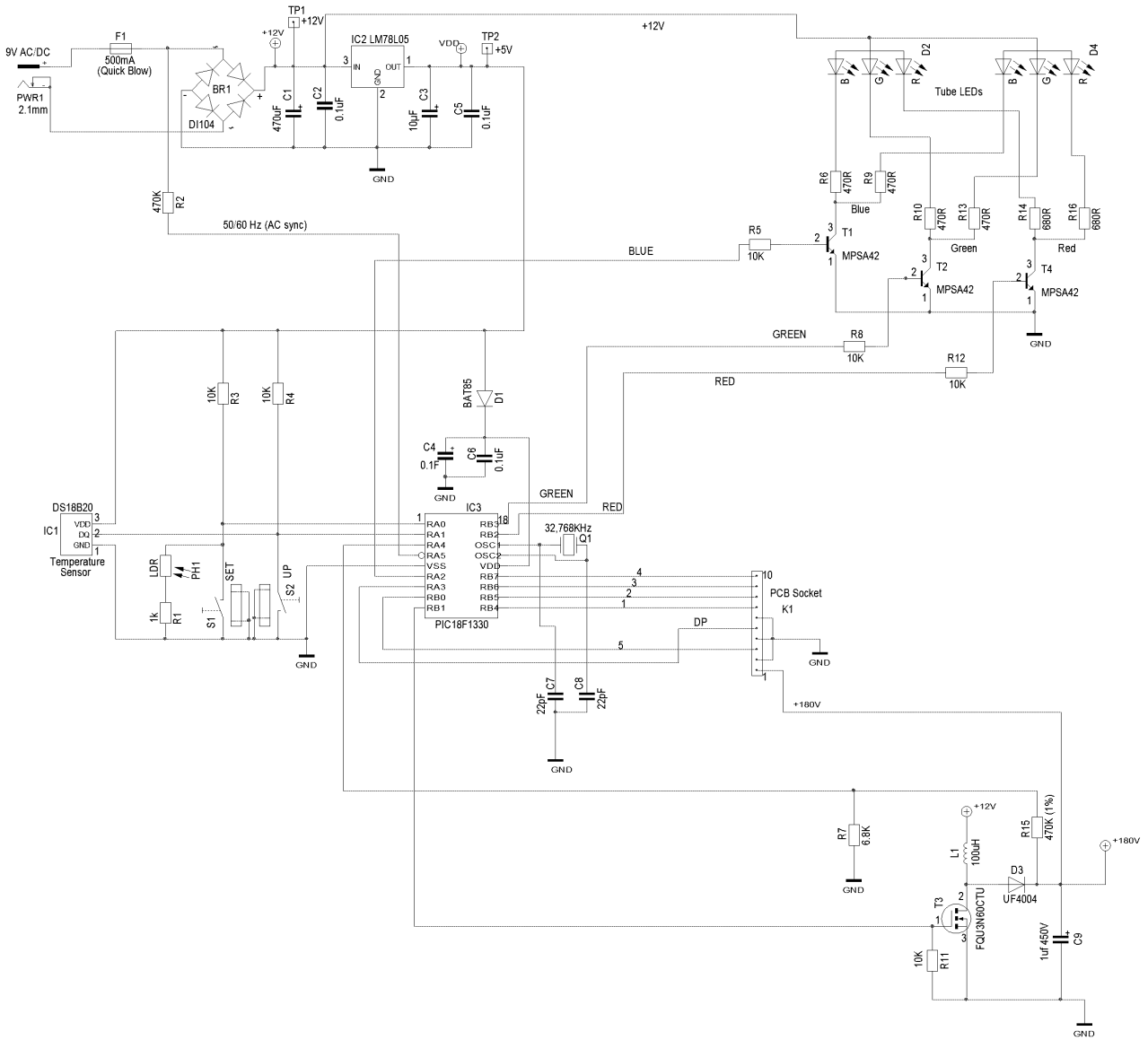
Dyadnix Nixie Clock kit

Circuit Diagrams & Problem Diagnosis manual (v1.3)

Unusual Electronics

Main Board	(Please use the "Zoom" control to see more detail)



Power Section

The unregulated AC or DC supply is rectified and converted to correct polarity by the Bridge Rectifier (BR1).

If using AC, the mains waveform used for time keeping is obtained before the rectifier and sent to the microcontroller via the high value (470K) resistor (R2) to keep the current to very low safe level.

