General description:

The BSX2 TNC is a Packet Radio terminal node controller designed to be functionally equivalent to the TAPR TNC2. The reason for this is to provide a cheap and reliable node controller that will run firmware written for the TNC-2 without alteration. In particular NET/ROM™ from Software 2000, TheNET and BPQ KISS modes are supported, making this unit a simple building block for a layer 3/4 networking system. However, there are some differences. The biggest difference is in the choice of modem circuitry and logic, a single AM7910 chip replacing all of the XR2211/XR2206 circuitry. Other significant differences are evident in the memory decoding, RS232 line driver, Baud rate generator and power supply. The printed circuit board is entirely new, the intention being to produce a smaller and cheaper unit.

Circuit description:

Power supply: The TNC PSU provides the following voltages: +12V & -12V (nominal), +5V and -5V regulated and battery backed 5V which drops to 3V on power off. Also provided are delayed voltage levels for orderly power-up of the Battery Backed RAM (bbRAM). The negative voltages are generated by 556 dual timer running as a charge pump. This has been optimized for minimum noise on all voltage rails; maximum ripple is less than 20mV. Regulation is achieved by 7805 and 7905 regulators. The 2N3904, Lithium battery and associated components constitute a standard battery backup power supply for RAM retention on power down. Note that 2 AA 1.5 Volt cells work just as well as a lithium cell and could be used instead; they simply do not last quite as long, but are considerably cheaper. I use the latter and have not yet had to change batteries in 2 years on a similar circuit! Another alternative is to replace the diode with a 1k resistor and the battery by a NiCad. The 74HC14 chip and associated components, supplied from the +5V(b) line are also configured in a standard circuit providing a 100 msec delay on power-up before enabling RAM access. Note that, apart from the large values, all electrolytic capacitors are tantalum types.

Clock: Three inverters from a 74HC04 provide a standard crystal controlled oscillator at 4.9152 MHz. A 60pF variable capacitor is provided to alter the frequency of the oscillator in case the clock produces a "sproggie" on the desired radio operating frequency. The output of the clock leads to a 4 bit binary counter. The divide by 2 output is taken to the AM7910 Modem and to Jumper 2 where a choice can be made between 4.91 and 2.45 MHz for the system clock. (The higher clock speed MAY require the use of "B" series microcomputer components, although most "A" components, except for some of the slower CMOS varieties, will work O.K. at the higher frequency.) The divide by 16 output of the counter is led to a 4040 12 bit binary counter, the outputs of which provide the SIO with its HDLC and RS232 baud rates (16 times) via two 8 pin DIL switches. Provision for up to 38kBaud is made. Although the SIO driven in this manner with some currently available software at 4.91MHz is capable of up to about 64kbaud, the "standard" rate of 56kbaud is not provided simply because it is not conveniently obtained from the existing 4.91MHz clock (the 16x clock works out at 4.91/8.33 for 56kBaud). For this baud rate, an external modem must therefore be attached to the Modem Disconnect socket (J4). A 600Hz timing signal is also supplied to the SIO which causes the Z80 to be interrupted 1200 times a second. This enables the maintenance of date/time functions and protocol timing functions.

CPU and Memory: The address space of the Z80 CPU is filled by 32k of ROM (27256) and 32k of RAM (43256). ROM address space is from $0000 to $7FFF while RAM address space starts at $8000. The memory backup and reset circuitry is standard with the addition of a VN10LM FET (NOTE: it must be a **LM** not L or KM version) Alternatively, a VN2222LM (NOT L or KM version) can be used in preference) switch to prevent memory corruption on power-up by disabling memory chip select while a known state has been reached. The L and KM versions of the FETs contain protection diodes that scupper isolation! The circuitry as it stands has provided, to date, the simplest solution to the problem of retaining memory under all conditions of transient, pulsed and not so transient power interruptions.

