Build yourself a nixie clock!

You may have seen them in old sci-fi movies and wondered how they worked. Well, here is your chance to experiment with nixie tubes by building your own nixie clock.

Digital displays such as LEDs and LCDs are everywhere nowadays, but have you ever wondered what was used before these technologies came along?

There were several commonly used digital displays—in fact, you may have even owned a digital clock with a mechanical display, where small tiles or cards were flipped over to show the number required.

However, there was another type of display quite common before LEDs and LCDs took over—nixie tubes. What is a nixie tube, you ask?

Well, nixies are a special type of neon bulb. You have most likely seen the small orange-glowing neon bulbs found in some powerpoints which are used as power-on indicators. These consist of a small glass bulb filled with neon gas. Inside the bulb are two wire electrodes, and when a high voltage is present across the electrodes, the neon gas between them glows a warm orange colour. Current through the bulb is limited by an external resistor, often over 100k when used on 240 volt AC systems.

A nixie tube works in the same way as a neon bulb, but instead of two similar electrodes using AC, they have specially-shaped electrodes and use DC. The anode is in the form of a fine mesh grid at the front of the viewing area of the tube, while the cathode is in the shape of the letter, symbol or digit you wish to display. So how can you display more than one symbol per tube? Simple—just stack a heap of differently shaped cathodes one behind the other with insulating spacers between them, and drive the cathode you want to light up.

While this sounds a bit messy, in fact it works rather well, and provides clear, sharp characters that can be driven by simply connecting the appropriate cathode to the negative of the high voltage supply. This arrangement is why you need DC to drive the nixie. If you used AC, both the character and the grid would illuminate, thus making the display rather hard to read!

Incidently, the name 'nixie' came about accidentally. A [Burroughs] draftsman making drawings of the device labelled it NIX I, for Numeric Indicator eXperimental No. 1. His colleagues began referring to it as 'Nixie', and the name stuck. (Scien-tific American, June 1973, pp. 66).

A warning

Like other neon tubes, nixies use high voltage. They need around 140 volts or more to strike, and then maintain around 120 volts or so across the tube while running, but these figures vary a bit.

This project uses a switchmode power supply to provide around 180VDC to drive the nixies. The supply can produce more than enough current to give you a nasty, or even fatal shock, so you must be careful when working on this kit, and the completed unit should be mounted inside an insulated enclosure for safety.

So, if you are not experienced at working with these voltages, then make sure you get the help of someone who is. Really, this project is not for the novice.

The circuit

To make things simpler, we will break the circuit down into several sections.

The brain of the clock is a Picaxe28X microcontroller (U7). This IC performs a number of functions, but its main task is to read the data from the real time clock IC, the DS1307 (U8), process that data, and then send it in the appropriate format to the nixies via ICs U9 to U11, which are 74LS374 eight bit latches. Using three latches allows the 28X, which only has 16 output lines available, to drive all six nixies without resorting to multiplexing. To drive the latches, the 28X only requires eight data lines and three control lines, leaving some outputs of the microcontroller spare to do other things, such as controlling the am/pm indicator, the colons, and the brightness of the blue LEDs under the nixie tubes.

The inputs of all the latches are connected in parallel, so they all see the same data, but only the latch who's control line is strobed transfers the input data to its output. This allows the microcontroller to simply send the data, followed by a pulse to the appropriate latch, to put the data on the correct pair of nixies.

The Picaxe28X also monitors the switches SW1 to SW5, which allow the time and date to be set and programmed into the real time clock. More detail on how this is done can be seen if you look at the software that the Picaxe uses (available from www.ledsales.com.au in the help section under 'kit info and downloads').

For more information on how the Picaxe controllers work, see www.picaxe.co.uk

Once the 28X has written the data to the 8-bit latches, the appropriate digits on the nixie displays will appear. These are driven by the 74141 nixie driver ICs. The ICs supplied are actually K155ID1 Russian-made equivalents of the 74141, as the 74141 are no longer available. The Russian ICs actually have better ratings than the original 74141s and are more robust.

The data is sent to each driver IC in binary coded decimal (BCD) format and the driver IC turns on the appropriate cathode in its nixie tube by grounding it. This is a rather convenient system, as the data is stored in the RTC chip also as BCD, so displaying the data is as simple as read-