The unregulated DC voltage from the output of the bridge rectifier is smoothed by the 470µf capacitor (C1) and fed to the RGB LEDs, HV power circuit and the 5 volt regulator (IC2).
The regulator is a low current (100mA) type to supply power to the microcontroller and temperature sensor chip only.

The supply to the microcontroller goes via a diode (D1) to charge a 0.1F Supercap (C4). The diode ensures that current can not flow back through the regulator during power failure. It is a BAT85 “Schottky barrier” type needed to ensure very low forward voltage and reverse current losses.

Microcontroller Pin Functions

1) This analogue input pin detects the SET button being pressed (voltage = 0V) and measures the voltage at the junction of the Light Dependant Resistor and R3 which represents the light level. (Brighter=lower voltage).
   R1 prevents the lowest LDR voltage being falsely detected as a button press.
2) Digital pin detects the UP button press and communicates with the DS18B20 temperature sensor using the “1-wire” protocol.
   R4 is a pull-up resistor for both the pushbutton logic level and the DS18B20 input/output.
3) Analogue input measures the feedback voltage from the HV generator.
   The voltage is reduced from 180V to about 2.57V by the potential divider resistors (R15 & R7). R15 is a 1% tolerance type to improve accuracy.
   The microcontroller uses this feedback voltage with “Proportional-Integral” (PI) algorithms to regulate the HV output voltage.
4) Digital input with “Schmitt trigger” counts the 50 or 60Hz mains frequency cycles.
   The AC voltage applied via R2 is clamped to normal levels by built-in protection diodes in the microcontroller port.
5) Ground pin.
6) Blue tube LED output.
7) Nixie Decimal Point (AM/PM) driver output.
8) “Charlieplex” Nixie driver output line 5. (see Charlieplex description later)
9) High Voltage (HV) generator PWM output. The microcontroller has a dedicated PWM module (Pulse Width Modulation) which is used to drive the power Mosfet transistor (T3).
   The pin oscillates at 62.5Khz with its' pulse width being adjusted according to the feedback voltage measurement algorithms.

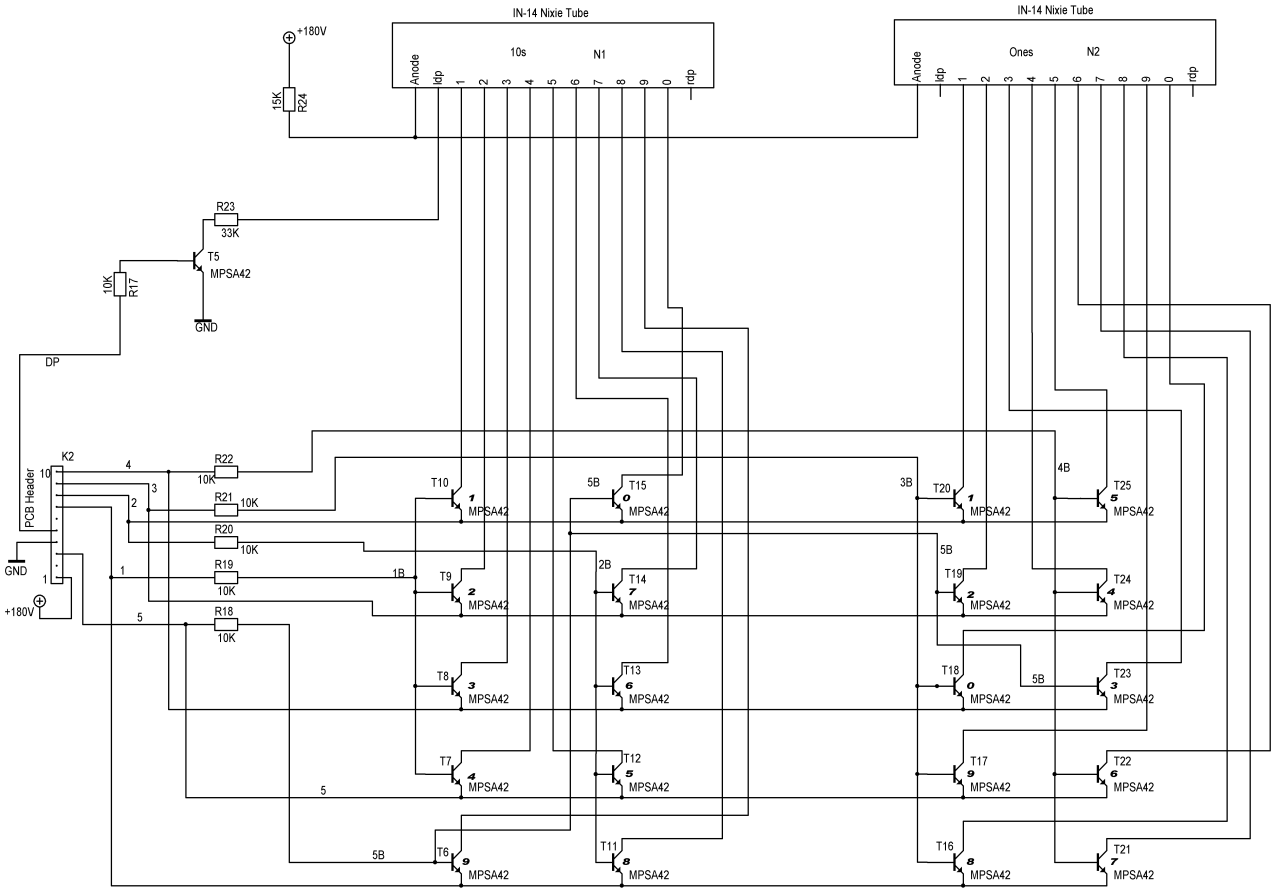
10 – 13) Charlieplex” Nixie driver outputs. (see Charlieplex description later).

