THE FOUR LETTER WORD

INTRODUCTION

The Four Letter Word was first produced by Raymond Weisling in 1973 and appeared in the June 1973 issue of Playboy magazine. Approximately 50 to 60 units were built between 1973 and 1975. In 1994 reconstruction of the piece was started using a small number of parts still on hand, enough for about four units, but for a variety of reasons it was sidetracked and somewhat forgotten. In 2001 a large number (perhaps 8000) of these jumbo Nixie tubes were found in a warehouse somewhere in New York, which prompted the completion of the work begun in 1994. What we have now (in 2002) is an item that looks much like the original (depending on what kind of plastic case is used), but operationally is a far cry from the original. The technology employed in the reconstruction was simply not available in 1973. Word generation is vastly improved and several very entertaining word-game modes have been added. And to add a little practical functionality, it now also has a clock feature to show time.

OPERATION

When the unit is first turned on it will always display a greeting message: "FOUR LETTER WORD BY RAYMOND WEISLING" followed by the word PLAY. At this point it will read and respond to the user settings on the DIP switch and begin displaying words. Due to internal and external indeterminate processes, the order and selection of words is always different. There should be no discernible pattern or sequences of words.

The indeterminate processes utilize pseudorandom number generators in the internal program and five external oscillators that are read as a five-bit number at certain points. Because these oscillators use imprecise components and do not in any way operate synchronously with the program, the combination of the two results in considerable indeterminacy, which is often erroneously called randomness.

USER SETTINGS

A five-position DIP switch is provided for setting different operational modes or user preferences.

DIP switch position 1

This selects the "letter hangman" mode when set to ON. In this mode a word is chosen internally while the display is completely blank. Individual letters are turned on or enabled one at a time until the whole word is visible. The sequence of letters enabled is varied and indeterminate.

Both this and the "stick hangman" mode are entertaining to watch because you invariably try to guess the word before it completely appears. It is even more fun with a friend.

DIP switch position 2

When set to ON this selects the "stick hangman" mode. In this mode a word is chosen internally while the display is completely blank. Then individual segments that form the letters are turned on in an indeterminate sequence until the entire word is displayed in full.

DIP switch positions 1 and 2 (both ON or OFF)

When both positions 1 and 2 are OFF, the unit displays words one after another at a rate that is indeterminate and somewhat related to how long it takes to create a replacement word that meets the requirements (see section on word selection).

When both stick hangman and letter hangman switches are enabled (ON), the mode becomes mixed, and all three operations modes (both hangman modes plus normal full-word appearance) are indeterminately mixed. The settings of these two switches have no effect on the clock mode, which always appears when time has been set and the mode switch is ON. However, both hangman modes involve a slower overall pace to word appearance, so more than 20 seconds may pass without a time display. The time interval of 20 seconds is not indeterminate, but the appearance is. If 19 seconds have passed since the last time display has appeared, and the word is changing, time will not be displayed. But if 20 seconds have passed, time will appear at the next word change under all circumstances. Since the hangman modes are slower, if mixed mode is selected it is possible that a word change will occur at 15-19 seconds since the last time display, so no time is shown, yet the new word is in hangman mode and might take another 15-30 seconds to change, so that the time might not appear for up to 40-50 seconds.

DIP switch position 3

This switch enables the clock time mode. The clock has no battery backup, so each time electric power is turned off and then back on the clock must be set to the correct time. If the time has not been set then the clock mode is disabled regardless of the position of this switch. Once the user has set the time and if this switch is set to ON, then the time is displayed every 20 seconds (minimum), but only inserted in between two words in sequence. The clock display is brief, and involves rapid flashing of the digits for about one second. Time is fleeting, catch it if you can.

DIP switch position 4 and 5

These two positions control the appearance or nonappearance of impolite, vulgar or so-called dirty words. There are four possible settings of these two switches as follows:

SW5	SW4	resulting operation
OFF	OFF	normal operation (no bias, no censorship)
OFF	ON	vulgar words biased to appear once every 7–14 minutes
ON	OFF	vulgar words biased to appear once every 3–10 minutes
ON	ON	full censorship of vulgar words

The two selections to bias vulgar words to appear use indeterminacy in setting the interval of time between displays and which word is selected from a list of about 20 such words. When full censorship is selected, none of the words in the same list is allowed to be displayed.

The normal mode does not treat these words with any greater or lesser frequency. The words are not, however, in the Word Bank (see the section on word selection).

DIP switch position 6

This sets the unit into a test mode. It is not a normal operating mode, but is provided to check components and construction. It will enter and exit the test mode at the time that words change. The ADVANCE button used for setting time advances the display from segment to segment. To exit this test mode DIP switch position 6 must be returned to OFF. Due to errors on the PCB (early version), a full six-position DIP switch may not be possible. A five position switch is recommended. Wires can be soldered to the sixth position and connected together externally by means of a clip lead for testing segments. Switch position 6 is nearest to the tactile buttons. (Early production boards are marked in reverse, but the marking has been covered over.)

SETTING THE CLOCK

The clock is adjusted by pressing one of two buttons. The SET button should be pressed once, at which time the Nixie tube display should show the hours flickering rapidly. The ADV (advance) button is then pressed until the hours desired (1 to 12) appears. Then press the SET button again to select the minutes digits, and then press the ADV button to move forward. The button has no auto-step, fast-advance feature; you must press it once to advance for each minute. (The setting mode is admittedly somewhat crude.) When the minute has been set, wait for that actual minute shown to begin, and then press the SET button to return to the word display. The seconds, though never displayed, is reset to zero when SET button exits the clock-setting operation.

CLOCK TIMEBASE

The clock can operate from three possible timing references. One is the internal crystal used by the microcontroller for its operation. The frequency of the crystal is not calibrated or trimmed, so some slight drift in accuracy over time is to be expected. The other two references are based on the local electrical power grid frequency, which is 60 Hertz (Hz) in North America and a few other isolated places, and 50 Hz most everywhere else. Generally the power generation authorities maintain long-term stability of this frequency, but it might go slightly up and down over a shorter time period. Since seconds are not shown, it is usually not noticeable that there is an error of even 10-15 seconds. The power-grid timebase is generally the best choice to use, but if the user is located where the power frequency is unstable, the crystal reference might be a better choice. These modes are selected by installing a jumper on the circuit board. The jumper marked W50 is for 50 Hz and the one marked W60 is for 60 Hz. If both jumper positions are empty (or jumpered), the crystal will be used. Install the jumper appropriate for the power line (mains) frequency for your location.

