**ATOM TECHNICAL MANUAL**

# INTRODUCTION

The Acorn ATOM microcomputer is available as a kit of parts for assembly by the user, or as an assembled and tested unit. Many different extensions may be added to the basic ATOM including further memory for user programs or high resolution graphics, an interface to a printer, and the extension ROM which provides floating-point arithmetic and the COLOUR statement. This technical manual contains the information needed in order to construct the ATOM kit and add any of the extensions. Use of the ATOM is described in the book 'Atomic Theory and Practice' and users with assembled and tested ATOMs may not need to refer to this manual.

When purchased directly from Acorn Computers Ltd the assembled and tested ATOM is guaranteed for a full six months if used correctly. The component parts of kits are also guaranteed for six months and a fast service facility for assembled kits is available at Cambridge. In general repairs at Cambridge are carried out within two weeks and they are invoiced at around ten pounds plus the cost of any replacement components for ATOMs over six months old.

The ATOM is compatible with the Acorn series of Eurocards for the 6502 micro-processor and it can be extended by adding one card inside the ATOM case, or any number of cards in an external card frame. Connection to the cards is by a standard Acorn bus connector, and this is described in this manual. The ATOM can therefore be used to develop programs for later use on larger computer systems, for data acquisition and control purposes, and as a personal computer.

One significant aspect of the ATOM is its capacity for expansion, first by adding further components to the circuit board and then by adding extra boards within the case. One extension allows connection of the ATOM to the Acorn ring whereby a number of computers can communicate and share peripheral devices such as disk drives, plotters, and printers. In this manual the addition of the standard extensions is described.

## CONSTRUCTION PROCEDURE

BEFORE YOU START
Carefully unpack the ATOM kit and check that all the component parts
are present and that none are damaged. In case of supply difficulties
substitute components may be supplied; for instance 100nF capacitors
may replace 47nF parts.
    For capacitors note that values may be expressed in two ways:

          0.1uF =    100nF
           lOnF =
           10000pF
            1nF =   1000pF
          0.1nF =    100pF     etc.

    Capacitors supplied with Acorn products are usually identified by a
three digit number, the first two digits being the first two digits of
the value followed by a third digit giving the number of zeros. For
example:

          101 is 10 and one zero which is 100pF.
          103 is 10 and three zeros which is 10000pF or lOnF.
          473 is 47 and three zeros which is 47nF or 0.047uF.

    Resistors are identified by coloured bands of which three at one
end give the value with a fourth giving the components tolerance:
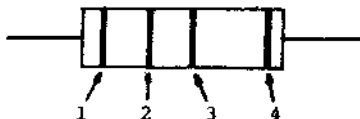


The first and second bands give the first two digits of the value with
the third indicating the number of following zeros:

          Black is 0
          Brown is 1
          Red  is  2
          Orange is 3
          Yellow is 4
          Green is 5
          Blue   is  6
          Violet is 7
          Grey   is  8
          White is 9

    For example consider a resistor with the coloured bands Yellow,
Violet, Orange, space, Silver. This is 47 followed by three zeros,
that is 47000 or 47K ohms. When writing the value of a resistor note
that 4.7 Kohms is usually written 4K7, and 270 ohms as 270R. The
fourth band identifies the tolerance as follows:

```
      Red    is +or-2%
      Gold   is +or-5%
      Silver is +or-10%
```

Any of these may be used with the ATOM.

SOLDERING TECHNIQUE
Assembling the ATOM will require a considerable amount of soldering
and a small electric soldering iron is essential. The iron should be
rated between 10 and 30 Watts with a diameter at the end of the bit
not exceeding 0.1 inches. Fine 22-gauge flux cored solder should be
used. People with no previous experience of this type of work should
not attempt the ATOM assembly without assistance. When soldering make
sure that the component is well pushed on to the board as shown, use a
minimum of solder, and once the solder has run remove the iron.
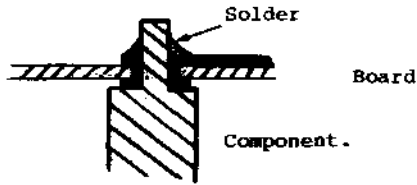


    Some of the integrated circuits used in the ATOM employ M.O.S.
technology and they can be damaged by static electricity. As a general
rule if there is no noticeable static charge in the area and no nylon
clothes or carpets are present all will be well. An earthed soldering
iron should be used when working on a board carrying M.O.S. circuits.
    The ATOM printed circuit board is double sided, through-hole
plated glass fibre. A layer of green solder resist ensures that
accidental solder splashes do not short out tracks and a white
component legend clearly indicates where each part goes.
    Examine the board for faults or damage before commencing work. Do
not solder through holes on the board connecting tracks from one side
to the other without a component in them as they may be damaged; in
any case these holes should have solder resist over them.

PARTS LIST
Parts supplied with the basic ATOM kit are as follows:

```
        IC6   74LS138           TTL Decoder.
        IC7   74LS02            TTL NOR Gate.
        IC8   74LS00            TTL NAND Gate.
        IC9   74LSO4            TTL Inverter.
        IC20 MM52164            Read Only Memory.
        IC22 6502-1MHz.         Micro-Processor.
        IC23 74LS138            TTL Decoder.
        IC25 INS8255            Peripheral Interface.
        IC26 7445               TTL Decoder/Driver.
        IC27 81LS95             TTL Buffer.
        IC28 81LS95             TTL Buffer.
        IC29 DP8304             TTL Transceiver.
        IC30 74LS138            TTL Decoder.
        IC31 6847               Video Display Generator.
        IC42 2114               Random Access Memory.
        IC43 2114               Random Access Memory.
        IC44 74LS393            TTL Counter.
        IC45 74LS04             TTL Inverter.
        IC46 LM358              Operational Amplifier.
        IC47 74LS163            TTL Counter.
        IC48 74LS00             TTL NAND Gate.
        IC49 74LS139            TTL Decoder.
        IC51 2114               Random Access Memory.
        IC52 2114               Random Access Memory.
        IC53 LM340T-5           Voltage Regulator.
        IC54 LM340T-5           Voltage Regulator.
```

```
        R1      4K7        R26      470R
        R2      4K7        R27      470R
        R3      470R       R28      470R
        R4      470R       R29      4K7
        R5      470R       R30      1K
        R6      75 or 82R  R31      4K7
        R7      8K2        R32      4K7
        R8      3K3        R33      47K
        R9      1K         R34      47K
        R10     270R       R35      470K
        R11     3K9        R36      4K7
        R12     470R       R37      10K
        R13-16 4 off 4K7   R38      1K
        R17-25 9 off 4K7   R39-41   3 off 4K7
```