Figure 1. The circuit diagram.
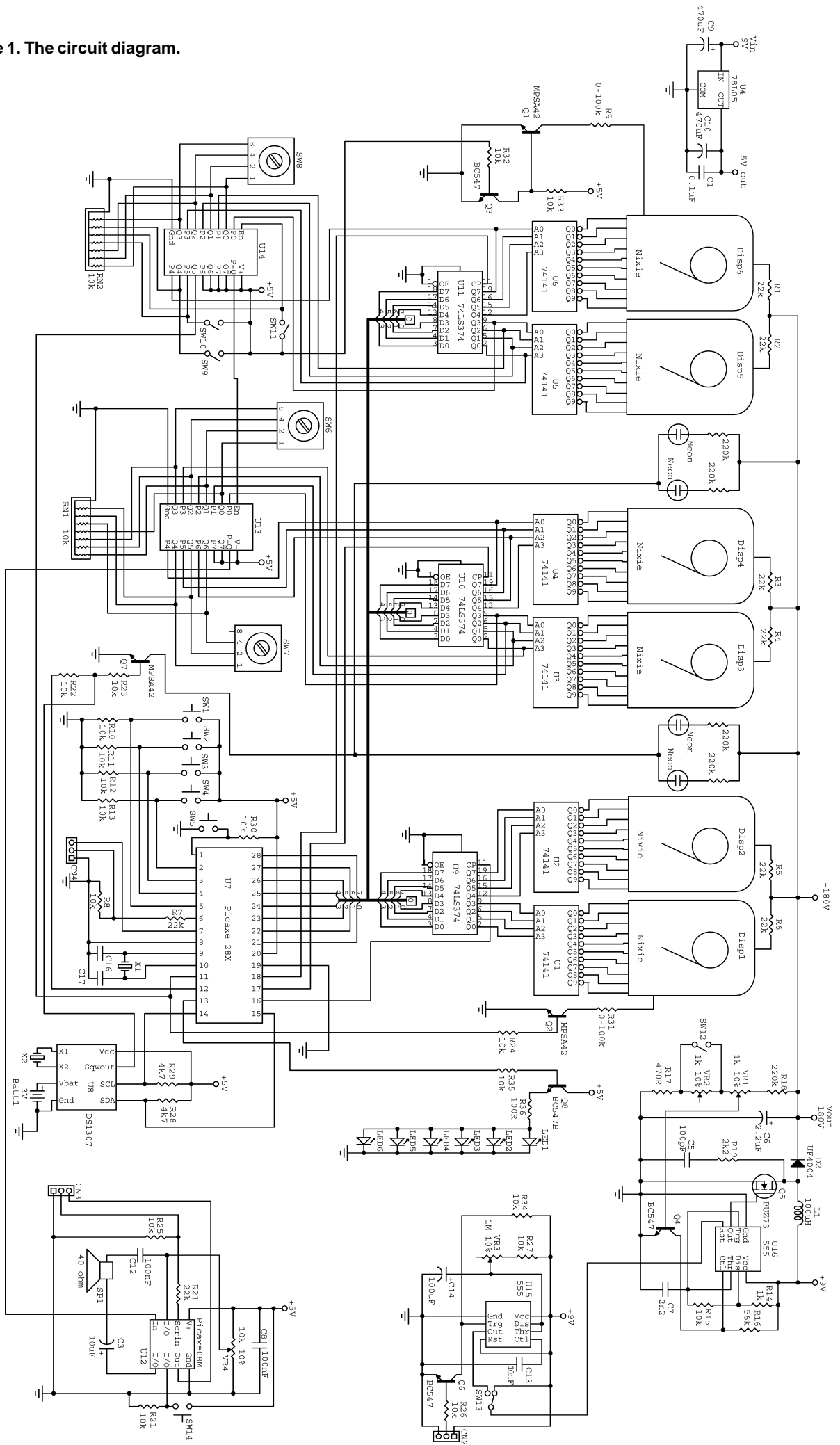
ing it from the RTC and transferring it to the display drivers via the latches, with little or no processing involved!

The alarm controls

The clock has an alarm function that works by comparing the time displayed on the nixies (including whether it is am or pm) to the time set on a series of switches, SW6 through to SW10.

SW6, SW7 and SW8 are BCD rotary switches which define the minutes units, tens of minutes, and hours units respectively. The tens of hours are controlled by a simple on-off toggle, SW9, where down (on) represents the tens of hours being a 1 and up represents 0. So, if you are setting the alarm time for an hour of 10, 11 or 12, SW9 would be down, otherwise it would be up.

SW10 sets the alarm time to am (switch up) or pm (switch down). SW11, determines whether the alarm is active or not. With SW11 down, the alarm will trigger whenever the time on the nixies matches the time set on the switches SW6 to SW10.

The comparison of the time on the nixies with the time set on the alarm switches is done by a pair of 74HC688 eight bit magnitude comparators, U13 and U14. U13 takes care of the minutes comparison, while U14 does the hours. The comparators provide an active low output to the alarm sounder circuitry (discussed next) to trigger it. SW11, the alarm active/disable switch, both controls the comparators by enabling or disabling U14 (which in turn controls U13) as well as turning the alarm-on indicator in the tens-of-hours nixie, DISP6, via Q1. However, as U14's enable is an active low input, but we need an active high to control the alarm-on indicator in the nixie, an inverter consisting of Q3, R32 and R33 is used to invert the signal.