WORD SELECTION

Considerable research and analysis, spread thinly over a 30 year period, went into developing the word generation scheme. To begin with, about 2200 English four-letter words were analyzed and three tables of letter-pair frequencies were derived. For example, the word BALE would have a count of one for the appearance of BA, AL and LE added to the tables for these pairs. The idea was that letter pairs that never appeared in the English sample would have a frequency of zero, while very common letter pairs might have a frequency of 20 to 50. The three tables constitute 676 data elements each (26 × 26).

The selection process involves generation of an indeterminate trial word and then looking up the three pair frequencies in the tables, and multiplying the values together to arrive at a "score" for the word. Initially this score was to be used as a fence; the next word had to be higher than the fence or else it would be rejected, but when rejected the fence would be lowered a bit to make it easier for a new word to jump over this fence value. If a word passed, the fence was raised up to the new score.

However, some word quality problems arose with this "fence nibbling" scheme. Below is a list of the eleven most frequent letter pairs for the three positions:

First Pair	*Second Pair*	*Third Pair*
CO	AR	RE
LO	EA	IL
BO	OM	LL
PA	OO	CK
TO	IN	NE
MA	EF	LE
HA	IL	ST
WA	AN	NG
BA	AL	TE
PO	AS	IT
LA	OL	AR

Let's try to find a word with a high score, not randomly but logically, from this list. If we select CO in the first table, then what goes with CO in the second? Just OM and OO, but then in the last table there is nothing beginning with M or O. The same will of course be true for LO, BO, TO and PO. It turns out that there are not too many words with extremely high scores. Because the fence goes down slowly and computers are rather fast, it was found that a small number of high-score words were hit far too frequently. (This algorithm worked better in a 1980 version on the Apple II computer because the pair tables were based on a hand-compiled sampling of only about two hundred four-letter words.) Words like LALL occurred very often, with a final LL or IL pair becoming annoyingly frequent (more frequent than an RE ending, for a number of reasons).

To avoid this problem, a different scheme was developed that was found to be more acceptable. Word scores are still made by multiplying letter-pair frequencies, but instead of using a moving fence, word scores have to fall into an acceptance band between a low score and high score. For each word displayed a new acceptance band (low and high score limits) is chosen from a list of about 20 different bands or sets of low and high limits. The bands have been adjusted to generally disfavor high scores, and favor mid-range scores with both narrow and wide bands. Low-score words near and including zero are never acceptable. Further checking discards words with three consonants in a cluster, such as ODST, and DRTO, or three vowels in a row, such as EAIS, regardless of their letter-pair scores.

Word selection using this method results in many letter combinations that are not real English words, but have forms that resembles many real words, and thus are generally easy to pronounce. For example, JALE, FAND, GURD, EATH, HOXY, and LOBO. These are entertaining because you can try to invent meanings for them. Perhaps the name of some future rock band or automobile will appear.

WORD BANK

With extra memory still available after all major programming work was completed, an additional Word Bank was added, containing some 1344 real four-letter words (there are also some socially significant abbreviations included). These represent a secondary source of words for the display. Each time a new word is to be displayed a decision is made, based on some weighted indeterminate criteria, as to whether the words will be generated by the trial-and-discard method or by a lookup in the Word Bank. If the Word Bank is chosen, the location in the bank is indeterminately selected and the word is sent to the display. It is not tested for any other criteria, since the words in the Word Bank have previously been carefully selected (some might violate the general rules, such as BUOY). The ratio of words generated by the letter-pair algorithm compared to the Word Bank selection is indeterminately adjusted once each minute. Some minutes will have more Word Bank selection than other minutes. See the section on Underline.

CIRCUIT DESCRIPTION

The heart of this device is the microcontroller, a Motorola MC68HC705C8A device that has 7684 bytes of program storage and 176 bytes of RAM. The program is stored in one-time programmable memory and is protected from copying or downloading. If you attempt to read the contents of the chip you will fail and might damage the part. The program is copyright by the author and represents an investment of considerable effort, spread out (quite thinly, of course) over almost 30 years of recreational linguistic work.

The data for each Nixie segment is sent out of the Serial Peripheral Interface (SPI) port on U2-32, which connects to eight shift registers starting at U11 and cascading in order: U11, U10, U9, U8, U7, U6, U5 and U4. The data is sent out in eight 8-bit groups (64 bits), using the SPI clock on U2-33. When a transfer is complete, U2-21 cycles the load pin of all eight shift registers to load the data from the 74HC595 serial registers to the chip's parallel output latches. The bits then affect the output pins of each shift register. The outputs then go to resistors and transistor cathode drivers, which in turn cause segments of the displayed character to illuminate.

A WORD ON RANDOMNESS AND INDETERMINACY

Microcomputer programmers can simulate randomness in software by creating and manipulating pseudorandom number generators. However, since microcomputers basically start operating the same program steps when power is applied, the result is that a pseudorandom generator always begins its operation from the same state, so the sequence of random numbers produced is always the same. To produce an apparent degree of randomness requires an external source of imprecise and non-repeatable information not related or in any way synchronized to the internal program.

The Four Letter Word has a five-bit indeterminacy generator external to the microcontroller, consisting of five simple oscillators each with a different frequency, determined by external components (resistors and capacitors) of imprecise values. These oscillators operate at approximately 135, 300, 425, 600 and 1400 Hz. Thus the relationship between individual oscillators is itself indeterminate, as each one oscillates at its own free-running frequency. When read as a parallel five-bit number, the value read is quite certain to be sufficiently unpredictable. The number read in on U2–24 through U2–28 is then used internally to set certain parameters or to cause the internal pseudorandom number generators to further scramble their data.