Serial I/O: Serial I/O is performed by a single Z80 SIO/0 chip. Channel A of the SIO provides the full duplex HDLC interface with the addition of a state machine consisting of a 2764 ROM and 74HC393 latch. Although only 256 bytes of the ROM are used, a 2764 is used because it is the cheapest eprom available! The function of the state machine is to extract the clock from incoming NRZI data and to convert the incoming NRZI data to NRZ data which the SIO can cope with. It would have been possible to use a Z80 SCC chip here and eliminate the state machine, but the TNC would then not have been compatible with the TAPR TNC2 and could not run NET/ROM™ and similar firmware. On the output side, a simple JK flip flop is used to convert the NRZ data to NRZI. Jumper 11 allows selection between NRZ and NRZI data if desired. NRZI is used for all current Packet activity. Channel B of the SIO is used as a RS232C interface. A 14C88 line driver is used for output (its the cheapest low power solution as well as being superior in performance to the op-amp solution used in the TNC2.). Schmidt trigger inverters are used for input. The port is configured as DCE (Data Communications Equipment). With appropriate firmware, the RS232 port will handle 38400 baud with no problems; in particular, multidrop KISS with BPQ node firmware is useful at this speed. Other outputs from the SIO drive the CONNECT and STATUS LED displays.
Modem: A single AM7910 chip is used as a modem. It derives its clock from the TNC clock and is configured to allow both narrow shift and wide shift operation. Wide shift operation generates and decodes 1200/2200Hz Bell tones while narrow shift generates and decodes 2050/2250Hz tones. The latter are not the same as the "standard" TAPR 1600/1800 tones but were chosen because they were of the correct shift and required the simplest encoding circuitry. Jumper 13 allows selection between tone types. No extra filtering is provided with the modem; on the whole, it was not found to be very effective in normal use. All that needs to be done is to ensure that the audio levels of the high and low tones from the rig are undistorted and within 3dB of each other and you will have no difficulty in copying signals. The DCD output from the modem is logically "OR"ed with a squelch line to provide facility for "squelch backoff" operation. Useful if you string several TNC's together on the same channel (simply connect the PPT line to the Squelch Backoff line to disable a TNC from transmitting when another is) or there is some other reason for the TNC to be inhibited from transmitting. The combined DCD line also drives a DCD indicator LED. Two jumpers are provided for test purposes. Jumper 10 allows a digital loop-back circuit (with modem disconnected) while Jumper 7 allows an analogue loop-back circuit (modem connected). Also provided is a PTT timer set at approximately 20 seconds. No transmitted packet should be allowed to be longer (especially on HF). This timer can be bypassed for testing purposes by Jumper 4. NET/ROM sometimes transmits longer packets, and for this, the value of the timing capacitor should be trebled.

Construction:

Construction is on a 130x160mm (approx) PCB. It is recommended to use sockets. Components are not critical, but tantalums are recommended for all 10µF values and, indeed, are essential in the power supply. Resistors are 1/4 watt varieties. Be sure to use HC chips and not LS counterparts. The loading characteristics for the different series components are different and, although most TNC's will work with LS chips, power consumption will be higher there may be some loading problems. This will be true if you use a 1488 chip instead of the 14C88 chip specified. If you do want to use a 1488, replace R16 (10k) with a 1k value. All components are shown on the PCB. Be careful not to generate solder bridges between tracks. A small heat sink is desirable for the 7805 regulator unless you are very meticulous in using CMOS only parts throughout (including EPROMS). A very effective method of heat-sinking is to have a small angle bracket bolted to the 7805 though the PCB and onto the case. Jumpers can either be hardwired, or a jumpering system of headers and removable links can be used. The baud rate selector system can either be done by buying expensive little slide switches or by using ordinary 16 pin DIL sockets and jumpering across them at the appropriate point with a staple or piece of wire stuck into the socket. The lithium battery is optional. Two suitable varieties are available on the market as far as I know. One from RS (Electromail) and the other from Farnel The board is drilled for the latter, being the cheaper, though the RS item will also fit by bending the leads. See Appendix 8 for details of components and where to get them from. The 556 should, for best results, be a normal NMOS type, not the low power version.

