BBC B+64K expansion clone.

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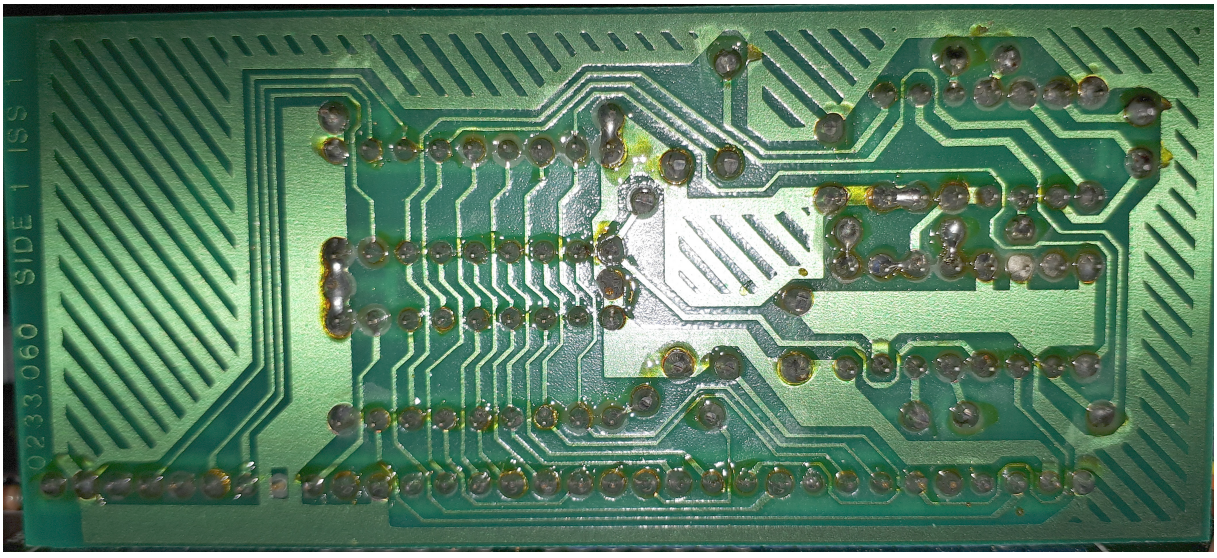
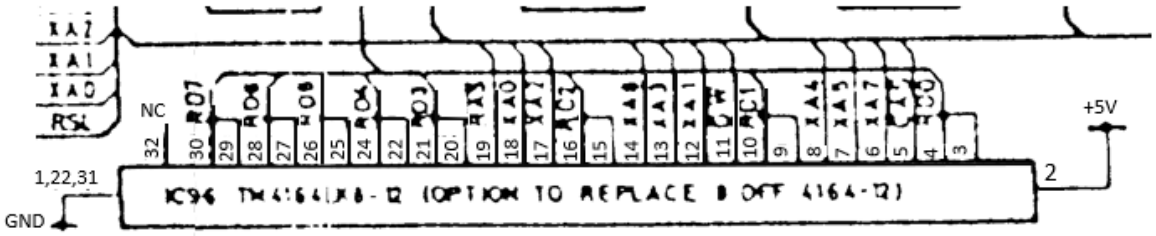
Usual disclaimer: the information provided here is provided “as is”, and the procedure worked fine for me. If you fry your BBC B+ after following this document, you will have my sympathy, but nothing more.

A while ago, I acquired a BBC B+ in full working order and decided I would like to expand the RAM by 64K RAM in order to turn it into a B+128K. However, the original Acorn expansion board is exceedingly rare, eventually I gave up trying to find one. I also looked at the alternative methods which can be found in various places on the internet (like startdot.co.uk) showing how to add SRAM to one or more of the existing ROM sockets. While this is fine, I fancied having the original setup, and I also did not want to occupy one of the ROM sockets for this. The original Acorn board allowed one to use all the ROM sockets for 16K or 32K EPROMS, giving 10 additional language or service ROMs plus four banks of sideways RAM. This document will describe how I reverse-engineered the board, and what to do if you want to build one for yourself.

