Bodan SIX - 6M Transceiver Kit

A kit by the DL-QRP- AG
Designed by DK1HE
(Manual translated to English by PA3HBB)

General Introduction

This booklet describes a homebrew transceiver for the fascinating 50MHz band without investing a lot of money, you too can explore this band. The cost of this kit is comparable to most of the low-cost 6M transverters but without the need for a separate driver transceiver.
The kit produces a clean 1-watt CW (A1A) signal and using a relatively small - about the size of a 3 element band I TV antenna you will hear and work lots of DX with this kit.
Thanks to the compact design of the kit, it can easily be used for portable work.
Here are a few of the major points of interest about the kit:

- Stand-alone design - just supply 11 - 15 VDC (@ 250mA)
- Excellent performance using standard parts (no SMD)
- Superb price vs. performance ratio
- Lightweight for portable use
- Small size (Eurocard sized - 100x160mm)
- Approximately 1.2 Watts of RF
- Sensitive direct-conversion receiver
- CW sidetone and auto-offset on transmit
- Clear documentation

The entire radio fits onto a standard Eurocard (100x160mm) (4"x6.5") and can be fitted to a standard Eurocard box. It has stable RF characteristics by using a double-sided PCB with one side devoted to a ground-plane.

Description of the Circuitry

1. Send and Receive Oscillator

Based around T5 (BF199), the oscillator is a Colpitts configuration with tuning provided by varicap diode D3 (BB109 or BB139) which is tunable via the front panel potentiometer P6 (main tuning). The crystal operates at 25.065MHz and is tuned to oscillation by L11, C40, C37 and C38. This signal is fed to T5 and the second harmonic is extracted with L10 to obtain a frequency of approximately 50.130MHz. With D3, the frequency can be "pulled" approximately 20KHz in each direction - giving a range of approximately 40KHz for the VFO. There is space on the PCB to fit a second crystal Q2 (same fundamental frequency) to increase the VFO range, if required.
The 2nd harmonic signal from L11 drives both the transmitter and the direct conversion receiver.

1. *The Transmitter Section*

The 50MHz VCXO signal goes via R15 to gate 1 of the buffer/driver MOSFET T4. R11 keeps this stage operating in Class-A mode. When in receive, Gate 2 of T4 has a small voltage (~1Volt) present supplied through R8. This effectively de-couples the capacitive effects of the inactive transistors T1 and T2 - so they do not affect the receiver. The drain connection on T4 is coupled inductively (via R7) to a tank circuit consisting of L9, C25 and C26**. R15 acts as a parasitic choke**. Resistors R5 and R6 hold T2 in Class-B. T2 is the driver following the buffer T4 and produces about 50mW ready to drive the final amplifier T1. L6, C18 **and C19** provide a 50MHz filter to damp unwanted oscillations prior to the signal going to the final amplifier T1. The PA operates in Class-C and produces about 1.2 Watts of RF at 50MHz with 13.5 Volts. T1 is a multi-emitter transistor (2N3553). Other PA transistors were tried, including the usual 2N3866 but were found to unstable at the high frequency. Following the PA transistor is a PI circuit filter and transformer made from C8, L4 and C7. This filter does two jobs, first it damps the harmonics and second it transforms the ~85 Ohm impedance of the PA down to ~50 Ohms. C7 and C8 should be tuned for maximum RF output. R1 and R2 along with the two chokes DR1 and DR2 kills any unwanted self-oscillations, C10, C11 and C12 are used to filter the power line to keep the PA stable under load. Because the PA is operating in Class-C the second harmonic is strong and this is filtered using a three-stage low pass filter consisting of L1 to L3 and C1 to C6. The cut-off frequency of this filter is 55MHz and in only introduces a 0.7dB loss at 50MHz. This filter also works to provide the front-end selectivity of the receiver.