Alarm generator

This part of the circuit consists of another microcontroller, a Picaxe 08M (U12). The M in the name of this IC stands for music, as it has two commands for playing tunes. The first is the Play command, which will play one of four inbuilt tunes, while the Tune command allows it to play any series of notes you desire. Numerous tunes can be downloaded from the Picaxe website.

Anyway, once the Picaxe 08M is triggered, it will play the tune for one minute, or until the snooze button SW14 is pressed.

The audio output comes out of pin 5

(output 2) of the Picaxe and goes via C3, a 10uF electrolytic capacitor, to the speaker.

The other components associated with U12 are R20, R25 and CN3, which are the programming components. R21 is a pull-down resistor for SW14, and C12 filters the input from the 10k potentiometer (VR4) connected to input 4 (IC pin 3) of the Picaxe. This pot is just an extra, you don't have to use it if you only want to use one tune with the Picaxe, but you can program the Picaxe to select a different tune depending on the position of the pot if you wish. It is expected that software to do this will be available on the LEDsales website soon after this kit is released.

Producing the high voltage

The switchmode circuit is designed around one of the most common ICs on the planet—the 555 timer chip. While several decades old, this chip still finds uses in a great many areas, including simple converters like this one.

The 555 is configured as an astable oscillator which oscillates at a frequency (around 45kHz) determined by resistors R14 and R15, and capacitor C7. The 555's output directly drives a high voltage MOSFET, Q5, that switches the current through an inductor, L1.

When the FET is on, current flows from V+ through the inductor to ground. As the current in the inductor builds up, the FET then turns off.

When the FET turns off, the current flowing through the inductor tries to continue to flow but can't flow through the FET, so the voltage on the FET's drain terminal rises until the ultrafast diode, D1 becomes forward biased. This allows the energy contained in the coil to be dumped into the high voltage capacitor, C6.

This cycle continues until the voltage across C6 reaches a value set by trimpot VR1 (and VR2, if the day/night switch is in the night position). R17, R18 and VR1 (and VR2) form the feedback divider for the circuit, and are chosen such that the voltage across C6 is divided down to around 0.7 volts. This voltage is applied to transistor Q4, a BC547. When the voltage across C6 rises to the point where the voltage from the divider is enough to turn Q4 on, then Q4 pulls down the Control pin of the 555, stopping it from oscillating and shutting down the converter.

As soon as this happens, the voltage across C6 begins to fall, as does the voltage into the base of Q4, and so Q4 turns off, allowing the converter to restart. This

is how the circuit regulates the voltage, and in practice it works quite well.

Resistor R19 and capacitor C5 form a simple snubber network, while C9 is the main reservoir cap for the circuit.