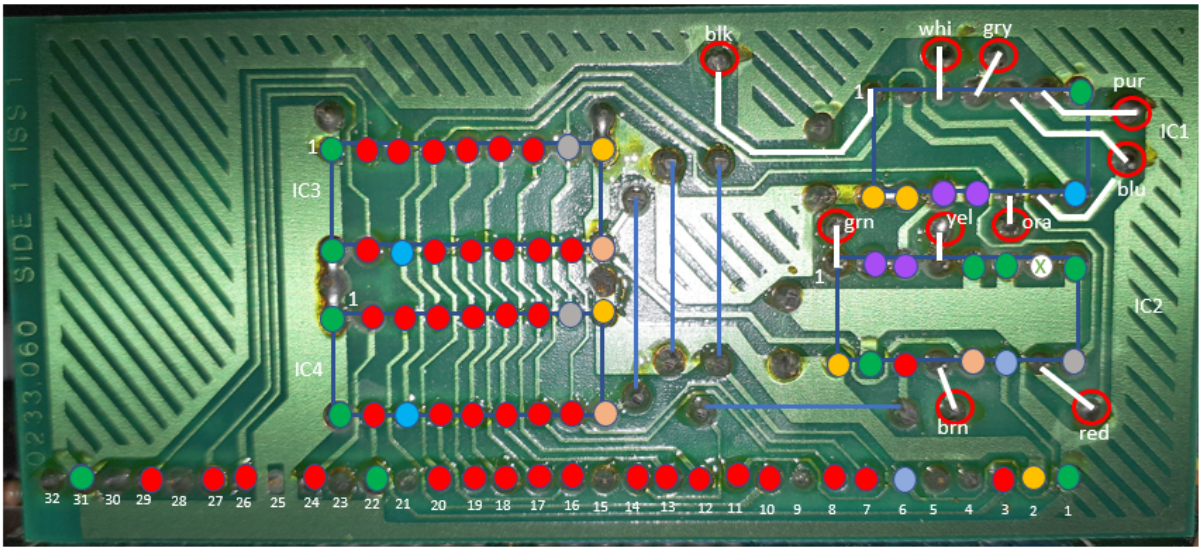
I was unable to find a circuit diagram for the board, not even in the B+ Service Manual. I searched for images of the board in the hope of making a clone/copy, the best I found were on http://www.bygonebytes.co.uk, however they only showed the font of the PCB, I could see the components quite well, but the interconnecting PCB tracks are all on the back of the board. The site owner very kindly agreed to take his motherboard out of the case and make high resolution photos of the board from the solder side:



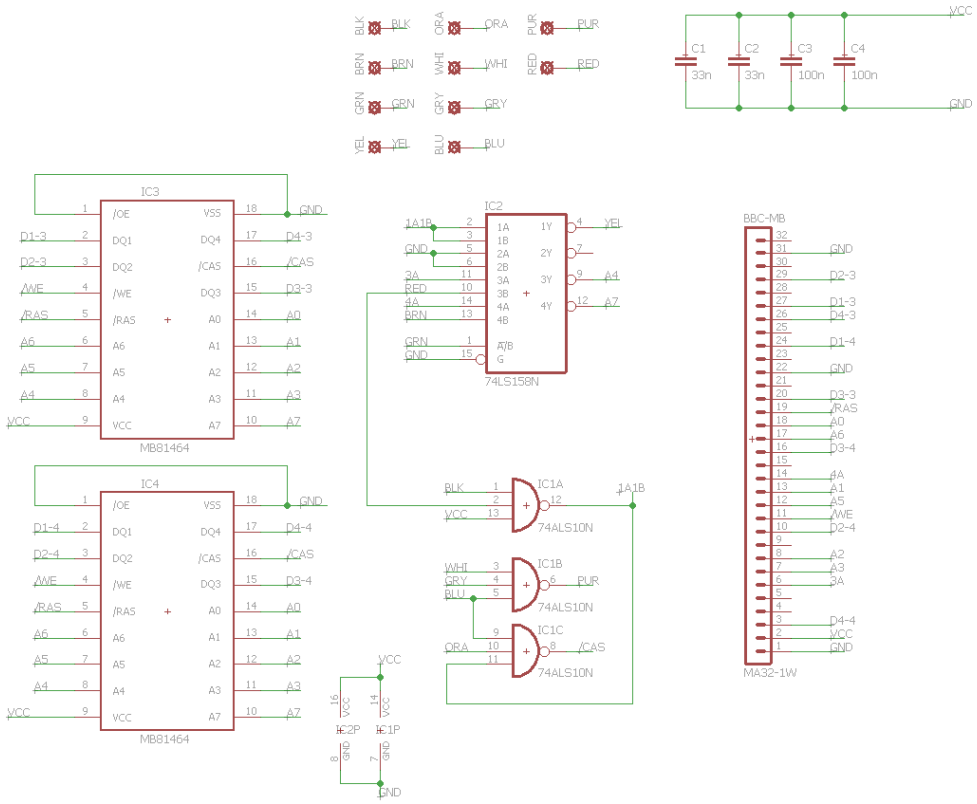
Next I had to figure out the pinouts of the connector on the mainboard, the image of the B+ circuit diagram in the service manual is particularly grotty, but after a bit of creative guesswork, I had the correct pin numbers added to the section of the diagram relating to the ram expansion connector:



