N4007
L61 T50-6x17T
C601 1000p
C602 2200p
L2 47uh
L62 T50-6x17T
C603 2200p
L63 T50-6x17T
C604 1000p
D19 1N4007
R-D
U2D 74LS08
Q24 FQN1N50C
R215 470K
R203 330
R204 330
L202 47uh
C203 1u
C204 0.1u
C207 0.22u
C208 0.22u
L401 1T
J2 Antenna
15T FT37-43
L400
L402 15T FT37-43
L403 1T
R205 100
R206 100
R208 100
R207 100
D27 1N63
D28 1N63
C209 0.1u
R210 10K
R211 10K
C210 0.1u
VFWD
VREF
C212 0.1u
Q29 2N7002
C211 1u
D31 1N4007
D30 1N4007
Q22 2N7002
D32 1N4148W
D33 1N4148W
L17 47uh
R217 470
L27 47uh
R216 470K
Q28 FQN1N50C
R219 4.7K
R218 4.7K
D34 1N4148W
R220 4.7K
C213 1u
Q23 2N7002
C2 0.1u
D3 5.6V
+5V
GNDPWR
VCC
GND
U2E 74LS08

Software settings for the v3 circuit

After these changes, a new hw_settings.ini has been generated. Due to lower and more controlled gain distribution, **txcal is no longer needed**.

The new hw_settings.ini to be used with the v3 PA circuit is part of the github main branch at https://github.com/afarhan/sbitx/blob/main/data/hw_settings_v3.ini.

Performance Data

This is the power output reference for measured RF voltages of sbitxv3 with IRF510s in the TX transmit power chain:

1. Predriver is a BFR106 with 1K feedback, 220 ohms base to ground, 100 ohms emitter bias and 10 ohms emitter degeneration (through a 470 pf). The 470 pf works to reduce the amplification at lower frequencies.
2. The 2N22219 x 4 driver has 2.2k as collector-base feedback and 220 ohms between base and ground. All emitters have 4.7 ohms from emitter to ground.
3. The IRF510s have 2 x 100 ohms resistors on each gate routed to the bias circuitry. There are no inductors in series with the effectively 50 ohms resistors.
4. Bias is set to 500mA (over 0.085 A tx draw at zero bias), effectively approx 1.35A total radio drain at Mic and Drive set to zero on USB
5. All the RF voltages are measured peak to peak by Rigol-1052 with: Horizontal Scale set to 500 us, channel 1 is 20v/div and channel 2 varies with the voltage range
6. IMDR measured with 2 tone, spectrum analyzer at 10 KHz span and 300 Hz resolution bandwidth.
7. Spur measurements at 70 MHz span, 10 KHz resolution bandwidth

Freq (KHz)	Scale*	Q11 collector	2N2219 A Base	2N2219 A Collecto r	IRF510 gate	PA Out (second ary)	LPF Input At the Diode cathode)	LPFoutput At the diode cathode	At RF Dumm y load	Total Curr ent	IMDR**	Worst Spur
3535	0.004	1.4V (unbal)	450mV	22V	11.5V	96V	96V	103V	100V 25W	4.6A	-35DB	7.07 MHz -44 dBc

7035	0.0037	2.7V	900mv	25V	16.6V	96-92V	106~	106-90V	105 25W	6.5A	-20dB	< -50dBC
10135	0.004	3.8V	1.3V	23.5V	15V	115V~	118~	105~	98 25W	5.6A	-19dBc	-49dBC 40 MHz
14035	0.006	5.6V	2V	29V	16.8V	99V~	103V	96V	90V 20W	5.2A	-18dB	-45dBc, 42 MHz
18035	0.006	4.4V	1.4V	20V	12.5V	174V?	188V	95V	88V 20W	4.5A	-21dB	-49 dBc, 54 MHz
21035	0.007	5.4V	2,56V	25v clipped	15.2	~110V	137V	88V	90V 20W	4.7A	-21dB	-43 dBc, 63 MHz
24895	0.006	3.6	1.68	19V	12.6	90V	91	70~	68V 11W	3.75 A	-23dB	-48dBc,
28035	0.006	5.4V	2.5V	17V	12V	88V	94V	60V	60V 9W	3.9A	-23dB	-50dBC, 56 MHz

* Scale for each band is set in data/hw_settings.ini
** Note that the IMDR figures are not how the ARRL measures. These 2 tone IMD figures are with respect to one of the two tones. The ARRL measures the distortion figure with respect to the peak envelope power. For comparison, you have to increase the IMDR by another 6 db. For instance, the -18 dBc IMDR of 14.035 Mhz, by the ARRL method would be -24 dBc.

The Exciter

The exciter portion has constant gain across the bands. It is software controlled to provide varying outputs. It is enough to test it on one band to know how it works everywhere else. The following is the RF and baseband outputs at various places in the circuit.

> Test setup Freq: 28035 KHz, scale factor: 0.006, Mode: CW, measured on a Rigol Ds-1052E with a P6100 at 10x, at 500us timebase.

Test Point	RF peak to peak
C212 (Output of the LPF), clean CW	600 mV
C4 (Output of the crystal filter), it will be dirty	830 mV
C64	2V
C63	1.2V
C60	1,4V
C58	1.6V
C56	1.36V
C52	2V
C45 (Output of the IF amp), it will be DSB	2.8V
C65 (Output of the modulator, after the pad) 400us	400mV~
R56 (Input of the modulator)	900mV~

Testing the crystal filter

Test setup

1. Set the mode to CW
2. Drive to 100
3. frequency to 28.035 MHz
4. Turn down the PA bias to prevent large PA out

On CW tx,

Conclusion

The IRF510 PA performs better and the spurs are now all well below the FCC limits. The power reduction after powering up remains a curiosity but the reduction is very nominal and will not affect any performance.

I am not aware of any other circuit that has managed to generate 25 watts from a pair of IRF510s at 13.5 v.