All of these resistors may be 0.25 or 0.33 Watt components with a tolerance of 5 or 10%.

```
        C1      10nF       C8      22uF *
        C2      22uF *     C9      22 or 47nF
        C3      22uF *     C10     10nF
        C4      22uF *     C11     10uF *
        C5      22uF *     C12     22uF *
        C6      10nF       C13     22uF *
        C7      47 or 100nF  C14-28 15 off 47nF
```

The electrolytic capacitors (marked *) may be replaced by any value in the range 10 to 47uF. They should be rated at 10 Volts or

greater.
    Other parts supplied with the basic ATOM kit include:

        Injection Moulded Case.
        Printed Circuit Board    202,000
        Four short and two long self-tapping screws.
        Self-adhesive key surround.
        Four stick-on feet.
        Key Assembly and fixing screws.
        X1      3.58MHz crystal.
        X2      4.00MHz crystal.
        L1      1mH choke.
        SK1     UHF Modulator.
        SK2     7 pin DIN socket.
        SK3     Power socket.
        Q1,2    2 npn transistors type BC107 or 184,237,239 etc.
        Loudspeaker,adhesive pad and wire.
        Loudspeaker Baffle.
        Nut and screw for Regulator.
        Heat sink.

    52 sockets for the complete set of Integrated Circuits as
  follows:

        1 off 8 pin 7
        off 14 pin
         6 off 16 pin
        24 off 18 pin
        7 off 20 pin
        3 off 24 pin
        4 off 40 pin


    The remainder of the components required for the extensions are
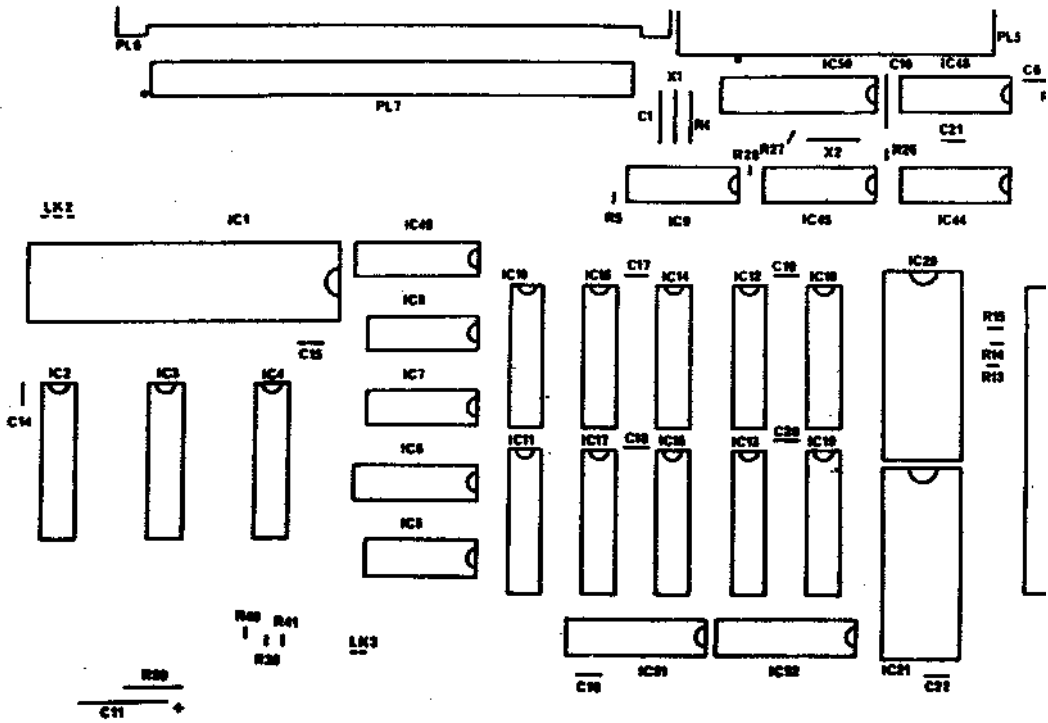listed in the appropriate sections later on.