14) VDD +ve supply. This is maintained by the Supercap when power is lost.

15 & 16) Watch crystal timekeeping pins. The crystal oscillator is used for timekeeping and also for clocking the microcontroller during power failure.
   The microcontroller normally runs on it's high speed internal oscillator.

17 & 18) Tube LED driver outputs.

Nixie Board	(Please use the “Zoom” control to see more detail)



“Charlieplexed” Nixie drivers

This design does not use the usual obsolete Russian Nixie driver chips often found in other designs.
Instead, it has a 4 x 5 matrix of High Voltage driver transistors (MPSA42).
The PIC18F1330 microcontroller does not have enough pins available to directly drive a conventional transistor matrix.
One solution is to use a technique called “Charlieplexing”.
This technique was developed by Charlie Allen at Maxim Integrated Products and used in some of their LED driver chips (http://www.maxim-ic.com/app-notes/index.mvp/id/1880).
More info about Charlieplexing can be found at: http://en.wikipedia.org/wiki/Charlieplexing.

Now it only needs five pins to drive the array of twenty driver transistors.

It works by making one pin LOW to provide the ground current source connection to a row of four transistor's Emitter pins.
At the same time, another pin goes HIGH via a 10KΩ resistor to a column of four (out of

the five) transistor's Base connections.
This will allow only one selected transistor to turn on.
(The other three microcontroller driver pins remain in High Impedance (Input) mode.)

e.g. A Low on line 4 and a High on line 1 will light digit 3 of the Left Tube (see table).
Only one digit of each tube is ever lit at a time. (The software alternate between tubes about 2000 times per second so that to the eye both tubes appear lit).

Nixie Tube N1 (Left Tube) “10s”					
5 (RB0)	4 (RB7)	3 (RB6)	2 (RB5)	1 (RB4)	NIXIE DIGIT
			Low	High	1
		Low		High	2
	Low			High	3
Low				High	4
Low			High		5
	Low		High		6
		Low	High		7
			High		8
High				Low	9
High			Low		0

Nixie Tube N2 (Right Tube) “One's”					
5 (RB0)	4 (RB7)	3 (RB6)	2 (RB5)	1 (RB4)	NIXIE DIGIT
		High	Low		1
High		Low			2
High	Low				3
	High	Low			4
	High		Low		5
Low	High				6
	High			Low	7
		High		Low	8
Low		High			9
	Low	High			0

Problem Diagnosis

The clock automatically monitors the High Voltage (HV) generator and if a problem is detected, it turns-off the HV and flashes the tube LEDs with colours/sequences to identify the error.

The HV generator always starts-up with a gradual “soft-start” process during which it checks for any problems whilst gradually increasing the voltage.

The soft-start occurs during power-on startup, resuming from timed/opto tubes off or after a HV overload has been detected.