Infrared option

The clock display can be controlled by an optional passive infrared sensor module which plugs into the PCB at CN2. This module senses if anyone is within range and sends a trigger pulse to U15, another 555 timer. This 555 is configured as a one-shot with a variable output period, dependent on the setting of trimpot VR3. Output time varies from around 1 to 100 seconds or so.
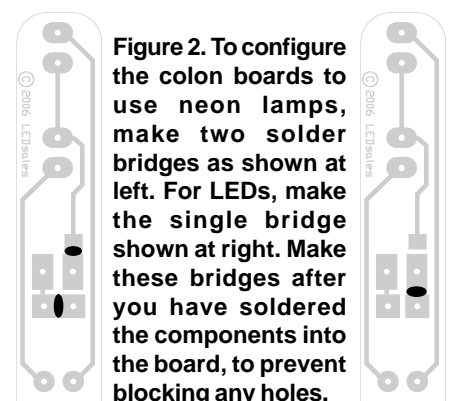
The output of this 555 goes to the reset pin, pin 4, of U16, the switchmode 555, via switch SW13. When SW1 is in the on position (toggle down) then U15 controls U16, but when the switch is up, pin 4 of U16 is connected to V+, which means it runs continuously.
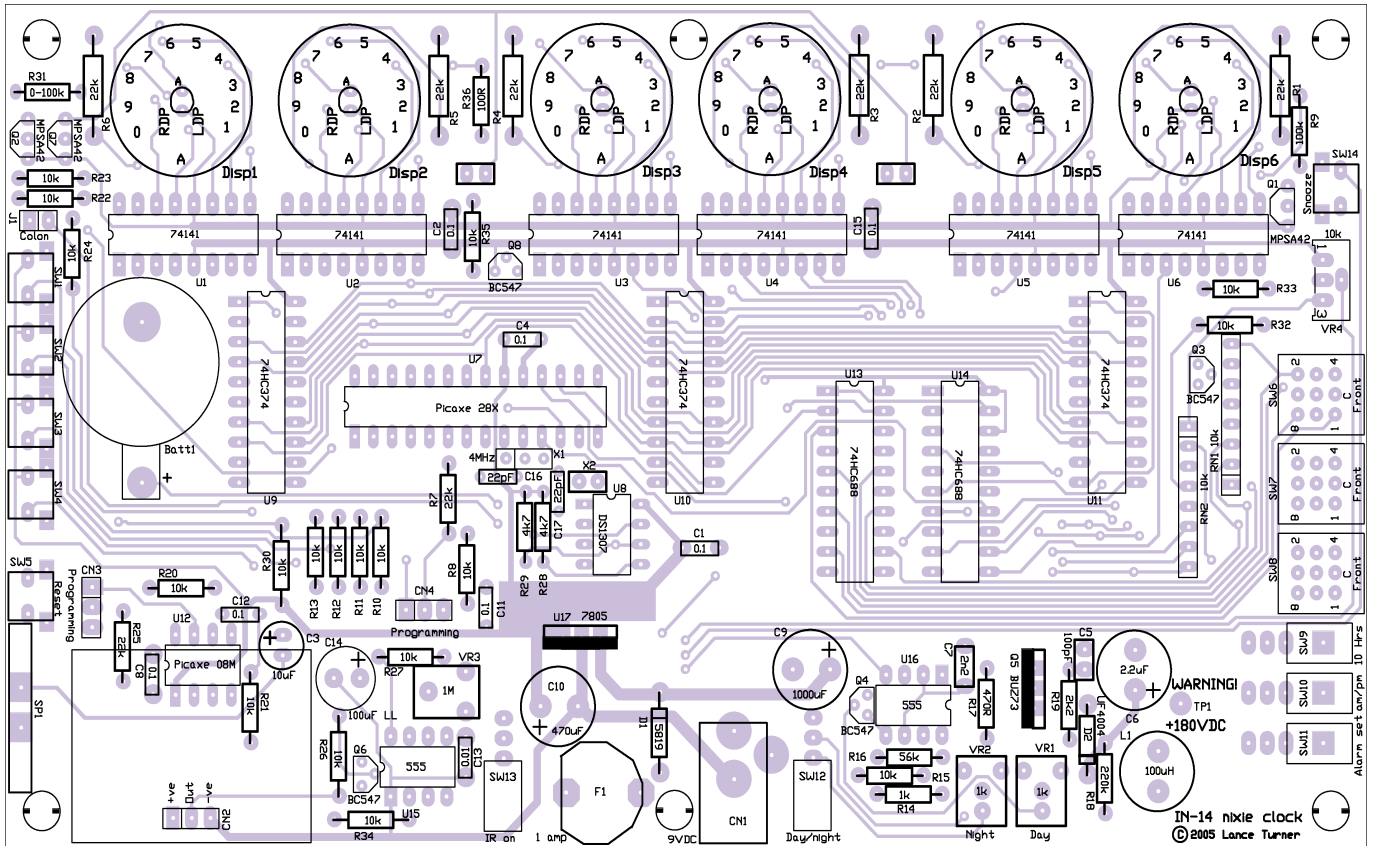
And that is about it for the circuitry. The various resistors around the circuit, and resistor networks RN1 and RN2, are used as pull-up or pull-down resistors, while the numerous 0.1uF capacitors such as C1, C2 etc are decoupling caps. The 5 volt supply for the microcontrollers and various other ICs is supplied by the power supply components, which include the 7805 regulator and C10. Schottky diode D1 is used to provide reverse polarity protection for the clock as some plugpacks have their plugs wired –ve to tip (just to confuse things and increase the chance of accidents!)

Colons—neon or LED?

We haven't discussed the colon boards and their associated components yet, so let's have a look at those.

The colons can either be 3mm x 10mm neon lamps, each connected in series with a 220k resistor, or the colon boards can be configured to drive two LEDs instead. In this configuration, the LEDs are driven

Figure 2. To configure the colon boards to use neon lamps, make two solder bridges as shown at left. For LEDs, make the single bridge shown at right. Make these bridges after you have soldered the components into the board, to prevent blocking any holes.

Here is the main board overlay, with the top layer in grey for reference.

from the high voltage supply, but they are connected in series along with both 220k resistors, so that current through the LEDs is less than half a milliamp. This doesn't sound like much, but for high brightness LEDs this is enough for reasonable brightness, and is actually less of a load on the HV supply than if using neons. See Figure 2 for configuring the separator boards.

The colons are driven from one of the PWM (pulse-width modulated) outputs of the Picaxe 28X via resistors R22, R23 and Q7, allowing the brightness of the colons to be controlled depending on the mark-space ratio of the PWM output signal. Two resistors are used so that the colons can be either steady or flashing. By connecting the junction of these two resistors to the open-drain squarewave output pin of the real time clock (which is configured to produce a 1Hz squarewave output), the drive signal from the 28X is gated on and off when the colon jumper, J1, is bridged. When it is open, the signal from the 28X is uninterrupted.

