TECHNI-GUIDE

HEATH MODEL IB-101 FREQUENCY COUNTER

by Ernie Welling

A frequency counter for the workbench? Until recently this would have been an impossible hope. Digital instruments which measure frequency by actually counting the cycles are expensive devices that conjure up the very essence of measurement accuracy and, as everyone knows, accuracy costs money. Then too, who needs one? Plenty of shops have muddled on without frequency measuring equipment or with something marginal that could be used in a pinch. Measuring frequency was not easy enough to be a worthwhile approach to many problems, although it wasn't hard to visualize that a fast and accurate device that was sensitive and had a high input impedance would be a great help.

The Heath frequency counter is just such a device and it opens up new approaches to many servicing problems and provides quick answers to many design difficulties. You can determine oscillator frequencies, align audio generators, check fm subcarrier frequencies and color TV subcarriers, watch drift, and a host of other things with the utmost simplicity.

There are almost no controls for the IB-101 — an ac on/off switch and a range switch (Hz/kHz) are all there are. Inside there is a capacitor to spot the 1 MHz crystal oscillator, an input sensitivity control and a trigger level control but these are all preset during calibration, a procedure that can be carried out without anything more elaborate than a transistor radio.

Operation of the counter is consequently quite simple. For frequencies below 99999 Hertz select the 'HZ' range and wait 4 seconds. The counting period in this range for the reading to update is 2 seconds. If the frequency is larger than the display can accomodate, an OVER signal lights on the panel. Going up to the 'KHZ' range will indicate the extra digits. For example, a frequency of 11,381,367 Hertz will read 11,381 on the 'KHZ' scale and 81,367 on the 'HZ' scale. The higher scale updates in 1/10 second.

Although the Heath specification limits the counter to 15MHz, we expected, and obtained, some performance up to 20 MHz. This performance will vary with individual ICs and accuracy probably drops off quite a bit. It's unlikely that this magnificent little instrument (it weighs 4½ pounds) is going to stay limited to 15 MHz and my guess is that it probably won't be long before a "divide by 10" accessory will make it work to 150 MHz, and other add-ons will be available to make it more versatile.

The Kit

Putting this instrument together will bring you into contact with a few components you may not have handled before. This does not mean that there will be difficulty — as usual Heath's excellent step-by-step manual takes care of you. One new feature to me in this manual was the printed 6″ ruler on each page where wire lengths are required.

If you're good at kit building this one can be done in

about five hours. The 26 integrated circuits are all plug-in and the hardest job is installing the IC connectors. These come in a 3ft. long continuous strip of joined connectors (made by AMP) which is folded and refolded to fit in the carton. There are 384 required and they supply about 10 extra. This means that the slightly deformed connectors at the folds must be straightened out and used or you will run out. Soldering these connectors onto the p.c. board is not recommended for the tyro. IC packages have connections spaced 0.1 inches apart and as a result there is very little space between the solder connections on the board. A good light, a steady hand, and experience in soldering techniques are absolutely necessary for this part of the project. Cutting, inserting and soldering the 26 sets of connectors took one hour and a quarter. I would advise anyone who started to have trouble with this part of the project to yell for help because the circuit board could easily be ruined beyond redemption if too many of the points get bridged with excessive solder which has to be removed. One unusual thing about the soldering is the warning "Never make a solder connection on the screened side of the circuit board", even though it is a dual sided board. The reason is that the circuit board has plated through holes — and this fact is never mentioned in the manual.

The Circuit

Techni-Guide is no place to start a description of digital logic without which counter operation cannot be followed but with the help of the block diagram we should be able to cover some of the IB-101's principles.

The input circuit consists of a dual-gate MOSFET amplifier, which provides an input impedance of one megohm, and two Schmitt trigger circuits. These triggers produce a square wave output to drive the decade counters. Each decade counter is an integrated circuit consisting of four flip-flops. Additionally the first decade counter has two NAND gates and functions to change the input square waves to a binary-coded decimal 8-4-2-1 output and to divide by ten. The BCD output allows any number from 0 to 9 to be represented by the output of the four flip-flops. One flip-flop represents 1 (2^0), one represents 2 (2^1), one represents 4 (2^2), and the last is 8