IMPORTANT NOTE
The ATOM printed circuit board is double sided with the sides being
identified by the legends "SIDE 1" and "SIDE 2". All the IC sockets,
the connectors PL/SK 1 to 7 and the passive components are mounted on
side 2 and they are therefore soldered *on* side 1. PL 8 and the
keyboard are mounted on side 1 and soldered on side 2. The component
layout diagram is a view of the circuit board from side 2 and it will
assist in identifying components whose legend is obscured on the board
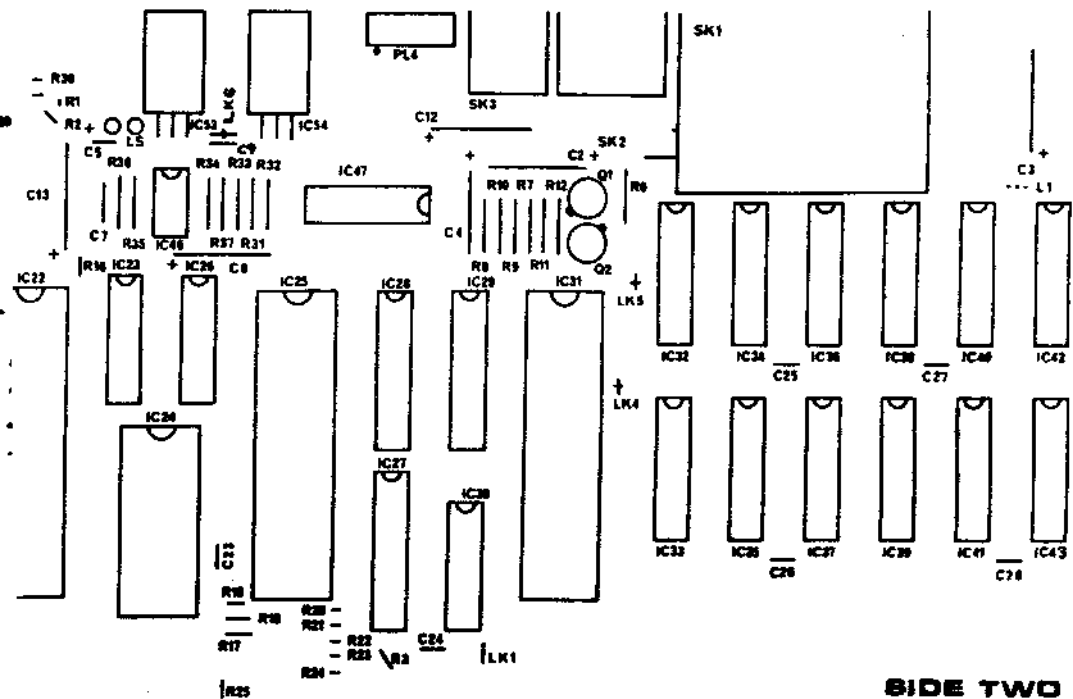itself.
    Read through the following instructions and then assemble the ATOM
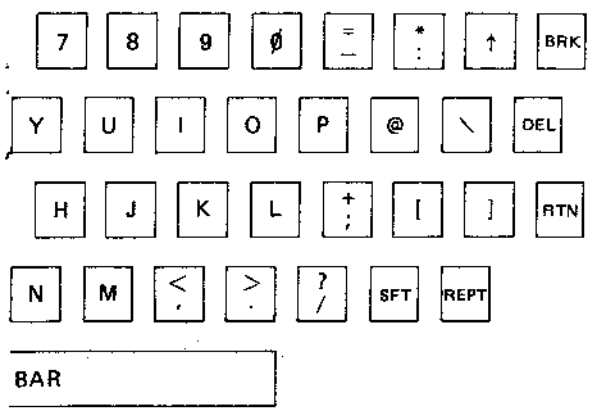step by step.

LINKS
Several links may be fitted to the PCB to cater for different
requirements. None of the links need to be fitted for a
minimal-configuration ATOM powered by an ATOM mains adaptor.

COMPONENT AND KEYBOARD LOCATION DIAGRAM

R30
R1
R2
C5
L5
IC53
LK6
IC54
C12
SK3
PL4
SK1
C13
R29
R34 R33 R32
C9
IC47
C2
SK2
Q1
R6
C3
L1
C7
R35 IC46 R37 R31
C4
R10 R7 R12
R16 IC23 IC26 C8
R8 R9 R11
Q2
LK5
IC22
IC25
IC28
IC29
IC31
IC32 IC34 IC36 IC38 IC40 IC42
C25 C27
LK4
IC24
IC27
IC30
IC33 IC35 IC37 IC39 IC41 IC43
C26 C24
C13
R18
R19
R20
R28
R21
R17
R22
R23 R2
C24
LK1
R24
R25

| 7 | 8 | 9 | Ø | = _ | * : | ↑ | BRK |

| Y | U | I | O | P | @ | \ | DEL |

| H | J | K | L | + ; | [ | ] | RTN |

| N | M | < , | > . | ? / | SFT | REPT |

BAR

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INTEGRATED CIRCUIT SOCKETS
The sockets supplied with the ATOM are fitted to the circuit board in
the locations for the ICs provided. Sockets are mounted on side 2 of the
board and they are then soldered on side 1. Fit the sockets the right
way round with pin I in the position identified on the circuit board as
shown:
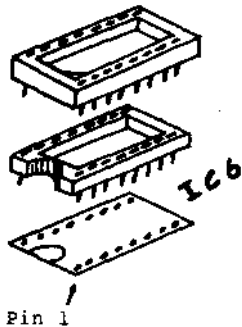


Pin 1

    Pin 1 of the socket is identified by a chamfer or cut out as
shown. Fit the sockets one at a time and ensure that they are pressed
fully down with *no* pins bent under them. First solder two diagonally
opposite pins and check that the socket is correctly fitted before
soldering the remainder of the pins. There is no need to cut off the
excess of the pins on side 1 of the board.

PASSIVE COMPONENTS
The passive components, that is the resistors and capacitors, are
fitted next. Each resistor and capacitor position is marked on side 2
of the circuit board with a legend ie R7 or C12 and a line showing the
two holes through which the leads pass. Identify each component from
the parts list and bend its leads as shown before mounting it on side 2
of the board with the leads poking through to side 1. Solder the
leads on side 1 and cut off any excess. The electrolytic capacitors
are polarised and the positive ends of them must be towards the + sign
on the board. Some electrolytics have an arrow or a band round them
indicating the negative end and this must point or be away from the +
sign. The 1mH choke is fitted in position L1.



KEYBOARD
The ATOM may already have its keyboard fitted; if not then proceed as
follows. Carefully remove the key assembly from its protective
backing and lay it key-top side down with the leads sticking upwards.
Check that all of the leads are straight and correct any that are bent
over. Taking great care not to bend any of the leads position the
circuit board over the key assembly such that the keys will be on side

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1 of the board, that is the side opposite to the ICs and passives etc. Lower the circuit board over the key leads so that they poke through the holes in the circuit board and then move the two parts until the fixing screw holes are aligned. Ensure that ALL of the *key* leads poke through the circuit board. Then fix the keyboard to the PCB using six self-tapping screws with insulating washers to ensure that they do not short out the PCB tracks. Solder each key lead on to the side of the large plated through-holes in the circuit board pushing the leads over to the side of the hole where necessary. Do NOT fill the holes with solder; when the solder cools it may contract and break the plated-through connection. Do not allow blobs of solder to fall through the holes into the keys.

CONNECTORS
The power jack socket and the D.I.N. socket for the tape recorder are mounted on side 2 of the board and soldered on side 1. The power socket, SK3, has two lugs which are soldered into the board and the third connection is made with a short piece of wire, such as an offcut from a resistor. SK2 is a 7 pin socket which is held by a spring clip through two holes *near* the front of the board and by the seven soldered leads.