Computer interfacing:

Computer interfacing is by RS232 cable attached to the D25 connector on the TNC. The TNC is configured as a DCE device. See Appendix 3 for full details. If XON/XOFF handshaking is used, it is only necessary to connect 3 pins, namely RXD, TXD and SG.

Radio Interfacing:

The Radio must be connected to the 180 DIN connector. See Appendix 4 for full details. (**NOTE** that the pins are not numbered in sequence. Sequential numbering of pins going around the semicircle is **1 4 2 5 3**)
Audio to the rig can be taken to the microphone input with or without a series resistor of about 100k to 500k, depending on the nature of the input, or directly to a "phone patch" input. Audio output can come from almost anywhere, the most common being the headphone output. It is best to take it out somewhere before the actual speaker leads, since the speaker may introduce some distortion to the received audio. Ideally, the audio input should be matched with a simple RC network (if necessary) so that high and low tone audio levels are equal or at least within 3dB of each other. The on-board resistors may need to be altered to suit. On my rigs, I find a single 1nF capacitor in series with the input provides all the necessary compensation for the receiver de-emphasis. Note: do not decrease R25 below 600 ohms or above 100k. Do not decrease R26 below 100 ohms for safety. The 0.1 capacitor could also be increased or replaced by two 10µF tantalum capacitors placed "back to back".

Testing:

After checking the TNC thoroughly for solder bridges, dry joints and correct component placement and values, the first part to check is the power supply. Remove all socketted chips and all jumpers and apply 12 Volts to the TNC preferably via a 500 mA fuse. Check the +12V and +5V lines. minimal current should be drawn. Remove power and plug in the 556 chip. Apply power and check all supply rails: +12, +5, -5 and -12Volts (the -12 Volt rail is nominal and can be anywhere between 8 volts and 12 Volts) Next plug in the 74HC04 chip (after having removed power) and check that the clock works with an oscilloscope (if available). Finally plug in all chips and jumpers (in their default positions - see appendix 1; All three way jumpers have their default positions marked with a dot on the PCB) Attach a terminal to the RS232 connection and switch on. A sign on message appropriate to the Firmware you are using will be displayed. Refer to the instructions relating to the firmware you are using for further testing. Note that there is no need to calibrate the modem. It suffices to ensure that it works since all tones are crystal controlled and synthesized by the AM7910 Modem chip. If The TNC does not work, the best solution is to start from the beginning, checking ALL components and their solder connections for correct value and absence of solder bridges. Also check that the chips are in the correct way round. Not all "point" the same direction! Finally check that the cabling to the terminal is correct and that the correct baud rate (See appendix 1) has been selected. Then refer to appendix 6 for more detailed debugging instructions.

Jmpr	Position	Function
J1	Open (default)	RS232C DCD line reflects connect status
	Closed	RS232C DCD line permanently on
J2	1 (default)	2.46MHz CPU Clock
	2	4.91MHz CPU Clock
J4	Open (default)	Enable PTT timer
	Closed	Disable PTT timer
J5	Open	Lithium Battery disconnected

	Closed (default)	Lithium Battery connected
J7	Open (default)	Normal modem operation
	Closed	Enable Analogue loop-back
J9	Open (default)	Normal operation
	Closed	Disable State Machine
J10	1 (default)	Normal modem operation
	2	Digital loop-back
J11	1 (default)	NRZI transmit Data
	2	NRZ transmit Data
J13	Open (default)	1200/2200Hz modem operation
	2	2050/2250Hz modem operation
J14	Open (default)	DCDB not connected.
	Closed	DCDB connected for NETROM operation.

Baud Rate Jumpers:

The Jumper in the extreme corner of the PCB belongs to the HDLC radio link and the one next to the 27256 EPROM belongs to the RS232 link. Jumpering adjacent to the edge of the PCB will give 38400 baud while jumpering at the other end will give 300 Baud. In between you have: 600, 1200, 2400, 4800, 9600 and 19200.