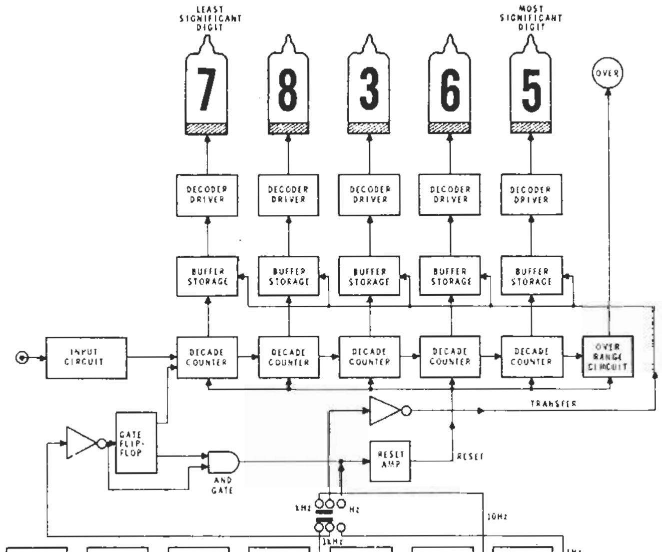
(2^3) Flip-flop outputs look like this for numbers from 0 to 9:

Number	Flip-Flops (1)	(2)	(4)	(8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

Remember that flip-flop output levels are designated 0 or 1 — it has to be one or the other. The BCD output from the decade counter is fed to the buffer storage and the 'carry' signal goes on to the next decade counter. Each of the counters performs in a similar way. The master clock circuit allows counting to proceed for 1 second in the 'HZ' range and 1 millisecond in the 'KHZ' range before inhibiting and resetting the counters. If the last decade counter has a 'carry' it drives a latching circuit that turns on the OVER lamp. This can only occur on the 'HZ' range.

The master clock is a free running multivibrator controlled by a 1 MHz crystal. Its square wave output drives a divider chain of six decade counter units which provide outputs of 1 kHz, 10 kHz, and 1 Hz. Part of the 10 kHz output is used in the set-up procedure for calibrating the counter's input sensitivity. Outputs of 1 Hz and 1 kHz are used to drive the gate flip-flop which in turn controls the period during which the input signal is counted.

The clock pulse also commands the buffer storage units to accept a new count from the decade counter and hold it until the next transfer pulse. Output from the buffer storage units, which are flip-flops, is fed to the decoder drivers which each reduce 8-4-2-1 input into decimal form with a decoding matrix. The decimal signal is then used to drive the appropriate cathode of the neon display tube.



BLOCK DIAGRAM

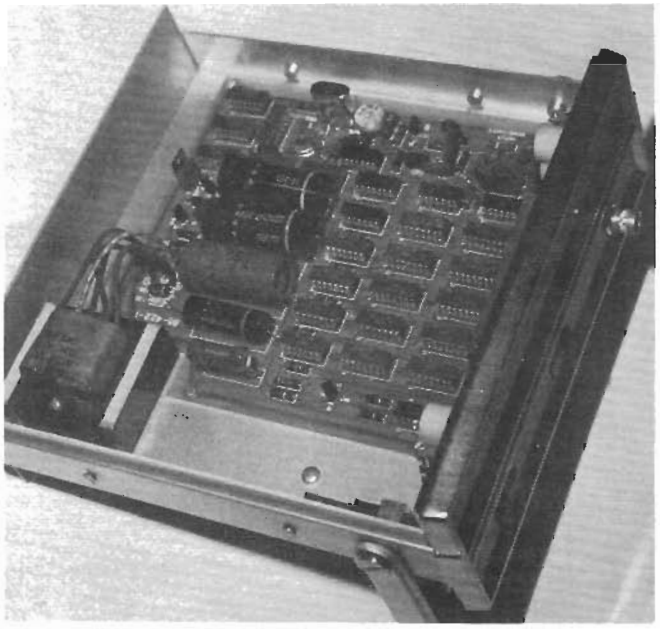
This is an incomplete circuit description of the IB-101 but sufficient to indicate the nature of its operation. A detailed account based on logic levels is included in Heath's manual.

Results

As I said earlier, the IB-101 is simplicity to use. Plug it into 115 V, switch it on and connect to the unknown frequency source and watch the numbers come up. The only thing to be careful about is the maximum input voltage rating. It is shown in the book as "AC only 200 volts RMS. 1 Hz to 1 kHz (derate at 48 volts per frequency decade)". Also included is a curve. In the circuit description under Input Amplifier it says "... Internal zener diodes protect the transistor against overload". You may wonder whether the derating curve has to do with damage to the input circuit — or whether it means that the readings are unreliable above those voltages. After having blown the input MOSFET (Q1) on our counter we conclude that input derating is to protect the transistor and it's not advisable to rely on the zeners. For this reason derating is important, and it is entirely likely that users will forget these limits when the unit is in operation. It would be as well to have a warning posted near the input connector.