Plugs PL4, PL5, PL6, PL7, and PL8 are not required on the minimum configuration ATOM.

LOUDSPEAKER
Fix the loudspeaker to side 1 of the board to the right of the keyboard using a double-sided sticky pad. Connect it to the two marked holes beside C5 using twin-cored wire and press the baffle over the loudspeaker.

MODULATOR
This is mounted on side 2 with the two metal securing lugs through the board and soldered on side 1. The +5 volt and input signal wires are soldered into the two holes indicated on the board beside the modulator.

VOLTAGE REGULATOR
Both regulators and a heatsink should be fitted to all ATOMs. The



IC 46 →
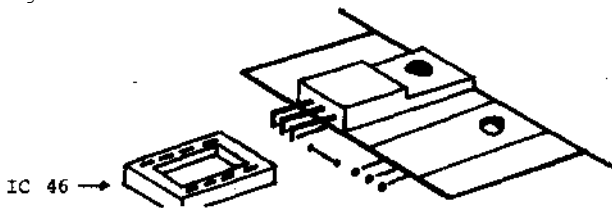
Bend the leads taking care not to break them off as they enter the body of the device. Fit the second regulator in an identical manner, and then slide the heatsink between the regulators and the PCB. Screw down the regulators with the nuts and screws supplied, taking care that they do not short out the adjacent tracks on the PCB, and then solder the leads on side 1 of the board. Cut off any excess lead.

CRYSTALS
The two crystals for the ATOM stand upright about a quarter of an inch above side 2 of the board. If necessary bend the leads so that they pass through the holes at positions X1 (3.58M) and X2 (4.00M). Take

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care not to break off the lead where it enters the crystal and check
that the metal can does not short to any adjacent components.

TRANSISTORS
Two transistors, Q1 and Q2, are fitted taking care that they are
oriented as on the circuit board legend.

INTEGRATED CIRCUITS
These may now be fitted in their sockets. Pin 1 of each device is
identified by either a semi-circle or *a* dot **as shown:**



Pin 1                    Pin 1

  **Devices** which are liable to damage by static electricity wi11 be
supplied in anti-static packing and they should not be removed from
this until required for insertion into their sockets. Identify each
device from the parts list and plug it into the appropriate socket. If
**the pins on the IC** are splayed out, press them a11 in together as
shown until **the device** fits easil$^y$ into the socket:



Splayed leads        Ready for insertion

  Take great care that no IC pins get bent under the IC when
inserting and ensure that a11 of the ICs **are** correctly aligned with
pin 1 in the right place. If available, **more 2114s** may be fitted in
positions IC 10 to 19 and 32 to 41 as described in the extensions
sections.

FITTING THE CASE
After checking that all soldering on *side* 1 is satisfactory the
circuit board may be fitted in the case. If any extension kits are
available they may be fitted as described in the relevant sections of
this manual. Take the top of the case, that is the piece with the cut-
out for the key-board, and lay it down with the pi11ars and screw
holes facing upwards. The assembled circuit board should be placed
over the case with the component side 2 upwards. Screw, but do not
tighten, four self-tapping screws into the four corner mounting
pi11ars in the case thus lightly holding the board in the case. Move
the board in the case so that a11 the keys clear the edges of the cut-
out in the top and then tighten up the four screws
  The bottom of the case is next placed over the circuit board and
moved so that it lines up with the top. If the connectors do not then
appear centrally in the cut-outs on the rear of the case bottom some
adjustment of the position of the board in the top of the case may be
required. Fina11y put two long self-tapping screws into the holes in
the case bottom and fix the bottom to the top by tightening them up.
  Four self adhesive feet may be stuck to the bottom of the case and

the surround for the keys is stuck to the top of the case when its
backing is peeled off revealing a layer of adhesive.

T.V./VIDEO MONITOR
The ATOM screen display may be on a domestic **television or a video
monitor**. To connect to a domestic television use the phono to
co-axial connecting lead supplied. The phono plug goes into SKI (the
modulator output) and the other end of the lead goes to the aerial
socket of the television. If the television has a graduated tuning
scale, set it to channel 36.
    A 1 volt into 75 ohm composite video signal for monitors is
available on pin 9 of PL4 with a corresponding 0 volt return on pin
10. These are indicated on the following diagram.
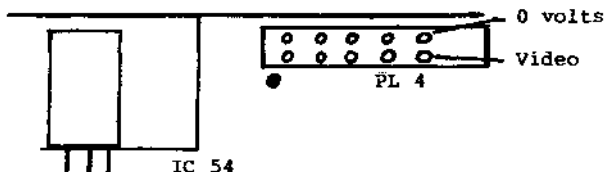


The normal ATOM produces a monochrome **picture, even if a colour
television or** monitor is used. The PAL **encoder circuit board can** *be*
fitted inside the case to give *a* colour picture.

POWER SUPPLY
The basic ATOM requires a power source of **8 volts DC** which is
regulated on the circuit board by IC53 **and 1054 to produce** *a*
stabilised 5 volts. The ATOM high-efficiency **mains adaptor** provides
such a source, and it is fitted with a jack plug **for connecting** to the
ATOM. The high-efficiency mains adapter is capable **of delivering** up to
1600 mA and powering a fully-expanded ATOM using **the low-power memory**
that is currently supplied. This current is **obtained as follows:**

Minimal system 2K RAM                       750 mA
10K expansion memory at 75 mA per K     750 mA
Bus buffers and 6522 VIA                    100 mA

    Note that ATOMs supplied before October 1980 used normal-power RAM
memory devices which have a current consumption of 100 mA per K; the
total current consumption of a fully-expanded ATOM using normal-power
memory is therefore too great for the ATOM mains adapter.