1. *Keying and Transmit/Receive Switching*

Pressing the Morse key switches the bias voltage on transistor T7 to make the +9V-S (+9V Send) line active and via T9 and T10 inactivate the +9V-E (Emphang - German for Receive). This switch (T9) also enables IC4 to create the side-tone. It also disables the RIT by lifting the voltage at the base of T8 and applies power to the TX LED.
The keying is full break-in and C59 and C60 suppress key-clicks and ensure a clean switching signal.

1. *Receiver Section*

From the antenna socket the signal passes through the low pass filter and is routed to the receiver via C14, it is fed through a tuned circuit consisting of C15, L5 and C16 to a JFET (T3) that acts as a small signal amplifier.
When in receive, the PA transistor (T1) is completely isolated. The pin-diode (D1) clamps this part of the circuit when the rig is transmitting.
Following T3 is a bandpass filter made from L7, C21 and L8, C22. The coupling loop in L8 provides approximately 12dB of pre-amplifier gain to the input of the direct conversion mixer NE612 (IC1). The pre-amplifier uses this gain to overcome the losses in the conversion process (approximately 5dB) and minimize the signals from band I television. At the input to the mixer, the signal should be approximately 5µV of receive signal.
The NE612 mixer uses the signal from the main oscillator (coupled via R14 and C32) as the Local Oscillator (LO) input on pin 6 of IC1. R14 reduces the

strong oscillator signal from the VCXO to a better value for the mixer (approximately 200 to 300mV).
The input on pins 1 and 2 of IC1 are subtracted from the LO on pin 6 and the audio is output on pins 4 and 5 of IC1. C30 and C31 provide a filtering action to create an audio bandwidth of approximately 2kHz and improve the frequency selectivity.
The clean audio signal is connected (via C33 and C34) to an operational amplifier TL-071 (IC6) where the signal is boosted by approximately 26dB. This strong audio signal is then routed to two identical active cascading CW filters in a dual op-amp TL-072 (IC7). This filter creates a 3dB bandwidth of approximately 150Hz with a loss of about 6dB that can be adjusted (with P4 and P5) to peak the filter at 750Hz. P4. P5 adjusts the center frequency of the filter. The resulting channel selection of these filters creates an excellent receiver.
After C67 and the volume control (P8), the signal is fed into a final audio amplifier (LM386 IC2), providing approximately 0.5Watts of audio with a gain of approximately 46dB. This is fed (via C45) to a speaker with minimum impedance of 4 Ohms.
When switching to transmit, the audio input to the final amplifier (IC2 pin 3) is muted via a pin diode D6 and transistor T6. The inverted input to the final amplifier is connected to IC4 and provides a 750Hz tone to the final amplifier to create a sidetone. Variable resistor P1 sets the volume level of the sidetone. IC4 is activated only when the rig is transmitting.

5. Frequency control and RIT

A varicap diode (D3) and the main tuning pot (P6) control the frequency. P6 and R57 provide a tuning voltage of 1 to 9 volts to the varicap diode and this controls the main frequency.
The RIT offset is generated with an op-amp (TL-082 IC5) and injected at the crystal, effectively altering the voltage on the varicap diode and thereby the capacitance and thus the frequency. It is disabled during transmit by T8. IC5 is used to provide a more linear operation to the otherwise non-linear capacitive effect of D3 and to allow both positive and negative offsets from the main tuning frequency. Pot P2 sets the center point of the RIT shift and pot P3 sets the offset shift (750Hz).

6. Voltage Stabilization

Using varicap diode tuning creates the need for a stable and constant voltage in the rig. Otherwise drift will appear on both TX and RX. This voltage stabilization is easily provided using a 9Volt IC regulator (7809 IC3). This device can be comfortably and conveniently driven from 11 to 15 volts DC.