Another thing to watch is the straight-in connection: the input plug goes straight to one of the MOSFET gates. Since the counter has to handle from 1 Hertz to 15 MHz, it was obviously not possible to put in a series capacitor that would perform over that range. Consequently the user has to do his own DC isolating and it would be wise to assume that you have to unless you are very sure what you are connecting the counter to.

What about accuracy? Heath's specification claims ±1 count ± time base stability. The time base is a 1 MHz crystal and would not be off by more than .002% so the major factor is the 1 count which is 0.01% at worst. Our unit was checked against a General Radio Frequency Synthesizer and was off less than 15 Hz at 5 MHz, which is 0.0003%. Quite some performance for a unit that is within reach of anyone who needs to measure frequency. Kit price is $269.00.



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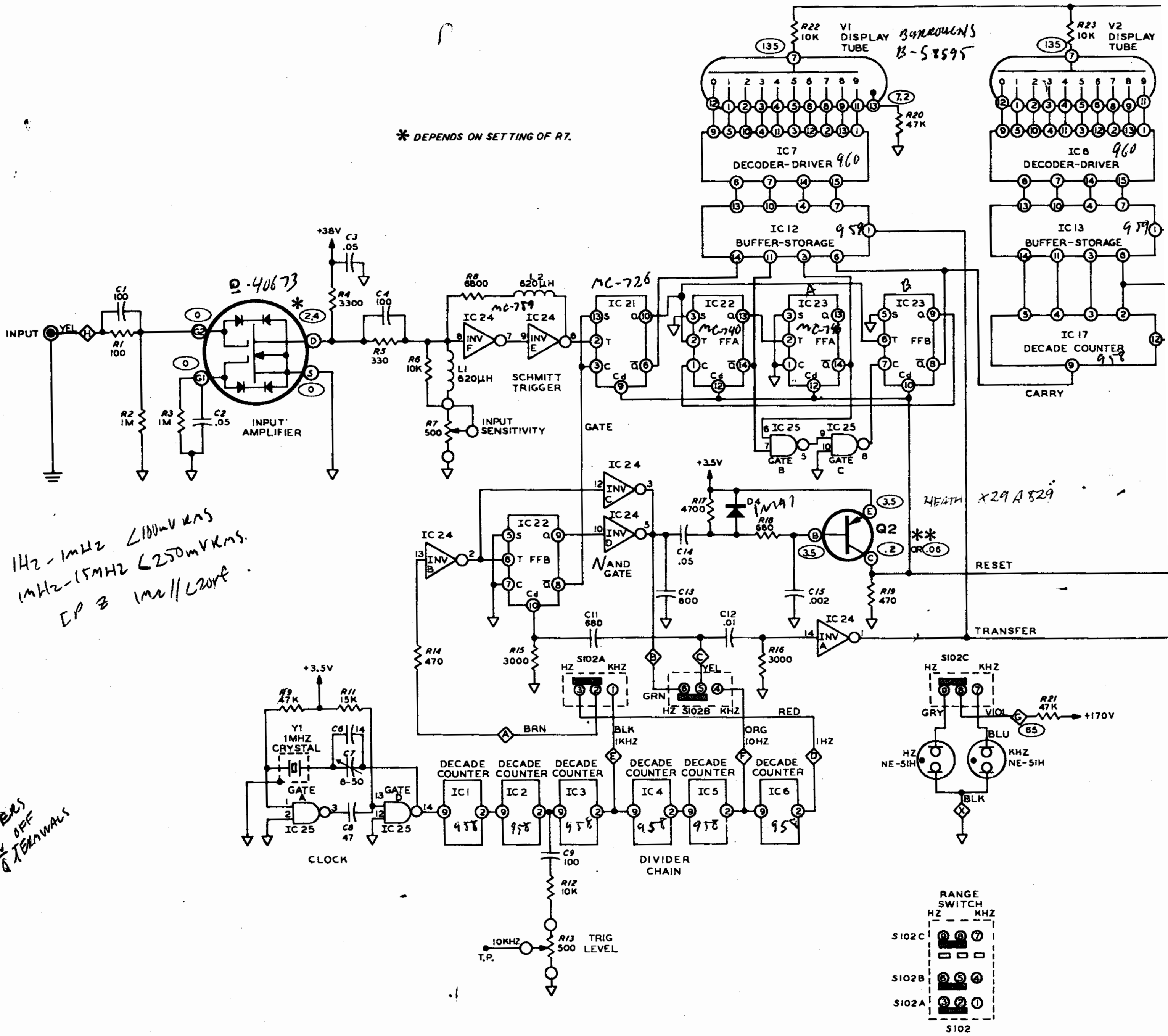