REGULATED SUPPLY
The ATOM may alternatively be powered by a 5v regulated supply. In
this case two links, LK6 and LK7, should be fitted to the board. The
power distribution on the board is normally separated into two
sections; one for each regulator. These sections should be joined
together by fitting a link at LK6 on the circuit board. The regulators
should be bypassed by fitting link LK7 on the board. The power socket,
SK3, is now for a stabilised 5 volt input and the mains adaptor must
NOT be plugged into it. This fact should be marked clearly on a label
attached near the power socket on the back of the ATOM.
    A circuit for providing a stabilised 5 volts at up to 3000 mA

capable of powering a fully expanded ATOM together with any Acorn
eurocard is given here:

## 5 VOLT POWER SUPPLY.



LM323K *

IN OUT
COMM

+5v

3A DC

0v

9V ⨀ 50VA

1500µF ⨀ 16v

## ❋ USE HEAT SINK
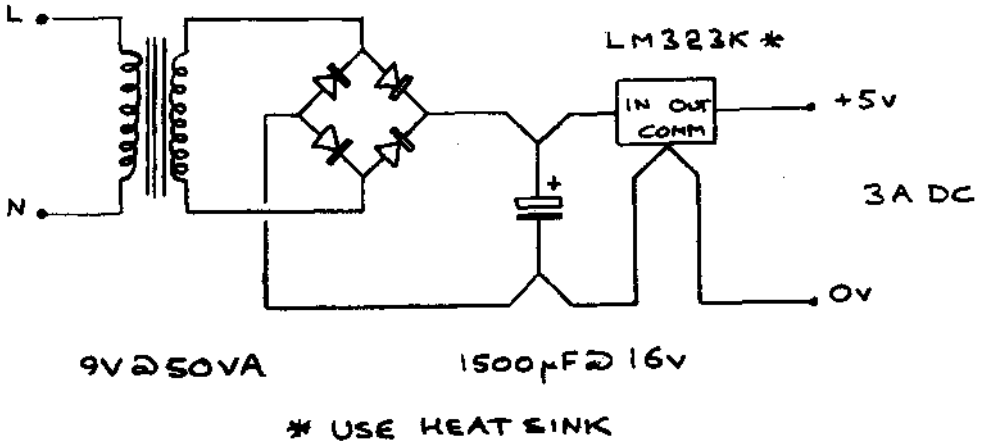
SWITCHING ON
When the T.V. or monitor is connected the power connector may be
inserted into SK3. The ATOM is now on. Press the break key to reset the
ATOM; the screen should now show:

 **ACORN ATOM**

 >█

At this stage *if* a television is being used it should *be* tuned until a
display is found. Both monitors and televisions may now require
adjustment of the vertical hold control. After further fine tuning in
the case of the television to obtain a sharp display, the brilliance
control should be set so that the background is slightly grey rather
than black. The contrast control is then adjusted to make the
characters as bright as required.
    If no display is found check that all the connections are correct
and in the case of ATOMs assembled from kits check that the
construction procedure has been followed correctly. When the display on
the screen is correct refer to the book 'Atomic Theory and
Practice' for details of how to program the ATOM.

TAPE RECORDER
Programs o data may be stored on standard audio tape using a domestic
tape or cassette recorder. The ATOM contains a Computer Users Tape
Standard (CUTS) interface, and connection to the recorder is by a 3
pin D.I.N. plug in SK2. Pin 1 is the output to the recorder, pin 2 is
the 0 volt or common connection, and pin 3 is the input to the ATOM
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from the recorder. These are shown in the diagram:



Back view of DIN plug
ie. Cable side

    Only a 3 pin lead should be used as the other 4 pins of SK2 carry digital outputs which may damage recorders with 5 or 7 pin connectors.
    Both recording and playback on the ATOM are crystal controlled and, except on very cheap recorders whose speed may vary, no trouble should be experienced when transferring tapes from one ATOM to another. The use of recorders with an input and output dedicated to connection to an external amplifier is recommended as opposed to those with only microphone and earpiece facilities; however good results should be obtained with most machines.
    The setting up of the recorder using a test program is described on page 8 of the book 'Atomic Theory and Practice'. Should correct results not be obtained the signal levels may require adjustment. Both the input and output are normally set to a level of 300 mV R.M.S. The output can be adjusted by changing the value of R29 so that the recorder's VU meter reads 70% on recording (70% = -3dB). The gain of the input amplifier on the ATOM may be changed by altering R34; hi-fi cassette decks are generally more sensitive and often require that this resistor is changed from 47K to 220K.

OUTPUT PORTS
Pins 4,5,6 and 7 of SK2 carry bits 1,2,0 and 3 respectively of port C of the INS8255 (address B002).. These are normally set to output mode and they will drive a standard TTL load. Bits 0 and 1 also drive the tape interface, bit 2 bleeps the loudspeaker, and bit 3 selects between the two possible sets of four colours. Refer to the book 'Atomic Theory and Practice' for further details.

# CIRCUIT DESCRIPTION

The block diagram of the ATOM shows the essential elements of a micro-computer system. The 6502 micro-processor is provided with a 1 MHz clock with which all action on its bus is synchronised. The bus has 8 data connections which allow data to be transferred from the processor to other devices or vice-versa. 16 address lines select the location to which or from which data is transferred; the most significant lines feed the chip select logic which selects the device being accessed whilst the rest of the lines select the location within the device.

The reset signal at break or power up causes the processor to fetch instructions down the data bus from the Operating System/BASIC ROM (Read Only Memory). Executing these instructions sets up the screen and scans the keys, and when BASIC statements are entered more instructions in the ROM interpret the statements and communicate with the screen, tape interface etc. using routines in the O.S. section of the ROM.

The block zero RAM (Random Access Memory), from #0000 to #0400, is used by the processor for scratch pad and stack memory. This RAM should not normally be accessed by the user.

The user RAM, that is the space in which lines of BASIC text are stored, can be the lower text space or, as in the unexpanded ATOM, the upper text space or graphics space may be used.

A Video Display Generator (VDG) produces synchronisation signals for the television or monitor picture scan in time with a series of refresh addresses which fetch data for the screen from the video RAM. The screen is "memory mapped"; each dot on the screen shows the information in a corresponding piece of memory. Normally only the VDG accesses the video RAM obtaining information with which to refresh the screen. When the information on the screen is to be changed the tri-state buffers are enabled allowing the processor to write new data into the RAM. The VDG is fed with a 3.58 MHz frequency from which the sync and refresh timing is derived. Both monochrome and colour information are produced by the VDG.