Randomness cannot be made more random, but pseudorandom generators can be made less determinate by altering their sequences or occasionally discarding a sequential number produced. Each of the four letters of the word generator has its own 16-bit linear feedback shift register pseudorandom sequencer, and each one is shifted at the same time, but based on the external five-bit value, one or more of the four generators is allowed to jump ahead to a different sequence, allowing the four different 65535-step sequences to slip out of phase with each other. With all of these factors combined, events are truly indeterminate. You may use the word "random" when describing it to visitors if you wish.

This indeterminacy is not only used for selecting letters and words, but also is used to select the mix or ratio of synthesized words (based on the letter-pair frequency algorithm previously described) and Word Bank words. It is also used to select word score bands, hangman letter or segment appearance sequences and numerous other attributes of operation to produce a varied and interesting display. The operation of the pseudorandom generator coupled with the external oscillators has been carefully adjusted to give the highest degree of unpredictability possible.

FUNNY UNDERLINE

These Nixie tubes have an angular shaped segment under the regular 14 segments. Was it intended to be an underline? (The original stock market quotation boards where these were primarily used, had two rows of tubes, with the top row inverted, so this segment probably had a different purpose.) This segment is programmed to appear for words that are derived or "synthesized" from the analysis of English four-letter words. This underline display is enabled for one out of every seven hours. For the other six hours it is off. For example, if the Four Letter Word is turned on at 8:50 and the time is set, the underline will appear for the first hour, from 8:50 until 8:59. When the hour rolls over the cycle counter for the underline is changed. The seven-hour cycle was chosen so it appears at a different time each day, yet repeats for the same hours every week (one week has 168 hours, so there are 24 occurrences of the underline per week). If you do not want the underline to appear, remove (or do not install) the four transistors marked UL on the circuit board.

The seven-hour cycle is also used to play the start-up identification greeting once at 30 minutes before the hour when the underline mode appears, as explained above. (The greeting is: "FOUR LETTER WORD BY RAYMOND WEISLING")

CONSTRUCTION NOTES

PRINTED CIRCUIT BOARD

The PCB is a single-sided board made with flame-retardant material. It was made to fit a series of original 1973 cases that were still on hand, and for this reason some parts are tightly spaced. One group of resistors is mounted vertically, on end, to conserve space. The top of the PCB is covered with a low-reflectivity ink to help reduce reflections and improve contrast of the neon glow display. The copper circuit paths are solder plated and covered by a solder mask to help make soldering easier. Since it is a single-sided board there is no metal in the holes so extra care must be used if any unsoldering is done to reduce the chance of copper delamination (lifting).

SOCKETS

The PCB has three holes for each tube pin. If you have original sockets, the socket terminals must have the very tip cut off, leaving a two-prong fork-like shape. This also makes it easier to remove any old wires from the original equipment from which the sockets were removed. These go into the outer pair of holes. Getting 34 pins into the holes will be a little difficult, but this was the only way to allow use of this socket or the use of other pins if sockets are unavailable. You may cut off one of the two prongs leaving just half of the fork; that will make it much easier to insert the pins. The Sylvania sockets, which have a large centre hole, have slightly larger pins than the Cinch sockets. The Cinch ones are marked with the name CINCH U.S.A. and also have a second set of 12 pin holes inside of the outer ring.

If you have no sockets, pins from D-subminiature connectors are exactly the same diameter, so any pins from PCB-mount straight D-subminiature female receptacles can be used. There are a few other socket pins that can be used, but some may require slight enlargement of the hole to work. These pins mount in the innermost holes, which are positioned exactly the same as the same as the pins on the tubes. The tubes can not be directly soldered since the kovar material is not easily wetted with solder.

MOUNTING

Holes are provided at the front corners and along the rear, plus holes are provided in the centre of each Nixie socket area. The idea here is to use threaded standoffs for each tube to ensure stability and no drooping of the board. Use any or all holes at your preference.

WARNING

Screw heads used in the centre of the socket may touch the tube seal. If this occurs the seal could be broken, destroying the tube. Use of original sockets with a minimum 0.36 inch (9,2 mm) height will not pose a problem, but use of other socketing schemes must take this situation into consideration. In some cases countersinking the hole to accommodate flathead screws may be necessary. Use a bit of putty, plasticine, Blu-Tac, bagel dough, or other similar substance to double check the clearance.

SWITCHES

The two buttons and DIP switch are meant to be mounted on the solder side of the board, to be activated from access holes in the bottom cover. Most (but not all) DIP switch packages will cover the pads, making it impossible to solder the leads. The pins from the switches may be bent outwards for form a “gull wing” shape that can be soldered to the pads, much like a surface-mount component. Additional solder pads are provided so that thin jumper wires can be added, if necessary. Some builders may choose to run wires from these points to switches or buttons mounted elsewhere. There are solder pads and holes extending from one row of the DIP switch, projecting into the push-button switch area, to allow placing a 9-pin connector in place of the switches and buttons, or to permit a neat single-row direct solder-in termination of a ribbon wire. The connector is assumed to be of the type that uses 0.025 inch square pins (0,63 mm) on 0.100 inch (2,54 mm) centres.

Note: Early PCB versions had a slight error with respect to placement of the DIP switch and the 12 mm tactile switches. They both could not be mounted on the same side of the PCB because the are spaced too closely together. One solution to this problem is to only use a five-position DIP switch, leaving the position closest to the push-buttons without a switch section. This position is only used to enable the segment test mode, so it is not a common setting that might be used frequently. The switch numbers referred to in the text will be offset by one, in this case, with section one where the board is marked with section two, etc. Use of external switches would also circumvent this difficulty.

The DIP switch sections have been renumbered. On the PCB they may read 6-5-4-3-2-1 starting at the edge, but for purposes of this document, they read 1-2-3-4-5-(and 6) starting at the edge. The original markings may have been obliterated.

POWER SUPPLY

The kit builder will have to supply a power supply. The PCB has full-wave bridge rectifiers and other parts to receive AC from a transformer. If an external DC source is available, then omit or jumper the parts on the board as necessary. It is assumed that the builder who makes an alternative power supply has the necessary ability to work this out. The suggested power supply is a wall-mounted ("wall wart") AC power supply (most are DC, but many AC types are readily available from DigiKey and other suppliers). Use of such a commercial power supply, which are usually approved by regulatory agencies for one or more countries, makes the overall unit much safer to operate. This way the mains line voltage (110 or 220 volts) is never brought into the case.