Building the BODAN-Six 50MHz-QRP-Transceiver

1. Building the PCB

There is nothing special you need to know about building the PCB for the Bodan-Six. The PCB plan shows the placement of the components. The Pi

filter on the output of the transmitter needs to damp the harmonics- this is achieved by winding the coils and mounting them as close as possible to the PCB. The prototypes had a tuning range of 50.102 to 50.140 MHz. The PCB allows for paralleling 2 quartz crystals to achieve a wider tuning range, but in the prototypes this was not tested.
The voltage regulator (IC3) gets a little warm under normal use - add a heatsink, if you feel the need.
The height of the heatsink on the PA transistor should be no more that 1/2" and is not supplied with the kit. A small clip-on finned heatsink is ideal.
All of the ICs should be directly mounted to the PCB without using sockets.
An easy way to wind the coils for the PI filter is to use a 7mm drill-bit as a former. (See the section " Coil Winding Details")

1. *Housing the Bodan-Six*

For optimum performance the RF output connector should be connected to the back panel of the metal case and via the shortest possible leads to pins 1 and 2 of the PCB. The shell of the connector should be grounded to the case as well.
For better frequency control you might want to change the main tuning pot for a 10-turn version.

Aligning the Bodan-Six Transceiver

1. *Aligning the CW Filter*

- Connect a 750Hz sine wave signal generator (sidetone of another radio…) via a 220K Ohm pot to pin 4 of IC1.
- Connect an oscilloscope or AF voltmeter across the speaker pins (13 & 12). Set the volume control (P8) to the middle. Adjust the 220K pot so you can just see/hear the signal.
- Adjust pots P4 and P5 for a maximum on your test equipment.
- If you don't have a sine-wave generator, you can use a general coverage receiver in SSB mode tuned to an AM carrier and adjust the tuning to be 750Hz off the zero-beat frequency - giving you a 750Hz tone.

1. *Aligning the VCXO*

- Set the RIT pot (P7) all the way to the left (grounded end) and the main tuning pot (P6) all the way to the right (+9Volts).
- Set the core of L10 to be ???
- Connect a suitable frequency counter across C36 and adjust L10 and L11 to get a reading of 50.140MHz. If you don't have a frequency counter, you can also use a general coverage receiver or a scanner with a digital display to get an accurate reading.
- Turn the main tuning pot (P6) all the way left and the frequency should be around 50.102MHz

1. *Aligning the Transmitter*

- Set the main tuning pot (P6) to 50.130MHz
- Set the cores in L9 and L6 to ?????
- Set trimmer capacitors C8 to 1/4 meshed and C7 to 1/2 meshed
- Connect an in-line power meter and a dummy load to the antenna socket

- Connect a morse key to the Key socket
- Connect the power through a multimeter to read the current consumed.
- Press the Morse key down the rig should switch to transmit.
- Adjust L10 and L9 for maximum power output, and then adjust L6. Keep adjusting these 3 cores until you get a peak output. Keep the transmissions short to avoid overheating the PA during the tuning process.
- Adjust C7 and C8 for maximum power out - this should be approximately 1.2Watts with the rig taking approximately 230mA of current from a 13.8Volt supply.
- Sweep the main tuning pot across the entire range and the output should not vary more than about 100mW.

1. *Aligning the Receiver*

- Connect the speaker???
- Turn the RIT pot all the way to the left (grounded end).
- Set the main tuning pot to approximately the center position
- Connect an unmodulated (carrier only) RF signal generator to the antenna socket. (If you don't have an RF signal generator, you can use a GDO or antenna analyzer coupled to 4 or 8 inches of wire to the RF input connector (or another radio transmitter running into a dummy-load with the wire wrapped around the coax of the transmitter.
- Adjust L8, L7 and L5 for maximum signal. Reducing the power of the signal source as required, until a maximum has been reached.