In the most basic ATOM the 1024 by 8 (that is 1 Kbyte) video RAM is divided into two sections. Half of the RAM is used for video so that a screen full of normal characters can be stored and the rest is used for the upper text space. Extended ATOMs will normally have RAM in the lower text space position and so the original video RAM together with the extension video RAM is used to provide the higer resolution graphics modes.

Another device on the bus is a peripheral interface which provides 24 input and output signal lines. Some of these lines are used to control the VDG and one in particular is a signal from the VDG indicating the vertical blanking period of the screen. During this period the processor can enable the tri-state buffers and access the video RAM without producing interference on the screen. This signal also provides the timing for the WAIT statement.

The INS8255 PIA interfaces with the ATOM keyboard in which the keys are arranged in a matrix. A 4 to 10 line decoder-driver is driven by the peripheral interface and its 10 outputs drive each row of the key matrix in turn. The peripheral interface is used to read the outputs from the columns of the key matrix as each input is driven and so the matrix position of any depressed key is determined.

A Computer Users Tape Standard interface is also connected via the peripheral interface. This standard saves data or programs on tape as a sequence of two different tones. A logical 1 signal is represented by a frequency of 2.4 KHz whilst logical 0 is a 1.2 KHz frequency. Each bit, that is 0 or 1, lasts for 3.3 mS giving an operating speed of 300 bits per second. The 2.4 KHz standard is derived from the 4 MHz
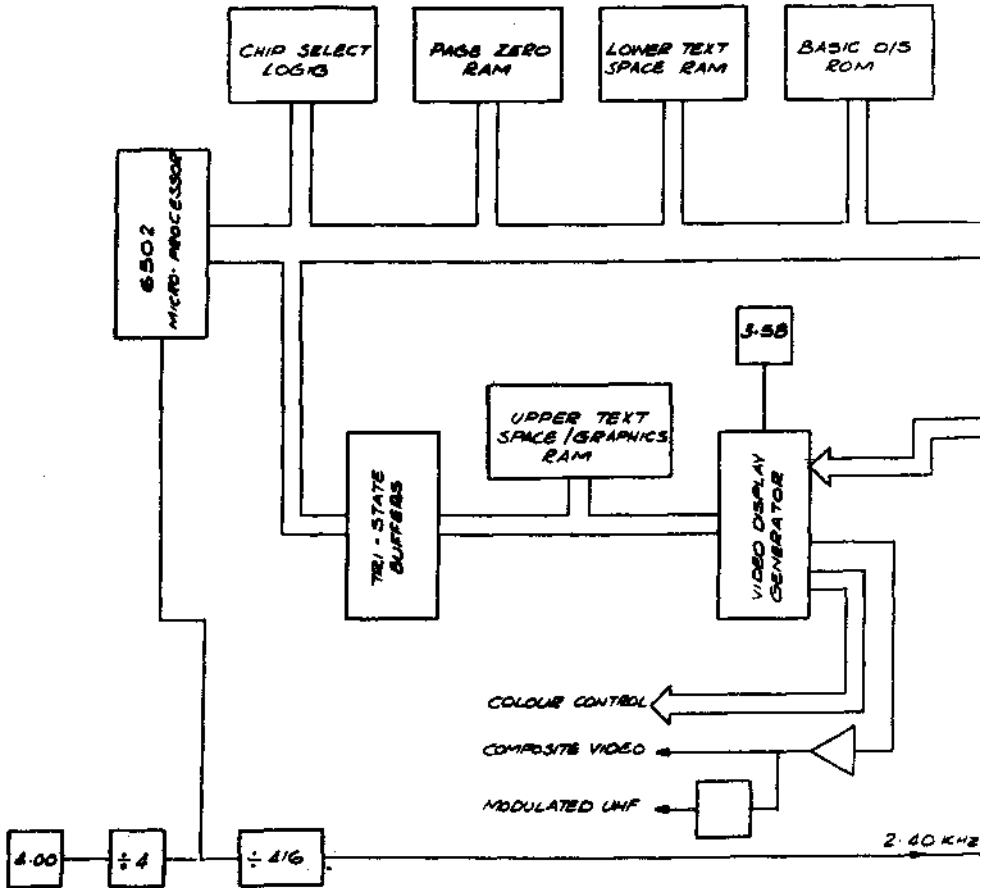
crystal with a frequency divider chain and it is fed to the peripheral interface and the tape output. The input from the tape recorder passes through an amplifier and *a* schmitt trigger before being fed into the peripheral interface. Another line *from* the peripheral interface is used to drive the loudspeaker.

Two more ROMs may be fitted in the ATOM. One contains instructions for interpreting additional BASIC statements which deal with floating point numbers, scientific functions and colour graphics. The other ROM can provide extra utilities, such as programs to deal with serial interfaces to the ATOM, and the comunications ring .

An optional Versatile Interface Adaptor (VIA) may be fitted giving input or output lines allowing the ATOM to interface to external hardware. Also a driver device can be added allowing the VIA to connect to para11el printers of the Centronics type.

Fina11y *a* set of bus buffers may be added a11owing the ATOM bus to connect to external devices such as extension RAM floppy disc drives etc.

CHIP SELECT LOGIC

PAGE ZERO RAM

LOWER TEXT SPACE RAM

BASIC O/S ROM

6502 MICRO PROCESSOR

3·58

UPPER TEXT SPACE / GRAPHICS RAM

TRI - STATE BUFFERS

VIDEO DISPLAY GENERATOR

COLOUR CONTROL

COMPOSITE VIDEO

MODULATED UHF

4·00

÷ 4

÷ 416

2·40 KHz

PARALLEL PRINTER

DRIVER

USER
I/O PORTS

F.P. EXT
ROM

UTILITY
ROM

V.I.A.