The kit has the option of LED uplights under each nixie tube. As standard, blue LEDs are provided, but of course you can change these to any colour you like, although the blue does contrast well with the orange of the nixies. These are driven by the 28X via R35, Q8 and R36. They can be set to one of 10 brightness levels, or can be turned off. They are all connected

in parallel for simplicity, and generally this works well, although there might be some slight variation of brightness between each LED due to them having slightly different forward voltage drops.

Lastly, Q2, R24 and R31 provide the am/pm indication, which is also controlled by a pin from the 28X. It should be noted here that R31 is listed as 0-100k. When any of the digits are on in this tube (DISP1), the right-hand decimal point that is used as the am/pm indicator will simply glow at the same brightness as the digit, providing R31 is 0 ohms. However, on the change of hours, when the digits are turned off briefly, all of the anode current from this tube will flow through the tiny decimal point cathode, causing it to briefly glow more brightly. Adding resistance between its cathode and ground will reduce this flaring, but will also reduce it's brightness when the digits in that tube are lit. It is probably best to leave R31 as a 0 ohm link so that the am/pm indicator is as bright as the digits, otherwise it can get lost against the large, bright digit, but the option is there to change this, and a 100k resistor is supplied in the kit for this purpose.

Building the clock

Assembly is quite straightforward if you work methodically. Start with the resistors, then the diodes (don't mix these up, they look very similar but have very different ratings!), capacitors and transis-

tors, followed by the IC sockets and U17, the 7805. Be sure not to mix up any of the transistors, as the MPSA42 are a high voltage type, while the BC547s are not! Just a word on the crystals; X1 will either be a 4MHz crystal, which only has two leads, or a ceramic resonator, which has three. If using a resonator, then C16 and C17 should not be used (and won't be provided in the kit), but if using a crystal, then these two capacitors should be installed, as they are the load caps for the crystal.

Next insert the pushbutton and toggle switches, the fuse holder and the power socket, and solder into place. Also install the header sockets for the nixie colon boards and the infrared option (even if you didn't opt for the IR control module) and the jumper header, J1. Also install the programming headers CN3 and CN4. They are both oriented so that the vertical plastic tab is facing in towards their associated microcontroller (the 08M for CN3 and the 28X for CN4) and the open side is facing the closest edge of the PCB. Don't install the ICs in their sockets yet—that comes at the testing stage.

Now for the scary part—the nixies themselves. Before you do this though, you should decide if you want the blue LED uplights under the tubes. This does look quite nice at night, and you can turn them off anyway if you don't like them, so it is recommended you install them. The LEDs

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are inserted into the board so that they sit flush. The longer lead is the anode and goes towards the edge of the board. Once these are soldered in place, you have to modify the nixie tube plastic bases to accommodate them. This is simple enough—just remove them from the nixie tubes, and drill a 6.5mm (¼") hole in the dead centre of each one. Start by drilling them at 3mm, then increase drill sizes until you reach 6mm. The bases are small and difficult to hold, so be careful, you don't want to damage them (or your fingers). Use a pair of pliers with some rubber in the jaws to hold them without damaging them. Alternatively, don't use a drill at all, but instead use a hot soldering iron (don't breathe the fumes!) but make sure you don't deform the bases with too much heat. Once the holes are drilled and you have removed any burrs, then fit them back onto the tubes. Now to fit the tubes to the board.

Take a nixie tube and start by gently straightening the flying leads and bending them all slightly away from each other so they fan out slightly. This will make it easier to get them into the board. Now, starting with the anode lead (the lead furthest away from the anode grid, identified by the white insulation it has on it just inside the base of the tube), insert it into the anode hole (marked A) in the board—don't push it through too far—2-3mm is enough for now. Work your way around the tube until all leads are partly inserted. The viewing area of the nixie tube should now face towards the front edge of the circuit board.

If you are happy that all leads are in the correct holes (make sure none have become crossed over!) then slowly work the tube into place until the plastic base is seated on the board and the tube is nicely seated in the base. Check that the tube is perpendicular to the board in both directions, and then bend the leads on the solder side of the board to hold the tube in place.

Now, solder three leads that are evenly spaced around the tube, check that the tube is still aligned, and solder the rest.

Repeat this for the other five tubes, being careful that all tubes line up when sighted from one end of the board and that they are all parallel to each other when looking from the front.

One last warning when soldering the tubes. Don't apply excessive heat, or heat for too long, as you may damage the tubes. While it is rare for a tube to crack, it is possible for the soldered connections inside the tube to fail, causing one or more digits to not light up. Providing you solder the leads quickly and are using a good temperature controlled iron, this won't be a problem.

Colon boards

The last thing to do is to assemble the two small colon boards. These have only two resistors and two tiny neon lamps or LEDs, depending on your preference. The neons look quite good when viewed end on, so don't be tempted to bend them so they lay flat against the boards, as it will be hard to position them this way. Remember though that as they are running from DC, only one of the electrodes inside the neons will light.