Indication	Problem
Red LEDs pulse once every 2 seconds until 20 seconds has elapsed. Then it will attempt to “soft-start” the HV again.	The HV generator has over-load tripped. ***Cause*** It may be caused by a fault in the HV generator section such as a short or dry joint. Or power adaptor voltage/rating being too low. ***Action*** If the clock re-starts OK, check your power adaptor is rated for at least 300mA and is 9-12 Volts type. (try another adaptor if unsure). Check for any dry joints around T3, L1, D3, C9, R7, R15 and microcontroller pins 3 & 9. If you continue to have occasional problems with no apparent fault, try reducing the overload sensitivity (option 92 in the special configuration options). If it does not re-start, see the “soft-start” diagnostics below. Also, try removing the tube board and power-on, if the fault stops, check for shorts around the tube pins and tube driver transistors.

HV Soft-start Problems	
Green LEDs flash rapidly (2 flashes /second). The error indication resets after 10 seconds and a new soft-start is then attempted.	***Cause*** The initial voltage detected on pin 3 of the microcontroller **before** starting the HV generator is too **low**. ***Action*** Check resistors R7, R15, and dry joints around L1, D3, Microcontroller pin 3. Check D3 polarity. And check your power adaptor voltage specification. (Voltage too low). If the fault only occurs occasionally, it is most likely due to a dry joint. If the fault is permanent, check for shorts to ground around all the above parts. The initial voltage on pin 3 should be at least 0.1 Volts.
Blue LEDs flash rapidly (2 flashes /second). The error indication resets after 10 seconds and a new soft-start is then attempted.	***Cause*** The initial voltage detected on pin 3 of the microcontroller **before** starting the HV generator is too **High.** ***Action*** Check that resistors R7, R15, are the correct values and any dry joints around R7. The initial voltage on pin 3 should be well below 2.9 Volts.
Red LEDs flash rapidly (2 flashes /second). The error indication resets after 10 seconds and a new soft-start is then attempted.	***Cause*** The the HV generator was unable to gradually increase the HV voltage. (The HV generator is not working) ***Action*** Check for any dry joints around T3, L1, D3, C9, R7, R15 and microcontroller pins 9. Check if R11 shorted. Check T3 is correctly fitted. Check C9 polarity. Possibly T3 faulty.

HV Soft-start Problems (Continued)	
Green/Purple LEDs flash rapidly (2 flashes /second). The error indication resets after 10 seconds and a new soft-start is then attempted.	***Cause*** The the HV generator detected a unexpected loading while trying to increase the HV voltage. (There should be no load at this time as the tubes should not be lit). ***Action*** Power-off and remove the tube board, if the error stops, check the tube board for incorrectly fitted transistors, shorts on tube pins,transistors or resistors. If the error occurs even with the tube board removed, check C9 polarity, Check for any dry joints around T3, L1, D3, C9, R7, R15 and microcontroller pins 3 & 9.

HV, incorrect tube digits and other problems can also be caused by the use of solder containing **Water-soluble flux.**

Solders such as “Kester 331” leave an electrically conductive flux residue that **Will** cause problems unless it is immediately completely washed off from **BOTH** sides of the boards.

The use of this type of solder or flux is **NOT RECOMMENDED!**

Tube Digits Problems

If several digits do not light, go to time setup mode and try to adjust the minutes between 00 – 59.
Make a note of which digits do NOT light for each tube and match it with the table below to find the possible cause.

10s Tube (N1)	Ones Tube (N2)	Problem
1, 2, 3, 4	7, 8	Microcontroller pin 10(RB4) - PCB header pin 7 – R19 disconnected.
0, 1, 5	1, 5	Microcontroller pin 11(RB5) - PCB header pin 8 – R20 disconnected.
2	0, 1, 2, 4, 8, 9	Microcontroller pin 12(RB6) - PCB header pin 9 – R21 disconnected.
3	0, 3, 4, 5, 6, 7	Microcontroller pin 13(RB7) - PCB header pin 10 – R22 disconnected.
0, 4, 5	2, 3, 6, 9	Microcontroller pin 8(RB0) - PCB header pin 3 – R18 disconnected.
1, 2, 3, 4		R19 dry joint.
5		R20 dry joint. Or T12 dry joint
	0,1, 8, 9	R21 dry joint
	4, 5, 6, 7	R22 dry joint
0	2, 3	R18 dry joint

Other possible problems are that a tube driver transistor has a dry joint or wrongly fitted – this should only affect the digit associated with that transistor, unless there are multiple faults, in which case you would need to check all connections on the tube board for dry joints, solder splashes or wrongly fitted parts.