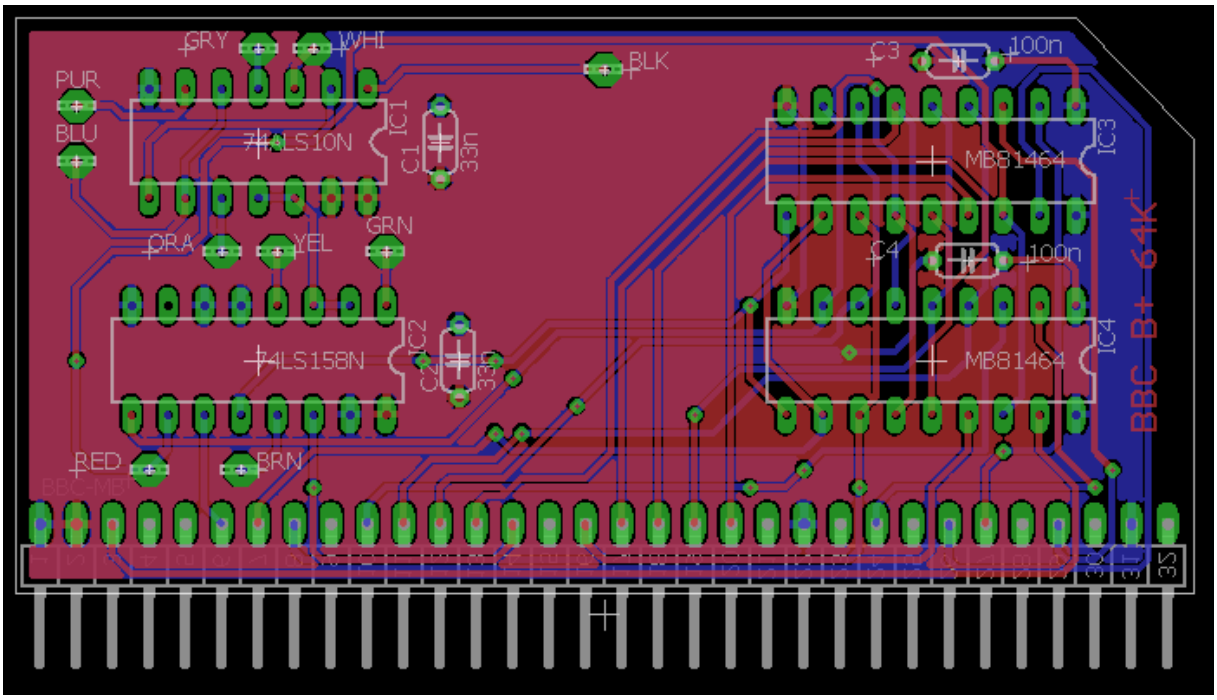
This enabled me to trace each track from solder pad to solder pad, figuring out what signal goes where.



This, in turn, enabled me to reconstruct the circuit diagram:



From there, it was easy enough to create a PCB layout, I decided to go for a functionally identical design, but not 1:1 copy of the original, for this reason I also went for a double-sided PCB.



I sent my layout files to a PCB manufacturer (in my case pcb-pool.com) that deals with small volumes and prototypes and waited for delivery. In the meantime, I sourced the components: the two TTL parts are still available, but the RAMs needed to be sourced from eBay. This leaves the connector and the four capacitors, which are also standard. Here is the BOM list:

BBC-MB	32x1pin 90-degree, 2.54mm pitch connector	
C1	33n	capacitor, package C050-024X044
C2	33n	capacitor, package C050-024X044
C3	100n	capacitor, package C050-024X044
C4	100n	capacitor, package C050-024X044
IC1	74ALS10N	TTL, DIL14
IC2	74LS158N	TTL, DIL16
IC3	MB81464	DRAM, DIL18
IC4	MB81464	DRAM, DIL18

Assuming you want to build one yourself, I will assume a more than passing familiarity with the BBC micro family, so will not cover things like how to take the computer apart, disconnecting the PSU, etc. There are plenty of information on this on the internet. Once you have the PCB and the parts from the BOM to hand, you will additionally need to prepare some lengths of wire, as described here (from the original Acorn fitting instructions):