If you have decided on the LED option for the colons, then make sure they are inserted the correct way around in the boards. The anode of each LED must go towards the bottom of the board.

Once you have installed the resistors and neons/LEDs on the two colon boards, solder the two pairs of right-angle header pins to the back of them. Press the pins with black plastic section on them into the back of the board until the tips of the pins just grab inside the edges of the holes. They won't be able to be inserted fully into the holes. This gives adequate clearance between the PCBs and the header sockets on the main PCB. Now make the appropriate solder bridges on the boards, as per Figure 2. Once the colon boards are finished just plug them into the main clock PCB.

Testing

The clock should now be ready to test. Before you apply power, you have to make sure that the MOSFET, Q5, has it's gate pulled to ground. If left floating with no IC in U16's socket, the FET can partly or fully turn on, shunting power through L1 to ground. This will cause heating of L1 and may blow the fuse. To make sure this doesn't happen, insert a small wire link into U16's IC socket between pins 1 and 3 (remember, U16 is upside-down compared to the other ICs on the board, so get the link in the right socket holes!). This will tie the FET's gate to ground, keeping it switched off.

Now, apply 9 to 12 volts DC to the power socket (with positive to the centre pin) from a current limited power supply, set to 500mA or so, and ensure that a nice regulated 5 volts is coming out of the regulator, U17. Check a few of the IC sockets
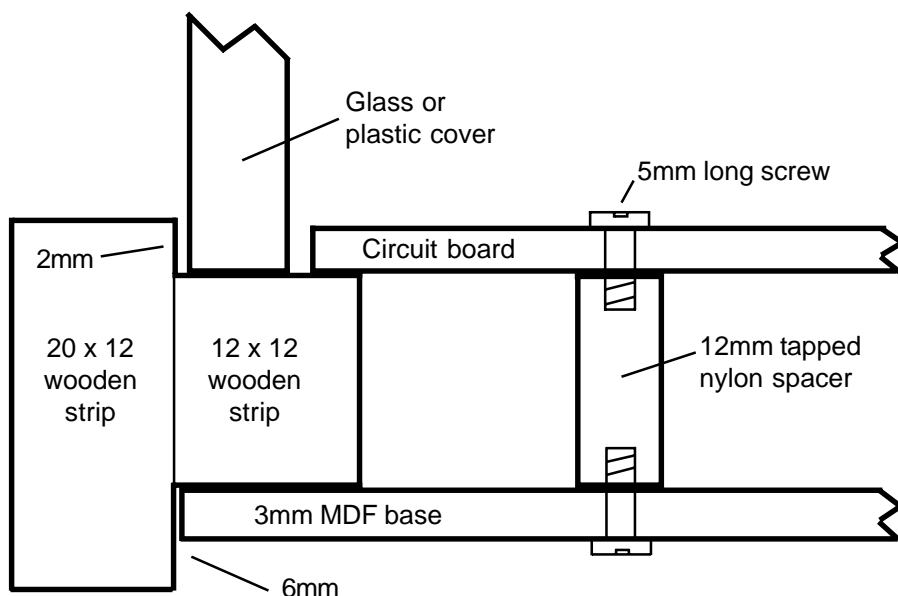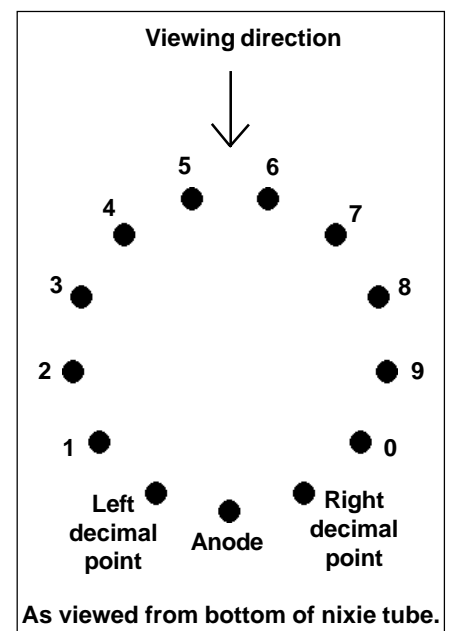

Figure 3. How to mount the board inside its case.

As viewed from bottom of nixie tube.

(there should be no ICs plugged into the board at this time!) and make sure that they have 5 volts across them. Note that the sockets for U15 and U16 will have the full 9 volts across them at pins 1 and 8, pin 8 being positive.

If all is well, disconnect power, remove the link in U16's socket, and insert U16 into the board. Now, connect a multimeter between TP1, the high voltage test point, and ground, and set the trimpots VR1 and VR2 fully anticlockwise. Also make sure SW12 is in the up position.