1. *Setting up the RX/TX and the RIT*

- Set pots P2 all the way to the left (+9V side) and P3 to the center position.
- Set the RIT pot (P7) all the way to the left (grounded side)
- Set the main tuning pot (P6) all the way to the right (so frequency is 50.140 MHz)
- Set the RF generator so that the zero-beat is heard on the Bodan-Six.
- Move the RIT pot (P7) to the center and, using pot P3, adjust the tone to be 750Hz. This should be a loud signal as the CW filters are aligned and only 150Hz wide.
- Turn the main tuning pot (P6) fully left to the lowest possible frequency.
- Set the RIT pot (P7) all the way to the left (grounded side)
- Zero-beat the RF signal generator (or other RF generating device) with the rig.
- Adjust pot P2 for a 750Hz signal.
- Move the main tuning pot (P6) to the middle, it is possible that the center tone will vary a little - adjust P2 for a compromise frequency.
- Test the offset at the bottom, middle and top of the VCXO range. Adjusting P2 as required, to obtain a reasonable compromise. This is necessary due to the non-linearity of the varicap diode (D3).

In normal QSO mode, set the RIT to the center position and when you transmit you will be transmitting on the zero-beat frequency of the received station as the RIT is switched off during transmit.

Have fun and we hope you learned something.

We wish you a lot of success on the air with your homebrew Bodan-Six QRP Transceiver.

Coil Winding Details

L1, L2, L3 and L4 are all the same - Air-spaced close wound. Use a 19mm length of 1mm Enamel Coated Copper Wire (ECW) (not supplied) and wind 6.5 turns around a 7mm drill-bit. Clean and tin the ends of the coils so that they can sit flush on the PCB. These coils form the output filter and it is important that they are very similar.

Locate the Neosid 7.1S coil formers (2.5mm diameter) and the tuning slugs (F40 Ferrite material) for these. Note that the ferrite cap is only fitted to L11.

L5, 10 turns of 0.2mm ECW
L6, 7 turns of 0.2mm ECW
L7, 10 turns of 0.2mm ECW
L8, 10 turns 0.2mm ECW with a coupling winding of 5 turns (0,2mm ECW) on the cold end
L9, 10 turns 0.2mm ECW with a coupling winding of 5 turns (0,2mm ECW) on the cold end
L10, 10 turns 0.2mm ECW with a coupling winding of 3.5 turns (0,2mm ECW) on the cold end
L11, 20 turns of 0.15 ECW and the ferrite cap

Check the circuit diagram to ensure that you solder the connections to the correct pins on the coil-former and be very careful when placing the metal covers over the windings that you do not cut into the coating on the wire.
For the cores that have coupling windings (L8, L9 & L10) use a small amount of epoxy to hold the windings in place - remember, this is VHF - not HF and a small movement in the winding couplings can really affect the performance.
Solder coil ends to the pins on the coil former quickly and then after checking everything is correct, solder the coil-former assembly into the PCB. Only after checking that all is correct should you attempt to solder the metal covers in place.

Part Number	Value	Number in kit of the value	(tick here when installed OK)
R1 R5 R34	1K	3	| | |
R2	150R	1	|
R3 R14 R16 R57	1K5	4	| | | |
R4 R54 R55	330R	3	| | |
R6	18K	1	|
R7 R15	27R	2	| |
R8 R9 R10 R19	100K	4	| | | |
R11 R29 R32	56R	3	| | |
R12	470R	1	|
R13	33R	1	|
R17 R18	47K	2	| |
R20	680R	1	|
R21	220R	1	|
R22	5R6	1	|
R23 (vertical)	4R7	1	|
R24	10R	1	|
R25	22K	1	|
R26 R40 R41	12K	3	| | |
R27	270K	1	|
R28	4K7	1	|
R30 R42	8K2	2	| |
R31	82K	1	|
R33	27K	1	|
R35	22R	1	|
R36 R46 R47	10K	3	| | |
R37	5K6	1	|
R38 R39 R50 R52	39K	4	| | | |
R43	39R	1	|
R44 R45 metal film	15K	2	| |
R48 R49 metal film	330K	2	| |
R51 R53 (vertical)	150K	2	| |
R56	820R	1	|
C1 C2 C3 C4 C5 C6	56p	6	| | | | | |
C7 trimmer	90p	1	|
C8 trimmer	25p	1	|
C9 C10 C13 C17 C19	4n7	5	| | | | |
C20 C24 C27 C28 C29	4n7	5	| | | | |
C11 C50 C57 C60 foil	0.1u	4	| | | |
C12 C47 C48 C55 radial	10u	4	| | | |
C14	2p7	1	|
C15 C21 C22 C35	18p	4	| | | |
C16 C38	100p	2	| |
C18	33p	1	|
C23 C40	820p	2	| |
C25	22p	1	|