From the low-voltage AC output of the wall transformer, another small power transformer can be used backwards, mounted inside the case of the Four Letter Word. That is, the part normally used as a secondary is connected to the AC from the wall transformer and then the original primary is used as the new secondary. This transformer must have split or dual primary windings intended for use at 115 or 230 volts (by means of alternate parallel or series connections). These are connected in series to provide approximately 165 volts of AC to connect to the two H points on the PCB. The reason that 220 volts is not produced is because the selection of the transformer is best done with the output of the wall transformer in mind. The selection uses a different voltage on the second step-up transformer winding to produce less than the 220 volts normally expected if the transformers were both the same.

This table will give you some possible voltage selections to use with different wall transformer outputs.

wall transformer output voltage	internal transformer winding to use
9	12
10	13.5
12	15 to 16
15	18 to 20

If 9 volts were to be fed into a 9-volt winding on a second transformer, there would be an output of about 220 volts (with the two mains supply windings in series as if for 220 volt use). If the second transformer instead has a winding for a higher voltage, say 12 volts, but is not fed 12 volts, the 220 volt output will be less. The table above assumes about a 3:4 ratio of voltages, so that the output is 3/4 of 220 volts, or approximately 165 volts.

This voltage goes to a full-wave bridge rectifier which will produce about 210 to 230 volts DC when there is no load. Bleeder resistors are provided to both discharge the filter capacitors and provide a minimum load on the supply. With the bleeder resistors specified, the DC voltage should be about 190 to 210 volts when no characters are displayed.

If a decision is made to use a 1:1 ratio of the transformer low-voltage windings, and the high-voltage from the second transformer is 220 volts, the DC output will be considerably higher. In this case the anode resistors (R31 to R38) will need to be increased in value to yield cathode currents that will not impair the lifetime of the tubes. You are on your own to work out the values and check the currents.

The capacitor may be a single unit rated at 250 volts or more, or two smaller ones rated at 150 volts or more each. The two are connected in series and the DC across each is balanced the pair of bleeder resistors. See Note 1 at the bottom of the parts list.

POWER SWITCH

There is no power switch included, and since the unit is a clock with no battery backup provision, it must be operated continuously if the clock option is used. If it is desired to turn off the Nixie tubes when nobody is around, and yet retain the clock function when the display is turned on again, a switch can be added to the second backwards-connected transformer to cut the high voltage to the Nixie tubes. If, however, the clock function is not used, the user may completely cut power to the unit in order to increase Nixie tube lifetime and reduce electrical power consumption. The clock digits will never appear, even if the DIP switch is setto select the clock mode, if the time has not been set since the power was first applied. This prevents a meaningless and incorrect time display after a power failure. (Don't you wish other consumer electronics products did this instead of flashing 0000, 8888 or 9999 forever, or until the user can find the instruction book and figure out how to set the time?)

PARTS LIST

This is the list of all parts mounted on the PCB.

description	*value/identifier*	*qty*	*reference designation*	*notes*
cap ceramic	22pf	2	C44 C45	
cap alum.	22µf/250v	1	C41	option, see Note 1 below
cap alum.	47µf/150v	2	C57 C58	option, see Note 1 below
cap alum.	470µf/25v	1	C40	
cap mono.	10 nf	1	C56	
cap mono.	100nf	9	C46 C47 C48 C49 C50 C51 C52 C54 C55	
cap mono.	100nf	12	all are marked "CBY"	bypass capacitors
crystal	4.000 MHz	1	Y81	
diode	IN4007	8	D1 D2 D3 D4 D5 D6 D7 D8	see Note 5
resistor	1.0M	4	R1 R2 R25 R26	
resistor	1.0k	8	R31 R32 R33 R34 R35 R36 R37 R38	anode current limiting
resistor	10M	1	R22	
resistor	10k	1	R13	
resistor	22k	1	R12	
resistor	33k	61	unmarked, all upright adjacent to driver transistors.	see Note 3
resistor	33k	14	R3 R4 R5 R6 R7 R8 R11 R14 R15 R19 R20 R21 R23 R24	
resistor	47k	3	R10 R16 R17	
resistor	100k	1	R9	
transistor	MPSA42	61	unmarked, all drivers in row	see Note 4
IC	74HC14	1	U3	
IC shift reg	74HC595	8	U4 U5 U6 U7 U8 U9 U10 U11	
v reg	7805	1	U1	
IC, MCU	MC68HC705C8A	1	U2	
IC socket	40-pin DIP	1	for U2	optional, but recommended
DIP switch	5 or 6 position	1	S82	5-position recommended if S83 & S84 mount nearby
tactile click sw		2	S83 S84	(12-mm size)
Nixie	B-7971	2	V91--V94	
sockets		4	see text	
wire jumpers				see Note 2

Note 1. The high-voltage power supply can use either one capacitor or two capacitors for filtering. C41 is to be used if a single 250-volt capacitor of about 10 to 25 microfarad is desired. If two lower voltage types are easier to obtain, C57 and C58 may be used. These are wired in series with voltage equalizing (and bleeder) resistors R16 and R17. C57 and C58 should be rated at 150 volts, with a capacitance of 20 to 50 microfarads.

Note 2. Jumpers are located at specific points on the circuit board. As many as possible were made the same length, but a few longer ones of various lengths are also found. Wire cut off from resistors may be used, or other tinned solid wire may be used. The jumpers are all shown with a line connecting two holes and having two thicknesses.