Now power up the board. If all is well, the multimeter should read somewhere around 100 to 140 volts or so. Slowly adjust VR1 until the output of the switchmode converter reads 180 volts. Now, switch SW12 down and adjust VR2 until the output of the converter is 160 to 170 volts (you can adjust this later to suit your own preference). Flip the switch on and off a few times to make sure the voltage reliably swings between the two setpoints.

To reiterate the previous warnings, please be careful when working on the board from this point on, as it now has potentially lethal voltages on it!

If all has gone well up until this point, then power down and wait for a minute or so for the voltage on the output capacitor of the switchmode to drop to a safe level. Now you can insert all of the ICs into their appropriate sockets, being careful that they are correctly oriented. Also, insert the battery into the battery holder, with the + side facing up.

Now, apply power once more and you should see the nixies come on, with the time set to 1 o'clock. If this doesn't happen, power down and check your work, looking for solder bridges, incorrectly oriented components, and dry joints.

If all is well, then you can try the various settings by pressing buttons SW1 to SW4. For instance, SW1 should cause the date to be displayed for 10 seconds. Of course, the date will be wrong at this point, but the display should respond. If this works, then all is well and you should be able to set the time and date as per the instructions in the 'How to set and use the clock' box.

Making it safe

A case is simple to make using a few dollars worth of wood. The prototype was housed in a base made from some 20mm x 12mm strip to which was glued a 12mm x 12mm strip to form a 'hat section'. This was cut and mitred to form the frame. A piece of 3mm thick MDF was attached to

the bottom and the board itself was fastened into the base using six 12mm long threaded nylon board supports and 5mm long screws each end. The use of screws less than half the length of the supports means it is impossible for the screws to compromise the insulation of the supports. If you are still concerned, use nylon screws as well.

To finish off, use a clear plastic or glass cover over the clock. Make it so that it just sits inside the lip of the base. See Figure 3 for a cross-section diagram. You might also want to make the cover so that it can be

screwed down to prevent prying fingers coming in contact with mains voltages!

As a matter of interest, the prototype was tested with a real-power meter and using a 12 volt switchmode plugpack, was drawing around 4.25 watts from the mains when the tubes were switched off by the infrared system, and 7 watts when all the tubes were lit. This equates to an energy consumption of around 37kWh and 61kWh per year, or about $5.55 and $9.20 per year to run (in Melbourne, at least) so the clock is not a huge energy user despite the bright display.   ✿

How to set and use the clock

Displaying the date
Press button 1 (marked SW1 on the board) and the date will be displayed. The display will revert back to the time after about 10 seconds, or you can press button 1 again to go back to the time display.

Setting the time
Press button 4 once for setting mode - the clock will stop.
   Press Button 3 to advance minutes
   Press button 2 to advance hours
Press button 4 to set new time and go back to clock mode.

Setting the date
Press button 4 once for setting mode - the clock will stop.
   Press button 1 once - date will display.
      Press button 1 to advance day.
      Press button 2 to advance month.
      Press button 3 to advance year.
   Press button 4 to set new date and go back to clock mode.

Setting colon brightness
Press button 3 - colons will go out.
   Press and hold button 3 - colon brightness will step up to full brightness in 10 steps, cycling back to colons out again - release button when wanted brightness is reached.
   Press button 4 to set colon brightness and go back to clock mode.

Setting nixie uplight brightness
Press button 2 - LEDs will go out.
   Press and hold button 2 - LED brightness will step up to full brightness in 10 steps, cycling back to LEDs out again - release button when wanted brightness is reached.
   Press button 4 to set LED brightness and go back to clock mode.
   Press button 1 to abort brightness adjustment and to set LEDs back to full brightness and return to clock mode.

Using the passive infrared control
SW13 turns the passive infrared control on or off (down is on). When in the off position, the nixies are always lit, but when in the on position, the nixies are lit only when the passive infrared sensor detects movement in the vicinity. Trimpot VR3 sets the on-duration of the display once triggered. This is adjustable from just a few seconds, to around 2 minutes.

Notes

If you get lost in the menu and the clock doesn't appear to be responding, just hit the reset button (SW5) and it will revert back to clock mode and the previous settings.

Note that if you power down the clock, the RTC will hold the time and date as it is battery backed. The colon brightness and LED uplight brightness will also be remembered as they are stored in the RTC RAM.
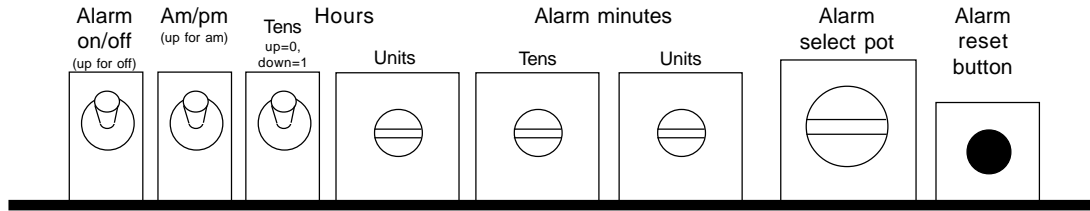
The alarm controls

Setting the alarm is quite straightforward. Just rotate the rotary switches to the appropriate time (the tens of hours is selected with a toggle switch), select am or pm, and turn the alarm on/off switch to on for the alarm to sound at the selected time.