NOTES:

1. COMPONENT NUMBERS ARE IN THE FOLLOWING GROUPS;
   1-99 PARTS MOUNTED ON THE CIRCUIT BOARD.
   100-199 PARTS MOUNTED ON THE CHASSIS.
2. ALL RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (k=1000, M=1,000,000).
3. ALL RESISTORS ARE 5% UNLESS MARKED OTHERWISE.
4. ALL CAPACITOR VALUES LESS THAN 1 ARE IN µF. VALUES OF 1 AND ABOVE ARE IN pF UNLESS MARKED OTHERWISE.
5. ▽ THIS SYMBOL INDICATES CIRCUIT BOARD GROUND.
6. ≡ THIS SYMBOL INDICATES CHASSIS GROUND.
7. ◇ THIS SYMBOL INDICATES A LETTERED CIRCUIT BO CONNECTION.
8. ⬭ THIS SYMBOL INDICATES A DC VOLTAGE TAKEN WI A HIGH IMPEDANCE INPUT VOLTMETER FROM THE P INDICATED TO CHASSIS GROUND WITH NO INPUT S TO THE COUNTER. VOLTAGES MAY VARY ±20%.
9. ** WITH THE RANGE SWITCH IN THE HZ POSITION, THE VOLTAGE IS .06 VOLTS. WITH THE RANGE SWITCH I KHZ POSITION, THE VOLTAGE IS .2 VOLTS.

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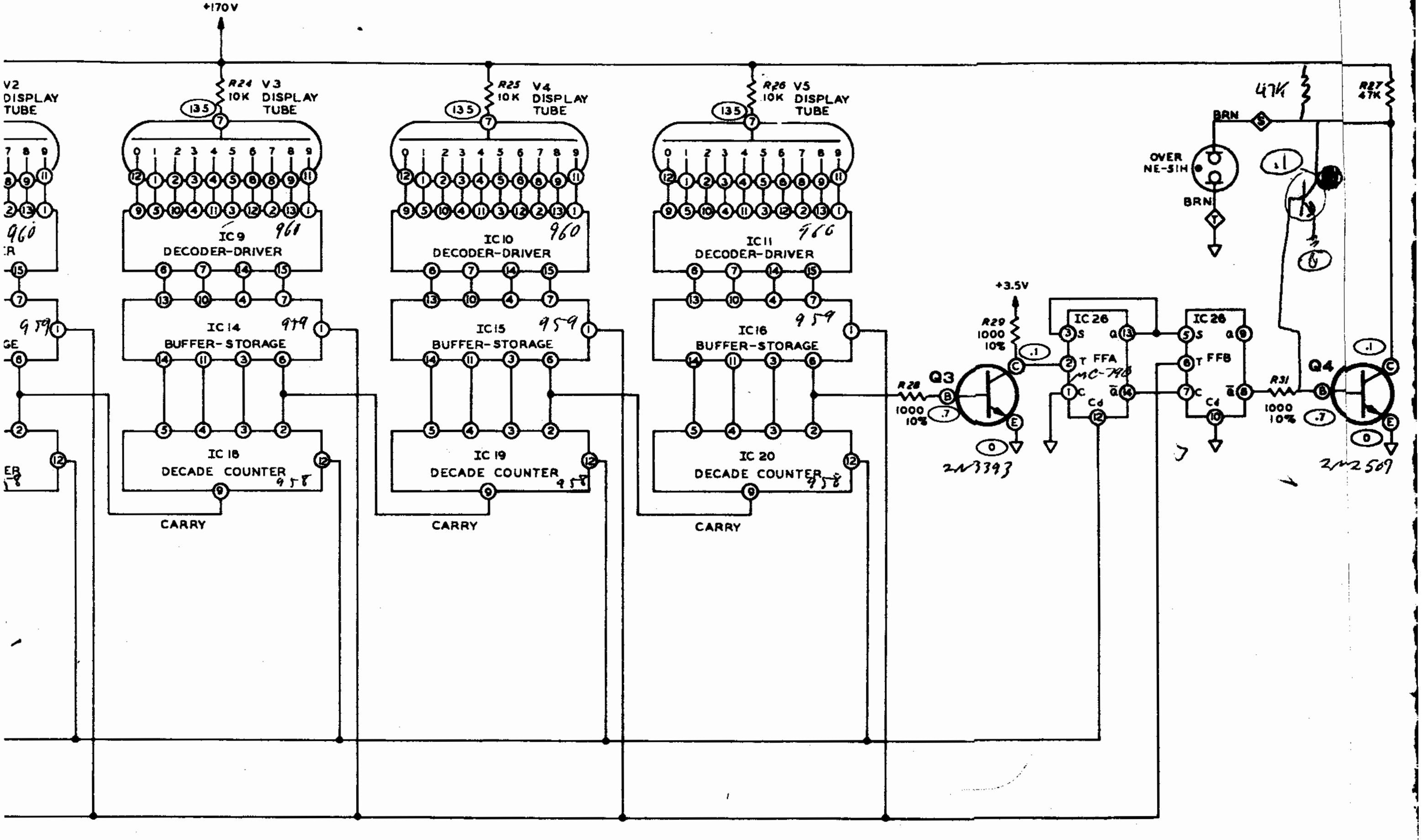