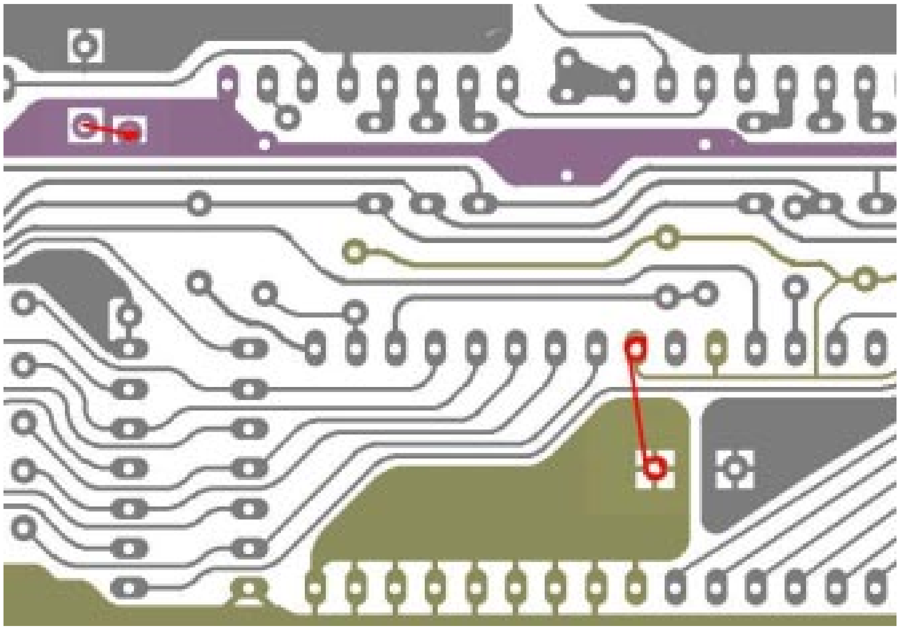
Note 3. Base resistors for all of the MPSA42 driver transistors are in a single row and are to be mounted upright with one lead bent back in a hairpin form. None is marked with a reference designation.

Note 4. The first PCB versions have the transistors located too close to be able to place them at the same height from the board. The way to mount the transistors is to mount them staggered, one low and then the next one high. See the illustration. This solution to a slight miscalculation problem is actually very attractive, so it is possible that it will not be corrected.

Note 5. The first PCB version had a location marked for D9. This diode is not used and the marking may be covered. A jumper wire is to be inserted into the holes for D9. Later PCBs do not have this part.

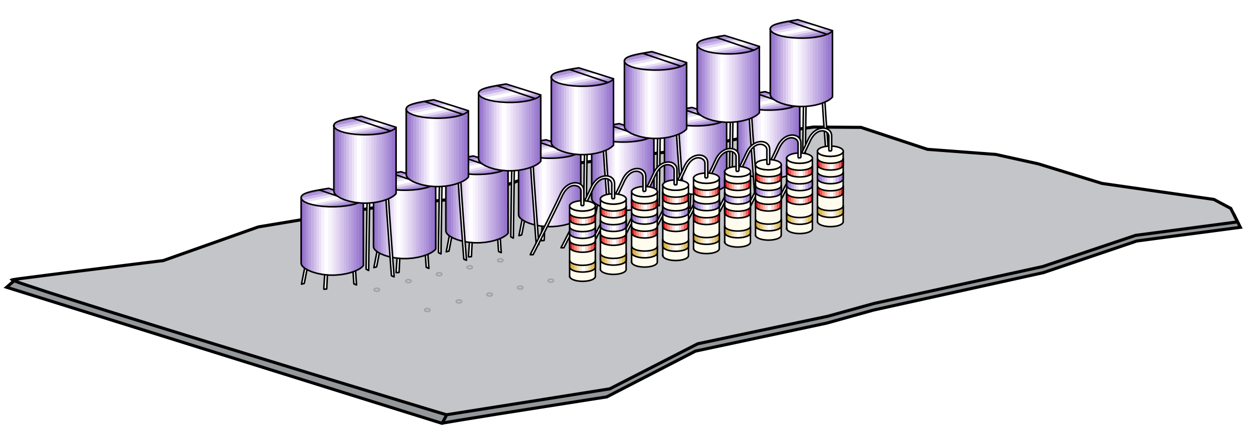
ERRATA — PCB ERROR

There are two small errors on the printed circuit board. The short red line in the upper left corner of the illustration below should connect the two points. The jumper wire can be longer and bent to meet the second hole before soldering. The longer red line in the lower right shows two other points that must be connected with another short piece of wire. For this one you may wish to slip a short piece of insulation onto the wire, but this is optional, since the solder mask insulates the wire from the one signal line that it crosses, and there will probably be an air gap as well..