Part Number	Value	Number in kit of the value	(tick here when installed OK)
C26	68p	1	|
C30 C31	47n	2	| |
C32	1n	1	|
C33 C34 C59 foil	0.47u	3	| | |
C36	82p	1	|
C37	150p	1	|
C39 C41 C42 C44	10n	4	| | | |
C43 C45 C61 C62 radial	100u	4	| | | |
C46 radial	220u	1	|
C49 foil	0.047u	1	|
C51	3n3	1	|
C52 radial	470u	1	|
C53 C54 tantalum	1u	2	| |
C56 foil	0.01u	1	|
C58 C67 radial	1u	2	| |
C63 C64 5% foil	15n	2	| |
C65 C66 5% foil	15n	2	| |
IC1	NE612	1	|
IC2	LM386N	1	|
IC3	LM7809	1	|
IC4	NE555	1	|
IC5	TL082	1	|
IC6	TL071	1	|
IC7	TL072	1	|
T1	2N3553	1	|
T2	2N2369	1	|
T3	BF244	1	|
T4	BF982	1	|
T5	BF199	1	|
T6 T10	BC337-40	2	| |
T7	BC327-40	1	|
T8 T9	BC546B	2	| |
D1 switcher	BA479S	1	|
D2 D6 switcher	1N4148	2	| |
D3 varicap (BB109)	BB139	1	|
D4 zener (BSX6.8)	ZPD6.8	1	|
D5 power	1N5402	1	|
Q1	25.065	1	|
L5 L6 L7 L8 L9 L10 L11	7.1S	7	| | | | | | x
CORES Neosid F40	F40	7	| | | | | | x
CAP Neosid 40	F40	1	|

Part Number	Value	Number in kit of the value	(tick here when installed OK)
Dr1 Dr2 Dr3 Dr4 chokes	4u7	4	| | | |
P1 linear trimmer	100R	1	|
P2 linear trimmer	47K	1	|
P3 linear trimmer	22K	1	|
P4 P5 lin 10X trimmer	2K	2	| |
P6 linear pot	10K	1	|
P7 linear pot	1K	1	|
P8 log pot	2K2	1	|
Fuse holder ends	Clip	2	| |
F1 Fuse	1 A	1	|
S1 Switch	Toggle	1	|
J1 Key 3.5mm	Mono	1	|
J2 Headphone 3.5mm	Stereo	1	|
J3 Power socket 2.1mm	DC type	1	|
J4 RF connector	BNC	1	|
LEDs 5mm pwr/TX	red	2	| |
Eurocase 160X100	Case	1 (optional)	|
P6 Tuning knob	20mm	1	|
P7 P8 Vol/RIT knobs	15mm	2	| |
Tuning knob cover	20mm	1	|
Vol/RIT knob cover	15mm	2	| |
PCB	Pcb	1	|
Instructions	Inst	1	|
EXT. CONNECTIONS			
Pin 24 to Pin 8	Use screened cables for these connections		
Pin 26 to Pin 6	(such as RG174 coax)		
Pin 25 to Pin 5			
Pin 29 to Pin 4			
Pin 21 to Pin 3			
P6 to Pins 22, 23, 7			
P7 to Pins 28, 9, 16			
P8 to Pins 32/33, 10/11			
S1 to pin 19, 20			
PWR LED to 31, 14			
TX LED to 15, 30			
J1 to 27 and GND			
J2 to 12, 13			
J3 to 18, 17			
J4 to 1, 2			

Enjoy your new rig es 72/73 de DL-QRP-AG and DK1HE