BUS
EXTENSION

PERIPHERAL
INTERFACE

DRIVER

KEY
MATRIX

TAPE OUTPUT
TAPE INPUT

LOUD SPEAKER
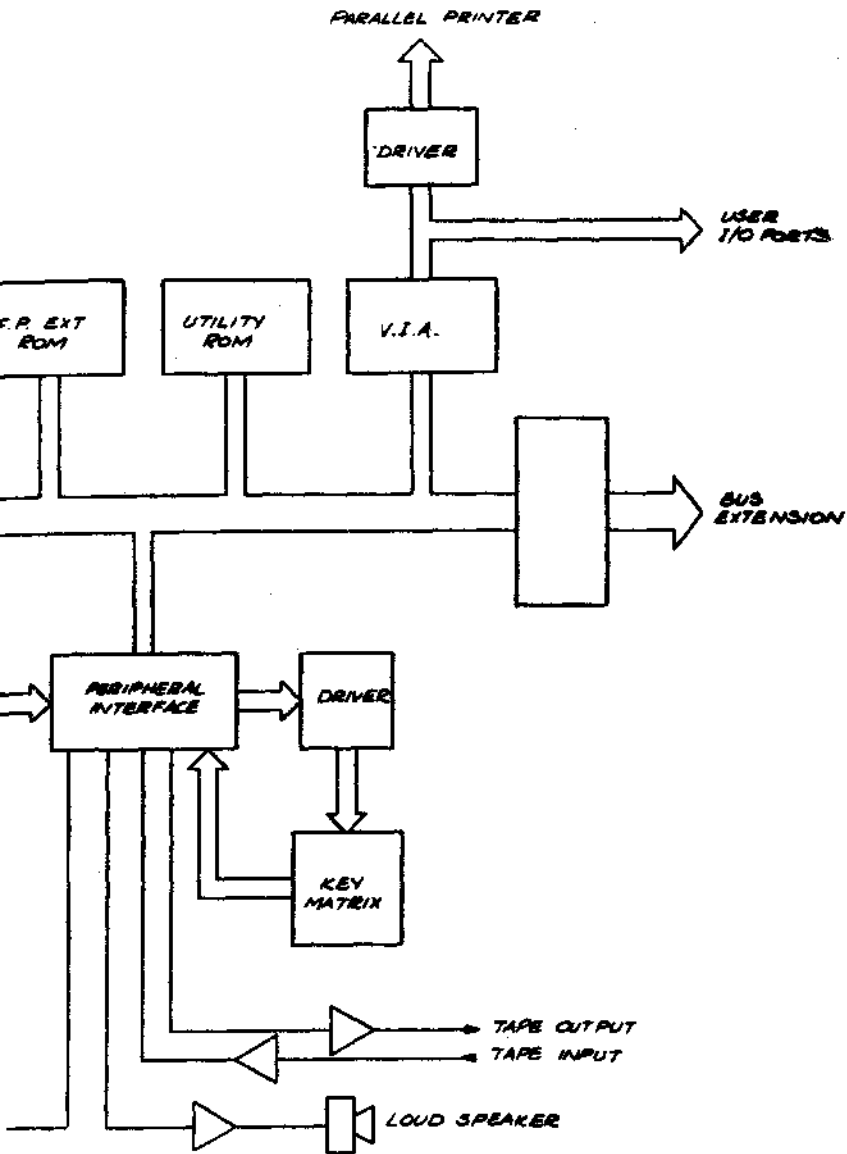
<pre>
                    ATOM MEMORY MAP

    FFFF Top of memory                      X
                                            X
                                            X
    F000 ROM         MM52164    IC20        **X**


    E000 Reserved -Disk Operating System
                                            X
                                            X
    D000 ROM         MM52132    IC21         X
                                             X
                                             X
    C000 ROM         MM52164    IC20         X
                                             X
    BC00 Empty                               X
    B800   VIA      6522        IC1          X
    B400 Extension              PL8          X
    B000   PPI     INS8255      IC25         X
                                             X
                                             X
    A000 ROM         MM52132    IC24        **X**
                                             X
    9800 Empty                               X
    9400   RAM       2114       ICs 32&33    X
    9000 RAM         2114       ICs 34&35  X
    8C00 RAM         2114       ICs 36&37  X
    8800 RAM         2114       ICs 38&39   X
    8400 RAM         2114       ICs 40&41    X
    8000 RAM         2114       ICs 42&43  X


    3C00 For RAM expansion off board
    3800 RAM         2114       ICs 18&19   X
    3400 RAM         2114       ICs 16&17  X
    3000   RAM       2114       ICs 14&15   X
    2C00 RAM         2114       ICs 12&13  X
    2800 RAM         2114       ICs 10&11   X


    0400 Reserved for Eurocards
    0000   RAM       2114       ICs 51&52   X
</pre>

    Any memory access to an address indicated by an X will cause IC 5 to
generate an 'on card' signal, and disable the off card address and data
bus buffers.

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**EXPANDING THE ATOM**

OPENING THE CASE
In order to add any of the ATOM extensions it is necessary to open the
case. Unplug the ATOM power connector before taking the case apart.
Under the case two screws are undone to remove the case bottom
allowing access to the component side 2 of the circuit board. When it
is necessary to solder in extra I.C. sockets the board is removed from
the top of the case by undoing the screws at each corner of the board.
    The case is assembled as described in the Construction Procedure.

LOWER TEXT SPACE EXTENSION
The first extension usually required is more RAM for BASIC text space.
The unexpanded ATOM has 1024 bytes (1Kbyte) of RAM provided by ICs 42
and 43 of which 512 bytes is the upper text space and 512 bytes is the
video RAM. Every time the ATOM is powered up or reset it automatically
checks to see if there is RAM in the lower text space and uses it for
programs if present; otherwise it defaults to the upper text space.
Each 1024 bytes of RAM is provided by two 2114-Ls and these must be
added in pairs. Each pair of 2114-Ls will provide text space for about
64 lines of BASIC.
    To use the lower text space IC6 must be fitted; this is a 74LS138
in a 16 pin socket. ICs 10 to 19 provide for up to 5 Kbytes of space
and they must be added in the order 10 and 11, 12 and 13, 14 and 15
etc. They are all 2114-L types and they require 18 pin sockets.The
memory addresses contained by each pair of ICs are as follows:

        ICs 10 and 11    #2800 to #2BFF.
        ICs 12 and 13    #2C00 to #2FFF.
        ICs 14 and 15    #3000 to #33FF.
        ICs 16 and 17    #3400 to #37FF.
        ICs 18 and 19    #3800 to #3BFF.

    The # sign above indicates a hexadecimal number, #400 = 1024
bytes. Each 2114-L consumes around 35mA, so an ATOM with the full 5K of
lower text space will require about 1125mA.