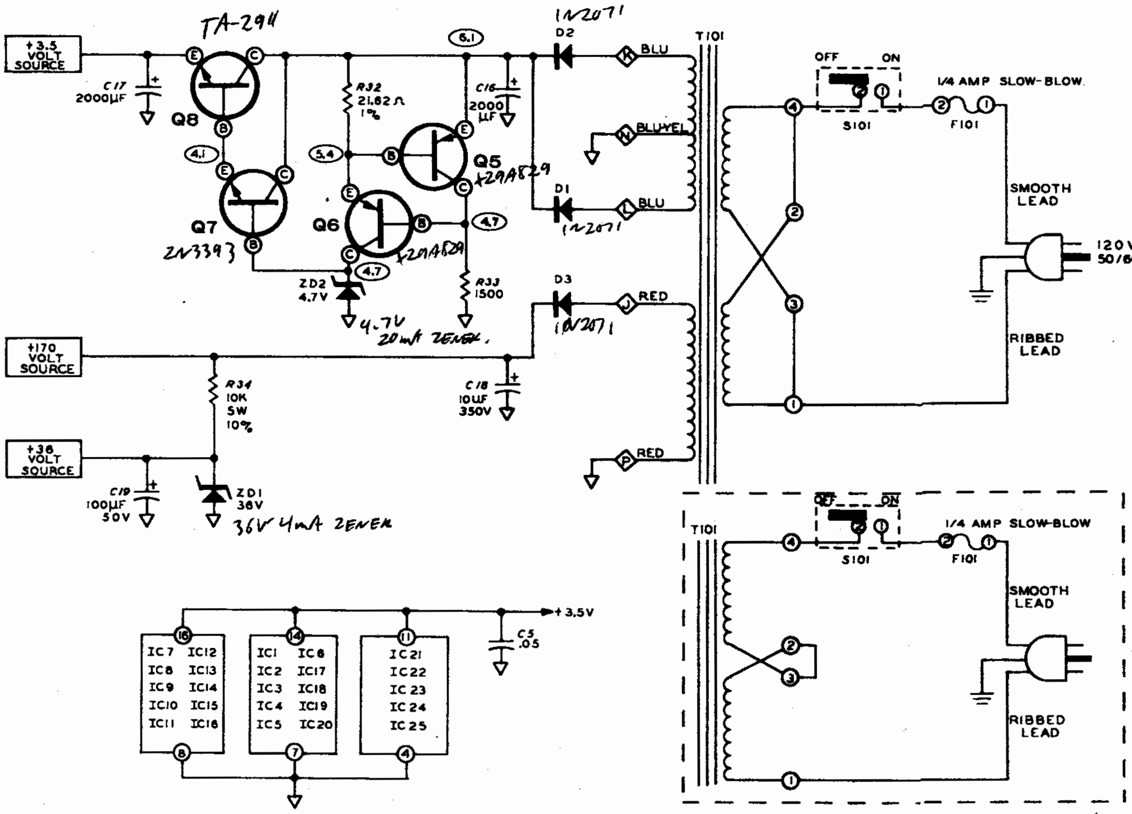

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