Other Problems	
The temperature displays either **“00”** or **“00.0”** (depending on display mode).	***Cause*** Most likely the DS18B20 sensor is incorrectly connected. The range that the display can show 0 - 125 °C (or 32 - 199 °F in Fahrenheit mode). ***Action*** Check the three wires between the board and the sensor for correct connections.
Temperature always shows **85°C**	***Cause*** The +5V supply to the DS18B20 sensor is faulty. ***Action*** Check the Red wire between the board (hole 3) and the sensor for correct connection. Test continuity between the red sensor wire and test point 2 (TP2) ***Cause*** The DS18B20 sensor can be easily damaged by connecting it the “wrong way round”. (wrong polarity) If it is subsequently connected properly, it is very likely to always show **85°C** due to the earlier damage incurred. ***Action*** Replace the sensor.
Clock does not use 50/60 Hz AC mains timekeeping when config option 13 is enabled.	***Cause*** Your power adaptor must provide an AC output for this option to work. You can check if the clock has detected AC by un-plugging the clock. When plugged back in again, the tube leds will flash **White** once before showing the time if AC is detected. ***Action*** Check your power adaptor the output should be marked AC or ~ . Check R2 and microcontroller pin 4 for dry joints.

Fuse blows.

Replacement fuse:

Manufacturer:
CamdenBoss
Manufacturers Part Number:
CF2470 FF 500MA

Available from:
Rapid electronics (www.rapidonline.com):
Order Code:
26-2554

500mA
quick blow micro axial fuse.

Replacement Mosfet:

Please contact us if you think a replacement Mosfet or Microcontroller is needed.

(DO NOT replace T3 with a different type.)

Cause

If the clock suddenly stops working, the most likely cause is a fault with the HV section.

Action

First remove the Nixie board.

Check for short circuit between T3 pins 2 & 3
If T3 has failed it may be due to inadequate anti-static (ESD) protection whilst handling or fitting the power MOSFET transistor (T3).
Check your Anti-Static wrist strap is still working and properly grounded. (Resistance may be about 1MΩ).
Cheap fabric types can deteriorate with age – replace if unsure.

If T3 is not faulty, Check D3 & C9 for shorts.
If no fault found with the HV section, Check the Bridge rectifier (BR1), C1, C2 and 5V regulator (IC2) for shorts.
If still no fault found, It may be the microcontroller pin 9 has either failed or shorted to another pin.
Also check R11 for dry joint or solder splash. (it normally keeps T3 turned-off if the microcontroller is removed from its' socket).

If no fault found

Connect a temporary replacement fuse and remove the microcontroller.
Apply power – If the fuse blows, remove T3 and repeat.
If removing T3 stops the fuse blowing, it is faulty.

If fuse still blows - re-check C9, BR1, C1, C2 & IC2 for shorts.

If fuse does not blow after removing the microcontroller, it may be faulty. Damage to the microcontroller pin could be caused by a partial failure of T3 or D3 which should be also replaced as a precaution.

Tubes and LEDs do not light (fuse is ok)	***Cause*** Sometimes plugging the microcontroller into it's socket while the supercap is still charged can cause it problems. ***Action*** Turn off the power and short the Supercap (C4) pins for a few seconds to remove any remaining charge. This will reset the microcontroller program. ***Cause*** The power supply voltage is too high. (If your power supply adaptor is rated for a current of over 500mA, the actual no-load output voltage may be much higher than the voltage marked. ***Action*** Use a different power supply adaptor.
Clock does not power-on again after the power was turned-off (The clock works again if the supercap is first discharged)	***Cause*** A faulty crystal or associated 22pF capacitors (C7,C8) prevents the clock resuming from sleep-mode after a loss of power. Other symptoms are: The Blue LED stays lit after the power-on self test and the clock does not keep time (when using the crystal for timekeeping). ***Action*** Check the crystal, capacitors C7&8 and Microcontroller pins 15 & 16 for any dry joints or shorts caused by solder splashes etc.

For further assistance:

Send a description of the problem with as much detail as possible to:
support@unusualelectronics.co.uk