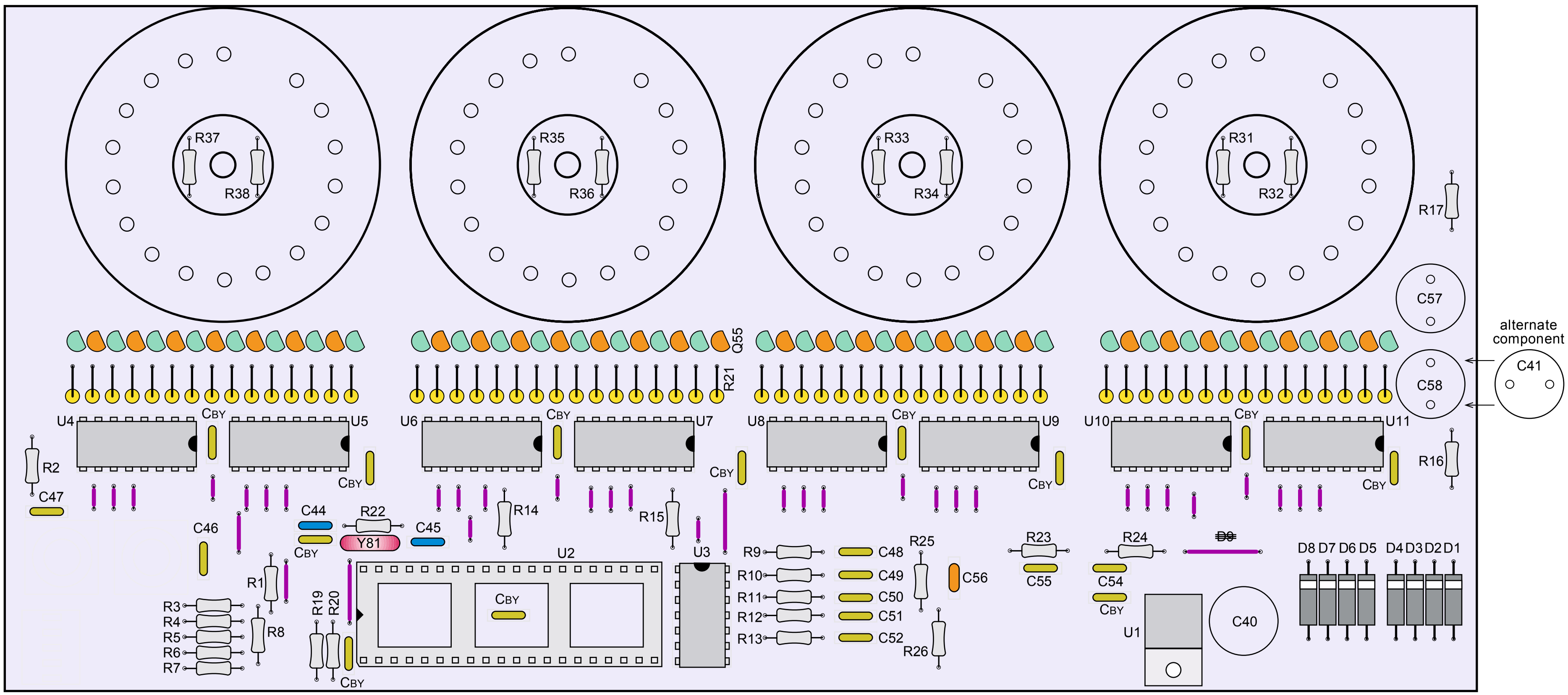


SPECIAL TRANSISTOR MOUNTING NOTES

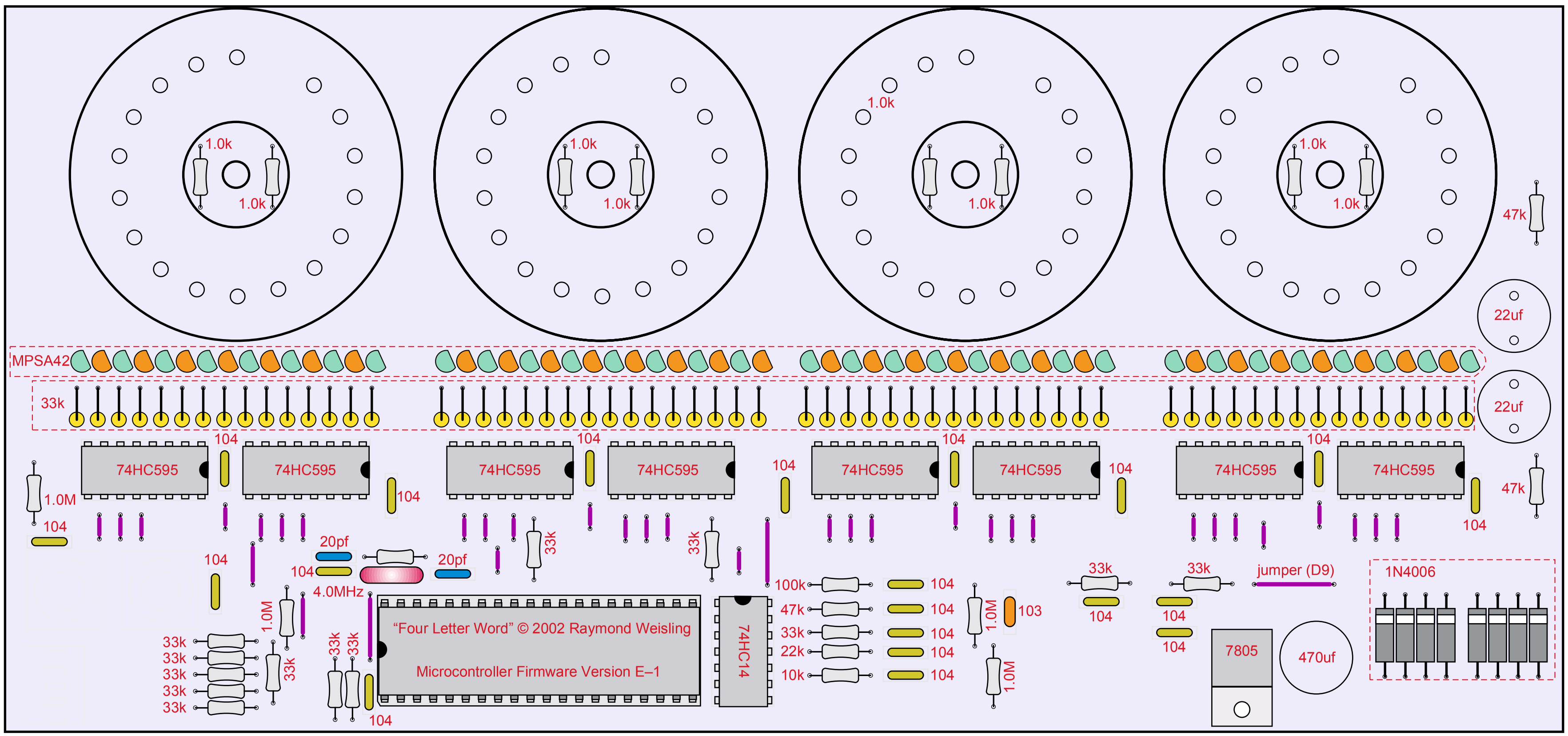
The holes for the MSPA42 transistors are just a little too close for the transistors to be mounted at the same height. The illustration below shows the preferred way of mounting them, with alternate ones mounted with short leads and then long leads. Mount the short ones first, aligning the tops as neatly as possible. When they are soldered into place, then add the upper row, with the bottom of the transistor resting on the "shoulder" of the lower ones. The height of the top row will probably come very close to the height of the original sockets, if those are available and used.