Appendix 2: J4 - Standard TAPR Modem Disconnect:

Pin 1 Carrier Detect to TNC. TTL signal, normally high. To be pulled low when valid data is received by modem. Required.

Pin 2 Carrier Detect from on-board modem. Normally connected to pin 1. Consists or logical OR of squelch input and AM7910 DCD line.

Pin 3 Special interrupt line to TNC TTL level signal normally used in TAPR firmware for modem calibration and bypass of state machine. In this design, modem calibration is not needed.

Pin 4 Special interrupt line from on-board modem Normally connected to pin 3.

Pin 5 RTS output from TNC TTL signal normally high used for modem and transmitter activation.

Pin 6 RTS to on-board modem. Same as Transmitter Key. Normally connected to pin 5.

Pin 7 Connect Status output from TNC TTL signal. Normally low. Goes high when the TNC enters a connected state.

Pin 8 Status output from TNC TTL signal. Normally low. Goes high when the TNC has unacknowledged frames in its transmit buffer.

Pin 9 CTS input to TNC TTL signal. Normally high. Pulled low when the modem is ready to accept Data for transmission.

Pin 10 CTS from on-board Modem Normally connected to pin 9. Physically tied to pin 6. i.e. it is pulled low when the transmitter is activated

Pin 11 Transmit clock (16x) to TNC TTL signal. Oscillates at 16 times the transmit clock rate.

Pin 12 Transmit clock (16x) from on-board modem Normally connected to pin 11. Signal from the on board HDLC baud rate generator.

Pin 13 Receive clock to TNC TTL signal to SIO Rx clock input. Expects a signal at the desired baud rate.

Pin 14 Receive clock from on-board modem Normally connected to pin 13. Derived from on board state machine.

Pin 15 TNC ground

Pin 16 No Connection

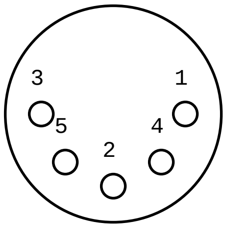
Pin 17 Receive data to TNC TTL input. This signal is passed to the on-board state machine for decoding from NRZI to NRZ.

Pin 18 Receive data from on-board modem Normally connected to pin 17.
Pin 19 Transmit data from TNC TTL output from TNC. Either NRZ or NRZI depending on the position of jumper 11.
Pin 20 Transmit data to on-board modem Normally connected to pin 19.

Appendix 3: RS232C Connections:

Pin 1 **FG.** Frame Ground. Connected to a Pad on the printed circuit board.
Pin 2 **TXD.** Transmit Data. Data input to TNC.
Pin 3 **RXD.** Receive Data. Data output from TNC.
Pin 5 **CTS.** Clear to Send output from TNC to control hardware handshaking.
Pin 6 **DSR.** Data Set Ready output from TNC indicating device ready.
Pin 7 **SG.** Signal Ground.
Pin 8 **DCD.** Data Carrier Detect output from the TNC. Depending on the setting of jumper 1, this reflects connect status.
Pin 20 **DSR.** Data Set Ready input to the TNC for hardware handshaking.
Pin 23 **CTSB.** Optional connection for NETROM operation.

Appendix 4: Analogue Port connections:



180 DIN
Connector

Pin 1 : Audio output to the radio
Pin 2 : Ground
Pin 3 : Push to Talk output to the radio
Pin 4 : Audio input from the radio
Pin 5 : Squelch input (pulled low to disable TNC transmission)

Appendix 6: Fault Finding:

Fault tracing in a non-functioning TNC are best accomplished by the following steps:
1. Ensure all Cabling is correct.
2. Ensure that the supply voltage is correct and of correct polarity.
3. Check on-board power supply voltages, +12, +5, -5 and "-12".
4. Check that the oscillator is oscillating at the correct frequency of 4.915 MHz. Other oscillator checks can be made on the Z80 pin 6 (4.912 MHz or 2.4576 MHz depending on position of JMP 2) and Z80 pin 22 (154kHz). Also check that all baud rate clocks are present and that they divide down properly on the baud rate jumpers.
5. Check the power supply of the RAM chip on pin 28 (+5V dropping to +3V on power down if battery backed power supply is connected)
6. Check that the RESET line remains low for a few hundred milliseconds after power-up and then goes high.
7. Make sure all components are of the correct value. Note the SIO is a type /0 NOT /1 or /2! A DART also sometimes works. ensure the compulsory CMOS chips ARE CMOS!
8. Check all address and data lines as well as the RD, IOREQ, and memory chip select lines (pin 20 on ROM and RAM chips). Lack of activity usually indicates a poor connection or a short on the PCB. In particular, check that you have not inadvertently put a 100nF capacitor

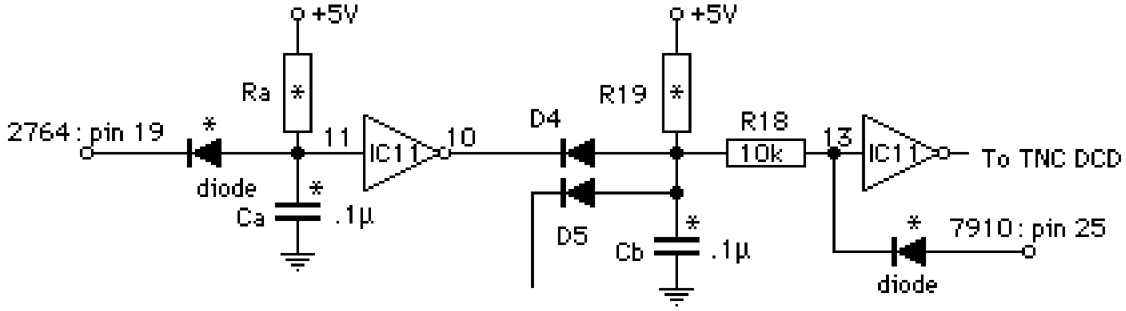
instead of a 100pF one in for C45. It may be necessary to trace all connections.

<u>If the TNC functions, but does not receive or transmit:</u>
1. Check that the audio into and out of the TNC is correct and undistorted. If the tones are "wrong" as compared with tones heard on the band, there could be a problem with the mode select lines on the AM7910 chip (pins 19- 24), J13 is in the wrong position or the Baud rate selection is incorrect. The audio level into the TNC should be sufficient (with squelch off) to allow the DCD light to light 75-90% of the time. About 5mV to 200mV is usually ample. If your RIG gives out particularly noisy unsquelched signals, it may be difficult to run the TNC without using Squelch. On HF experimentation is the norm - the DCD mod (appendix 7) helps.
2. Check the wave form of the audio actually going into the AM7910 chip. High and Low tones should have equal amplitude, if not, a simple RC network can be added in front of the TNC to alter the relative amplitudes of the tones. For the MODEM to operate, the tone amplitudes should ideally be within 1.5dB of each other.
3. Make sure the State Machine ROM is not faulty.
4. If all else fails, give me a call!

Appendix 7: Modifying the BSX2 for STATE MACHINE DCD.