VIDEO GRAPHICS EXTENSION
More graphics RAM can be added increasing the screen resolution and
allowing the use of the higher graphics modes. These modes are
described in the book 'Atomic Theory and Practice' and they each
require different amounts of video RAM provided by fitting pairs of
2114-Ls as follows:

        ICs 42 and 43    1024 bytes = 1 Kbyte.
        ICs 40 to 43     2048 bytes = 2 Kbyte.
        ICs 38 to 43     3072 bytes = 3 Kbyte.
        ICs 32 to 43     6144 bytes = 6 Kbyte.

    If only ICs 42 and 43 are in use the fitting of IC30 is optional.
When IC30 is not present a wire link, LK1 on side 2, must be soldered
on the circuit board. IC30 is a 74LS138 in a 16 pin socket and when it
is fitted the wire link must be cut or removed, ICs 32 to 41 may then
be added.
    The address locations provided by each pair of 2114-Ls are as
follows:

```
ICs 42 and 43    #8000 to #83FF.
ICs 40 and 41    #8400 to #87FF.
ICs 38 and 39    #8800 to #8BFF.
ICs 36 and 37    #8C00 to #8FFF.
ICs 34 and 35    #9000 to #93FF.
ICs 32 and 33    #9400 to #97FF.
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Each 2114-L consumes about 35mA and so ATOMS with a 5 Kbyte lower text space and the 5 Kbyte video RAM extension (i.e. a total video RAM of 6 Kbytes) will require an 1500mA supply.

FLOATING-POINT EXTENSION
A Read Only Memory containing the floating point, scientific functions, and colour routines may be added to the ATOM. This ROM goes in position IC21 on the circuit board using a 24 pin socket and the extra current consumption is negligible.

VERSATILE INTERFACE ADAPTOR
The VIA is a 6522 device requiring a 40 pin socket and fitted in the IC1 position. It provides two input/output ports each having 8 data bits and 2 control lines. These lines appear on the 64 way connector, PL6, which is of the Vero 17-3704L type and the pin numbers are given on the circuit diagram. The base address of the VIA is #9800 and a description of how to operate it is in the book 'Atomic Theory and Practice'. It will be necessary to remove the circuit board from the case in order to fit the 64 way connector on side 2.

Each interface pin of the 6522 can drive one standard TTL load, that is it can sink 1.6mA down to 0.4V and it can source 100uA into 2.4V. In input mode each pin presents one standard TTL load.

The circuits below show how the 6522 can drive a lamp or relay and how it can sense the state of a switch or transistor. Other circuits may be more suitable for some applications, these are only suggestions:
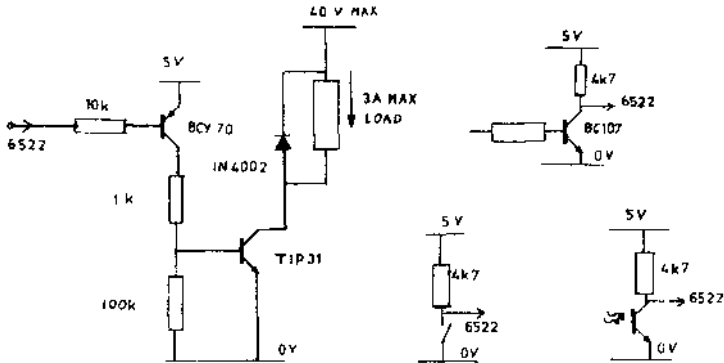


In some applications the 6522 may need to interrupt the processor in which case the wire link LK2 is required which connects the interrupt line to IRQ (or NMI). The 6522 requires an extra 50mA from the power supply plus any current it sources into external loads.

PRINTER INTERFACE
The ATOM can drive a para11el printer of the Centronics type when the
6522 is fitted in position IC1 and a 74LS244 is in position IC50. The
64 way connector is not required as the printer connects to PL5 which
is a 26 way header, 3M type 3429-1302. A mating ribbon cable socket
for this is part number 3399-6000. Note that one port of the 6522 is
now used by the printer and is no longer available for user I/O. The
printer connector pin numbers and signal names are shown on the
circuit diagram and when flat ribbon cable is used the wires are in
the right order for connection to the 25 *way* E connector usua11y used
on printers

BUS BUFFERS
When the 64 way connector PL6 is fitted the standard Acorn bus appears
on this connector. Using this extra memory or interface cards may be
added. ICs 2,3,4 and 5 must be fitted to the ATOM in order to use the
bus. ICs 2 and 3 are 81LS95s which buffer the address bus and IC4 is a
DP8304 (equivalent to INS8208) which is a bi-directional buffer. IC5
is a 74LS30 which determines whether the, address being accessed is
inside the ATOM or on the other side of the buffer. The buffer, IC4, is
only enabled for addresses outside the ATOM so that bus conflicts do
not occur. The addresses for which the buffer is enabled are:

          #0400 to #27FF
          #3C00 to #7FFF
          #E000 to #EFFF

    If IC6 is not fitted addresses #2800 to #3BFF also enable the
buffer and the lower text space is then outside the ATOM so that an
external memory card may be used.

EUROCARD EXTENSION
Any one of the Acorn Eurocards can be fitted inside the ATOM case and
connected to PL7 which carries the Acorn bus in para11el with PL6. The
bus buffers must be fitted in order to use PL7.

OTHER EXTENSIONS
PL8 is a 20 way plug to which other extension boards may be fitted via
a 20 way ribbon socket. Resident software for other extensions can be
in the utilities ROM, IC24. Norma11y PL8 is fitted to side 1 of the
circuit board and its pin connections are as fo11ows:

          20 NRST        19 IRQ
          18 R/NW        17 1MHz
          16 A2          15 A3
          14 A0          13  D7
          12 A1          11 0 volts
          10 +5 volts   9 NMI
           8 D0          7 D 3
           6 D2          5 D 1
           4 NB400       3  D 4
           2 D5          1  D 6

    LK3 is made in order to connect IRQ from PL8 to the 6502. NB400 is
an active low enable signal for the address range #B400 to #B7FF and
it comes from IC49 pin 5.