Depending on what the software in the Picaxe08M has been written to do (this software is still pending at this time), pressing the alarm reset button will stop the alarm sounding, resetting it for the next day. It may also feature a snooze control, depending on how long the button is held down.

The alarm select pot is not yet used but will eventually allow the selection of one of several alarm sounds/tunes, depending on the pot position.

| Alarm on/off (up for off) | Am/pm (up for am) | Tens up=0, down=1 | Hours Units | Alarm minutes Tens | Units | Alarm select pot | Alarm reset button |

Important notes and errata

• The 100 ohm resistor, R36, might interfere with the R/H colon PCB, so the resistor should be mounted on the bottom of the circuit board and soldered from that side to prevent this. R36's leads should be clipped flush with the top side of the board.

• Before fitting any of the nixie tubes, it is a good idea to test them using a high voltage supply and suitable resistor to ensure they are still gassed and in working order. The tubes are tested before each kit is sent, but it is possible that they could sustain damage during transit (although very unlikely). If you don't have a suitable supply, then build the high voltage power supply part of the kit first and use the high voltage output from TP1 on the PCB. A negative ion generator is also good for testing tubes, as it will make the gas inside the nixie glow when the tube is brought within a few millimetres of the ion generator's ion needles.

• C9 is listed on the PCB as 1000uF but should be 470uF, which is the component supplied.

Parts list

Part #	Value/description	Units per kit
U1-U6	74141 nixie driver	6
U7	Picaxe 28X	1
U8	DS1307	1
U9-U11	74LS374	3
U12	Picaxe 08M	1
U13, U14	74HC688	2
U15, U16	555 timer	2
U17	7805 regulator	1
Q1, Q2, Q7	MPSA42 250 volt NPN	3
Q3, Q4, Q6, Q8	BC547 NPN	4
Q5	IRF740 high voltage MOSFET	1
C1, C2, C4, C8, C11, C12, C15	0.1uF mono ceramic	7
C3	10uF electrolytic	1
C5	100pF 100V ceramic	1
C6	2.2uF 250V	1
C7	2.2nF mono ceramic	1
C9, C10	470uF	2
C13	0.01uF monolithic ceramic	1
C14	100uF low leakage electrolytic	1
C16, C17	22pF ceramic (see text)	2
D1	1N5819 1 amp Schottky	1
D2	UF4004 ultra fast diode	1
LED1-LED6	Blue 4.8mm wide angle LEDs	6
R1-R7, R25	22k ¼ watt	8
R8, R10-R13, R15, R20, R21-R24, R26, R27, R30, R32-R35	10k ¼ watt	18
R9	100k ¼ watt	1
R14	1k ¼ watt	1
R16	56k ¼ watt	1
R17	470R ¼ watt	1
R18	220k ¼ watt	1
R19	2k2 ¼ watt	1
R28, R29	4.7k ¼ watt	2
R31	1-100k ¼ watt	1

Part #	Value/description	Units per kit
R36	100R ¼ watt	1
RN1, RN2	10k, 8 pin, 7 resistor SIL resistor network	2
VR1, VR2	1k trimpot	2
VR3	1M trimpot	1
VR4	10k side adjust pot	1
L1	100uH inductor	1
X1	4MHz resonator	1
X2	32.768kHz crystal	1
SW1-SW5, SW14	Right-angle PCB pushbutton	6
SW6-SW8	BCD right-angle PCB rotary switch	3
SW9-SW13	SPDT right-angle PCB toggle	5
SP1	25mm 100 ohm speaker	1
CN1	PCB coaxial power socket	1
CN2	3 way SIL vertical header socket	1
CN3, CN4	3 way polarised header socket	2
CN5, CN6	2 way SIL vertical header socket	2
J1	2 pin header and jumper	1
	8 pin IC socket	4
	14 pin IC socket	2
	16 pin IC socket	6
	20 pin IC socket	5
DISP1-DISP6	Nixie tubes	6
	Heatsink for 7805	1
Batt1	Button Cell battery holder	1
	Lithium button battery	1
PCB1	Main circuit board	1
	Tapped PCB spacers	6
	3mm x 6mm long screws	6
	High voltage label	1
PCB2-3	Colon circuit boards	2
DISP7-DISP10	Neon dots/amber LEDs	4
R1, R2 - colon board	220k ¼ watt miniature	4
	Right angle header pins - colon board	2