WIRING CONFIGURATION TABLE

WIRE COLOUR	SIGNAL NAME	WIRE LENGTH	TO POINT (MAIN PCB)
BROWN	QA	255mm	IC 45 pin 14
RED	C/D	265mm	IC 46 pin 9
ORANGE	4M	155mm	IC 53 pin 6
YELLOW	ENB	145mm	IC 40 pin 13
GREEN	RSL	125mm	VIA hole *
BLUE	2M	175mm	IC 26 pin 6
VIOLET	ENCAS	165mm	IC 52 pin 10
GREY	PGRAM	155mm	IC 40 pin 12
WHITE	AL5	170mm	IC 40 pin 10
BLACK	0/1	305mm	S13 north pin

The lengths of wire should be soldered to the corresponding pad on the 64K PCB option board, i.e., BROWN to BRN, etc. and then to the BBC B+ mainboard. The black wire should end with a female plug header like this:

The others end with ~1mm tinned wire. Once more from the original Acorn fitting instructions:

Modifications to the Main PCB.

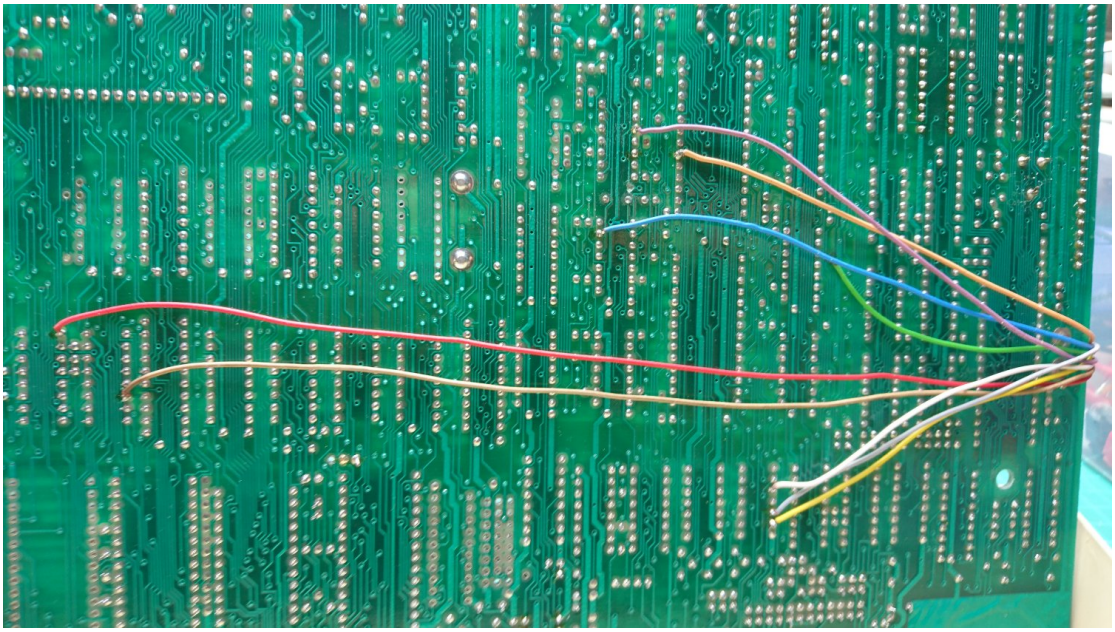
1. On the solder side of the main PCB locate and cut the track that connects pin 13 to pin 14 of IC40. When cutting the track, take care not to damage the adjacent signal tracks on the PCB.

2. Locate and cut the track connecting to pin 10 of IC52.

Having completed the modifications, the daughter board may be fitted. The daughter board should be positioned such that the solder side of the daughter board is to the outside (adjacent to the case) Of the machine. Insert the pins of the daughter board into position IC96, having previously cleared this position of any excess solder, and solder the board in place. Great care must be taken to ensure that the board is vertical. If the daughter board is permitted to lean towards the side of the case it will prevent the case lid from being fitted.