The G0BSX "BSX2" TNC uses an AM7910 modem chip for signal modulation and demodulation. One of the problems with this otherwise excellent chip is due to the fact that it was designed for fairly quiet telephone lines rather than noisy radio channels. Therefore, the method of Data Carrier Detect (DCD) used was an amplitude system which results in a high false carrier detection rate on noisy channels. This has the effect of reducing channel throughput and slowing "turn around" time.
It is possible with a minimum number of passive components and using a spare on board Schmidt trigger inverter to allow the use of a STATE machine DCD system rather than the existing analogue DCD system provided by the on board AM7910 chip. This produces a number of advantages over using the modem chip DCD signal (which requires squelched operation on FM), namely:
1. False DCD due to random noise is all but eliminated. As mentioned before, the AM7910 modem uses an amplitude DCD detect system which gives a lot of false signals on noise. Using the state machine (a digital Phase Locked Loop system) provides a DCD signal ONLY when an incoming signal can be synchronised to the local 16x clock.
2. Higher audio volumes (with consequent better decoding) can be used on HF settings.
Since the BSX2 uses the TAPR state machine (with permission) all that is needed is a small modification using a couple of delay monostables. One is created using a spare Schmidt inverter and the second is created using an existing inverter that is already part of the DCD circuitry. The AM7910 DCD output line is disconnected completely.
The STATE machine's carrier lock signal on pin 19 of the ROM chip is used. The signal on this chip is HIGH on DCD lock and outputs a negative going pulse train when no lock is present. The pulse train requires incoming random data for its existence and therefore incoming audio noise must be of sufficient amplitude to provide this. FM receivers can be run squelched with this mod since the addition of the diode from the DCD pin on the 7910 to pin 13 of IC11 will cause the DCD line to be inactive on NO audio input.

State Machine DCD Modification: Circuit.



The circuit modification is shown above. The 6 components marked with a * character are new components. All other components are already in existence on board. These five components are: Ca, Cb, Ra, Diode and R19. R19 is, of course, already on board - it just needs to be replaced with a different value.

<u>The circuit works as follows:</u>
In the resting state, a pulse train keeps Ca discharged via the diode. When a signal causes a DCD lock to occur, Ca charges up and switches the inverter. The value of Ra and Ca determine the delay before this occurs. This is necessary, of course, to prevent rapid switching during the pulse train. Once the Schmidt trigger inverter has switched, rapid discharge of Cb occurs thereby activating the on-board DCD line via the second (existing) inverter. Once DCD lock is lost, the first pulse on pin 19 of the STATE rom will immediately discharge Ca and the first inverter will again switch.
The discharging impetus now being removed from Cb will cause it to charge via R19 and, after a short delay, the on-board DCD will revert to "off". The time constant of the first delay (Ra and Ca) is chosen so that it is longer than most intervals between pulses in the pulse train on pin 19. A value of about 30 milliseconds is adequate and is provided by RC values of 470k and 0.1 µF.
The value of the second delay must be longer than the first so that a single false trigger will not cause loss of DCD. A value of 50-60 msec is adequate and is provided by RC values of 820k and 0.1µF (560k and 1M values could also be used, if HF operation is contemplated).
<u>Detailed method of on board modifications:</u>
1. Unplug the AM7910 modem chip and bend out pin 25 before plugging it back in.
2. Unplug IC11 (74HC14) adjacent to the RAM chip and bend out pin 11 before plugging it back in.
3. On the UNDERSIDE of the board, connect a wire link from pin 10 of IC 11 to pin 25 of IC15.
4. Replace R19 (10k) with a resistor of value 820k or 1M. (see above)
5. Solder a diode (1N4148 or equivalent) between pin 19 of the STATE eprom (IC14) and the bent out pin 11 of IC11 with the cathode (the "+ve" end with a black band) pointing towards pin 19 of the STATE EPROM.
6. Solder a 470k or 560k resistor between the bent out pin 11 of IC11 and the +5V rail (you can use pin 14 of IC11 if you wish) It would be easier if you soldered to the anode lead of the diode rather than the actual IC pin - it could get pretty crowded on the pin if everything went there!
7. Solder a 0.1µF capacitor from the bent out pin of IC11 to ground (pin 7 of IC11 is useful).
8. Solder a 0.1 µF capacitor from the ANODE ends (-ve) of D4 and D5 to ground. (You will have to find this pad on the underside of the board.)
9. Solder a diode between the bent out pin 25 of the AM7910 and pin 13 of IC11. (+ve to pin 13) (Thanks to G8IPG for this addition to the mod.)