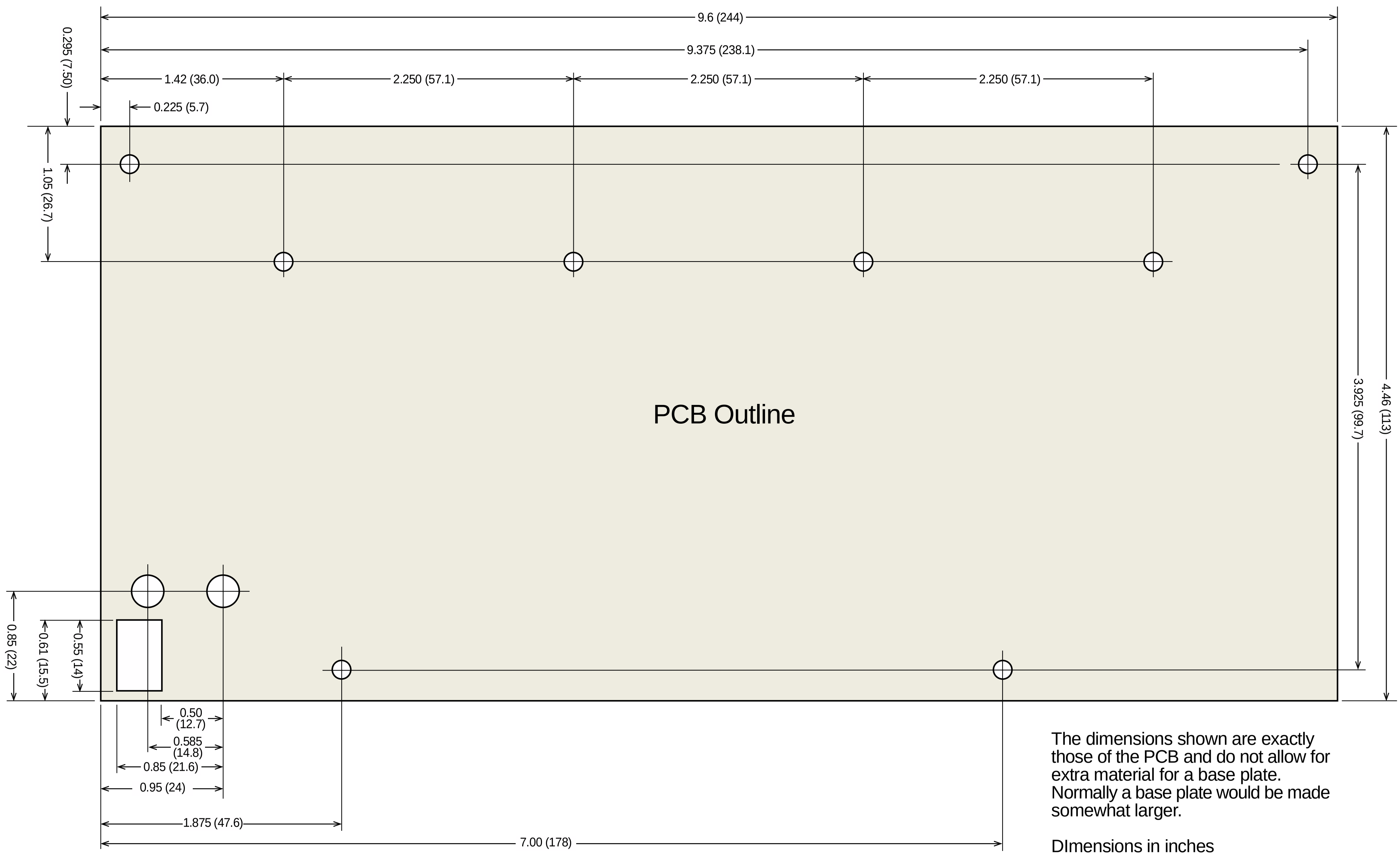
Component Locatios and Reference Designations