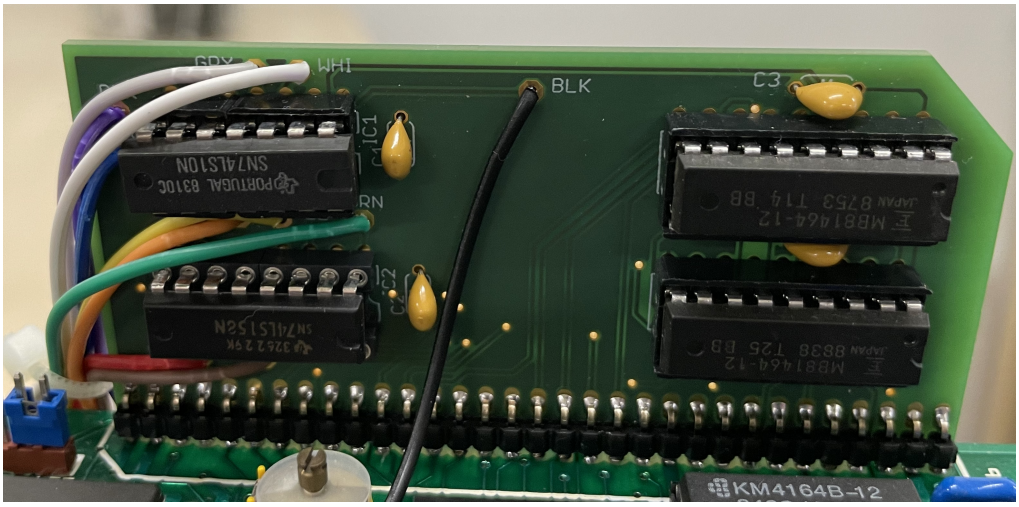
Having installed the daughter board, the 10 flying leads must be connected. With one exception (the black lead) all the leads are routed around the rear of the daughter board and under the PCB, the solder connections to be made on the solder side of the main PCB. The black lead travels over the main component side of the main PCB and will be connected by means of the shell housing already fitted to the lead.

It should look like this when you are done:

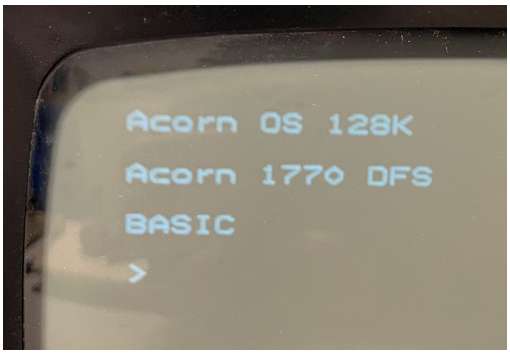


Not Acorn's best thought out upgrade.

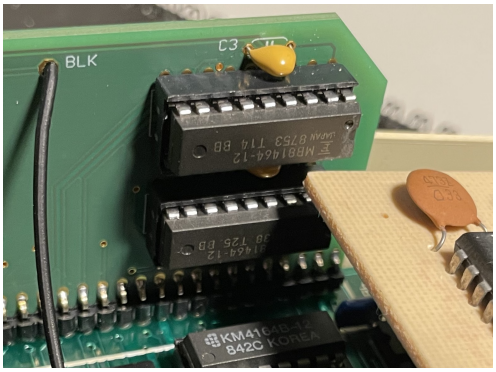
The new upgrade board should look like this when fitted:



Reassemble the computer. Your DFS ROM should be 2.26, other B+ specific versions 2.2 or above should also be OK, as long as they include the SRAM utilities, however V2.28 for example, did not work for me. I used 2.26 from here:
https://archive.retro-kit.co.uk/bbc.nvg.org/rom/Acorn/fs/index.html
The DFS ROM also modifies the boot up banner to show “Acorn OS 128K”. If you did everything correct, you will be greeted with something like this at power-up:



Well done, you now own a BBC B+128K! I have included two variations on the PCB, “B+64K” and “B+64Kb”. When fitting the PCB, I noticed that the RAM chips (IC3&IC4) might be more comfortable if they were placed a bit more to the left. The top right-hand corner of the keyboard PCB is near to the two RAM chips, they do not touch, but for anyone who does not like this, I modified the design to move the ICs away from the keyboard: “B+64Kb”. This version has not been built or tested, however I only modified the physical layout, the circuit is the same, so it should work fine.



Anyone wanting to have a B+64K RAM board of their own are free to use the PCB CAD files to build one. I will not be selling or manufacturing any of these boards due to lack of time, for example it would be fairly complex to test them. I would need to install each one into a B+ including all the flying connections, and then verify that it works.

References:
Acorn BBC B+ 128k Additional User Information
http://www.8bs.com/othrdnld/manuals/hardware/BPlus128KAdditionalUserInfo.zip

Acorn BBC B+ 64K Sideways RAM daughter board fitting instructions
http://www.8bs.com/othrdnld/manuals/hardware/BPlus64KFittingInstructions2.zip

Acknowledgments:
Chris Richardson of 8bs.com who prompted me to build this by refusing to sell me the one he had. 😊

Derek Walker of bygonebytes.com who provided the high-resolution photos of the PCB, without which, none of this would have been possible.