Semiconductors:

IC1	Z80A cpu (CMOS optional)	IC11	74HC14
IC2	27256 eprom (CMOS optional)	IC12	74HC107
IC3	43256 or 62256 ram	IC13	74HC374
IC4	Z80 SIO/0 (CMOS optional)	IC14	2764 eprom (CMOS optional)
IC5	74HC139	IC15	AM7910 or AM7911 modem
IC6	74HC04 (HC essential)	IC16	7805 regulator (TO220 1.4A)
IC7	74HC393	IC17	556 timer (standard version)
IC8	4040	IC18	79L05 regulator
IC9	74HC14 (HC essential)	IC19	74HC14
IC10	14C88 line driver (See text)		

Note: HC series essential for the 74HC14 and 74HC04 chips. the rest can (at a pinch) be LS series

VT2	VN10LM or VN10KM
VT3-VT8	2N3904
VT1	VN10LM, VN2222 or 2N3904 (see text)
D1,D2,D4,D5,D7,D8,D13,D18	1N4148
D3	33V Zener
D6,D11,D14,D15,D16,D17	1N4001 (for better regulation, use Schotky diodes)
D10	18V Zener
D12	6V8 Zener
D19-D23	LEDs to suit personal preferences

Resistors:

R1	10k	R2	1k	R41	10k
R2	10k	R22	100k	R42	100k
R3	10k	R23	100	R43	10
R4	100k	R24	1k	R44	10
R5	1k	R25	100k	R45	10k
R6	1k	R26	10k	R46	10k
R7	100k	R27	10k	R47	10k
R8	100k	R28	10k	R48	100k
R9	100k	R29	10k	R49	100k
R10	100k	R30	470	R50	1k
R11	10k	R31	470		
R12	10k	R32	470		
R13	100	R33	470		
R14	100	R34	470		
R15	100	R35	10k		
R16	10k	R36	10k		
R17	10k	R37	10k		
R18	10k	R38	10k		
R19	10k	R39	10k		
R20	1M	R40	10		

VR1 10k trimmer

Capacitors:

C1	10p	C21	.1µ	C41	100µ
C2	60p trim	C22	.1µ	C42	.1µ
C3	.01µ	C23	.1µ	C43	10µ tant
C4	100p	C24	.1µ		
C5	100p	C25	.1µ	C45	100p
C6	100p	C26	.1µ	C46	10µ tant
C7	10µ tant	C27	.1µ	C47	10µ tant
C8	10µ tant	C28	.1µ	C48	10µ tant
C9	.1µ	C29	.1µ	C49	10µ tant
C10	2n2	C30	.1µ	C50	10µ tant
C11	.1µ	C31	.1	C51	1n
C12	.1µ	C32	.1	C52	10µ tant
C13	1n			C55	.1µ
C15	.1µ				
C16	.1µ				
C18	.1µ				
C19	.1µ				
C20	.1µ	C40	1000µ		

Miscellaneous:

X1	4.9152 MHz Crystal
L1,L2	10uH chokes (Optional - Only needed if you start running a few kW!)
SK1	D25 (Female right angle pcb mounted)
SK2	180 deg DIN (female pcb mounted)
B1	Lithium battery (1/2 AA size) (optional) 2 AA cells can be used instead.

Headers for jumpers:2 pin - 7
3 pin - 3
Links for jumpers: 5 (clock spd selct, NRZI selct, Loopback selet, bbram backup, HF selct)
Fuse and holder (500mA - optional)
on/off switch (optional)
sockets for chips (recommended)
Printed circuit board

Kits of parts are been available from Ron Mallett, G0NJD (QTHR) (0742 588359) for about £45. Shopping arround the mail order houses does not cost any less if you buy all components new. If you are paying more than £65 for all the components you are definitely shopping in the wrong places!!
A custom made ready drilled box (highly recommended) for about £10.00 from H.J. Morgan Smith, Unit 3, Vernon Building, Westbourne Street, High Wycombe, Bucks (0494 532421)

Happy Building. Its worth in in the end!

Good Luck. Any problems, give me a call.
Peter Meiring, G0BSX.
67 Tom Lane, Fulwood, Sheffield, S10 3PA. (0742 309478 - after 8pm only please)