Component Values and Other Information

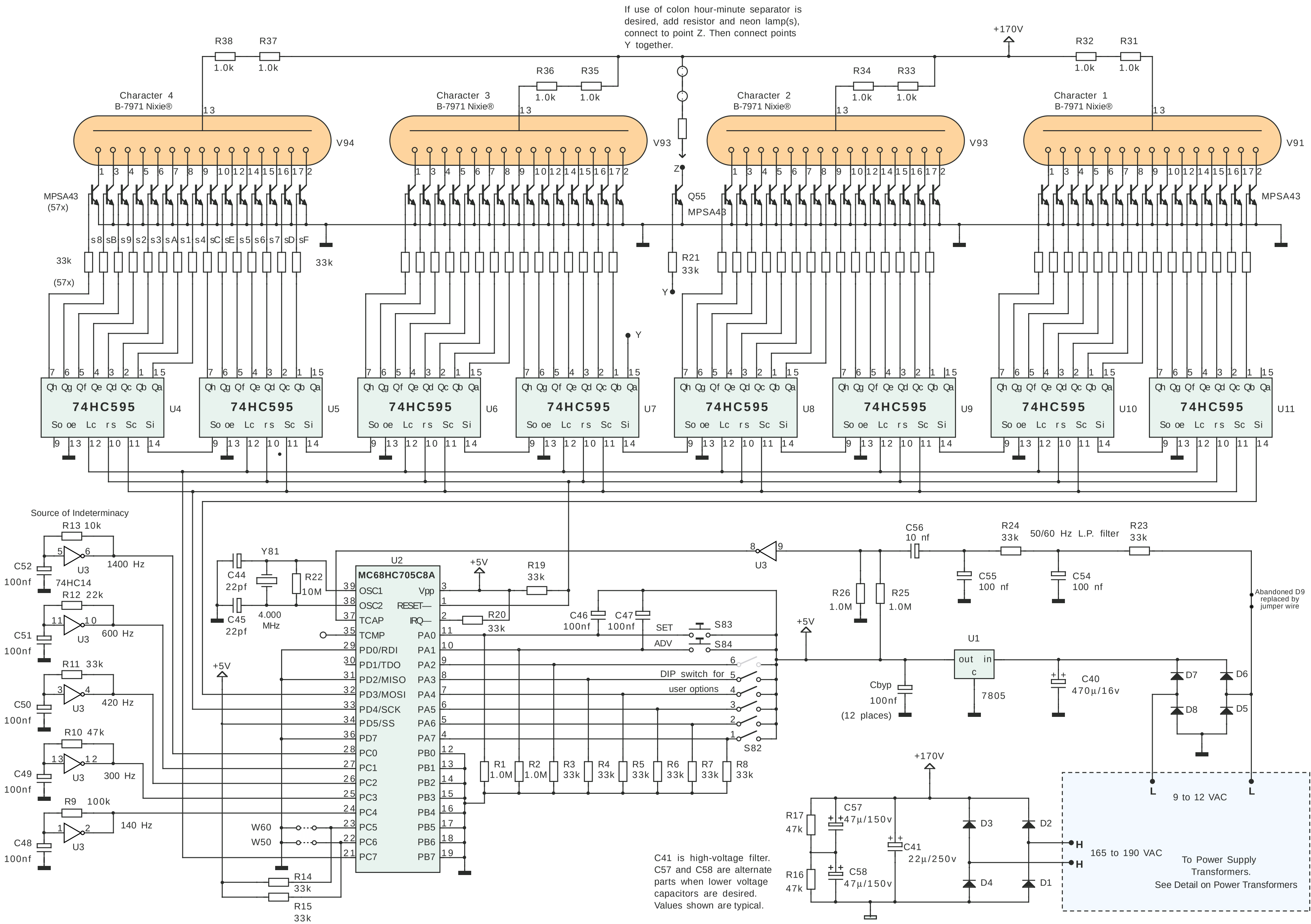


Four Letter Word PCB mounting and switch access dimensions



The dimensions shown are exactly those of the PCB and do not allow for extra material for a base plate. Normally a base plate would be made somewhat larger.

DImensions in inches (mm in parenthesis)

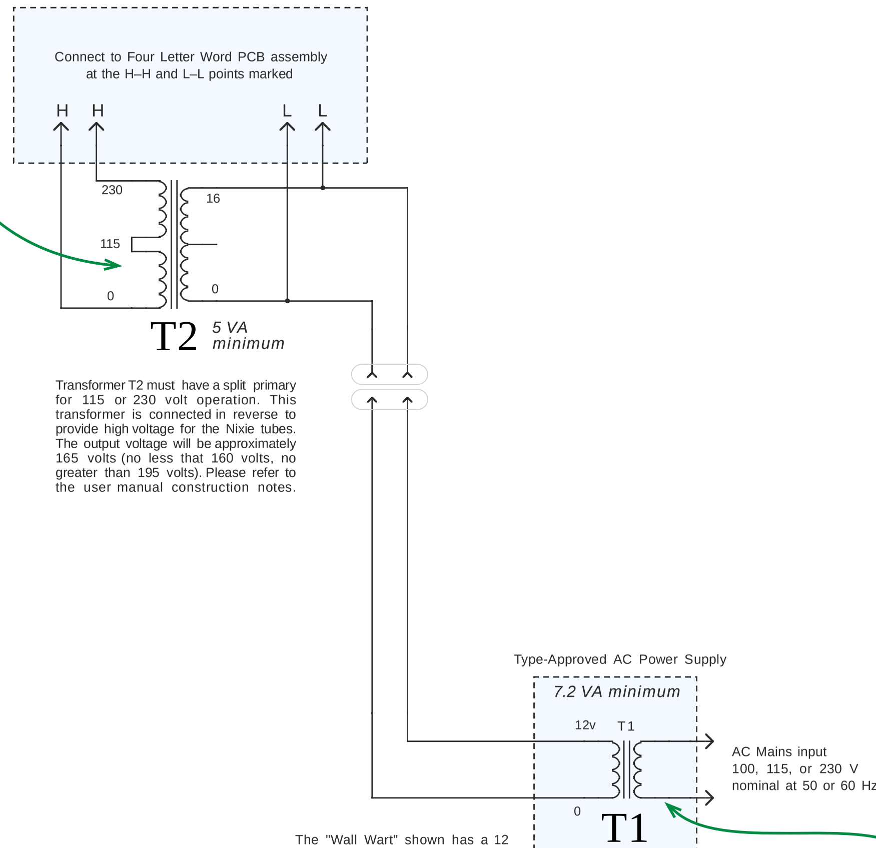


Jumper W50 installed will select 50 Hz power line for clock time-base
Jumper W60 installed will select 60 Hz power line for clock time-base
W50 and W60 open (no jumper) uses 4.00 MHz crystal (Y81) as time-base.

FOUR LETTER WORD — schematic diagram. Revised 27 August 2002

Suggested step-up transformers for T2:

A. Tamura "Flat Stack" 3FL16-350 (Digi-Key part number MT1110–ND) (low profile)
B. Tamura "Splitform" 3FS416 (Digi-Key part number MT2211–ND)
C. MagneTek Triad VPP16–310 (Digi-Key part number 237–1083–ND)



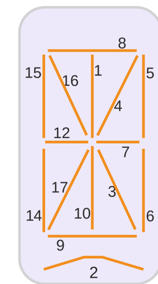
Transformer T2 must have a split primary for 115 or 230 volt operation. This transformer is connected in reverse to provide high voltage for the Nixie tubes. The output voltage will be approximately 165 volts (no less that 160 volts, no greater than 195 volts). Please refer to the user manual construction notes.

The "Wall Wart" shown has a 12 volt secondary. This connects to the second transformer's 16 volt winding (as shown). Other voltage combinations are shown in the construction notes of the user manual.

"Wall Wart" type suitable for AC Mains Voltage, frequency and plug style used in your country. These are typically built with fuses and thermal protection, and should be fully approved for the safety standards and regulations that exist in each country if purchased from a reliable local (domestic) supplier. We recommend not to take shortcuts where safety is concerned.

Suggested wall wart transformers for T1:

A. Tamura 820A0061–03 (Digi-Key part number MT7102–ND)
(The Tamura one is 12 volts at 1000 mA, 12 VA, larger than necessary)
B. CUI Stack DPA120060–P1P (Digi-Key part number T607–P1P–ND)
(This is closer to optimum, 12 volts at 600 mA, 7.2 VA)



B-7971 Nixie Tube segments and pin number reference.

FOUR LETTER WORD — Power supply detail. Revised 27 August 2002