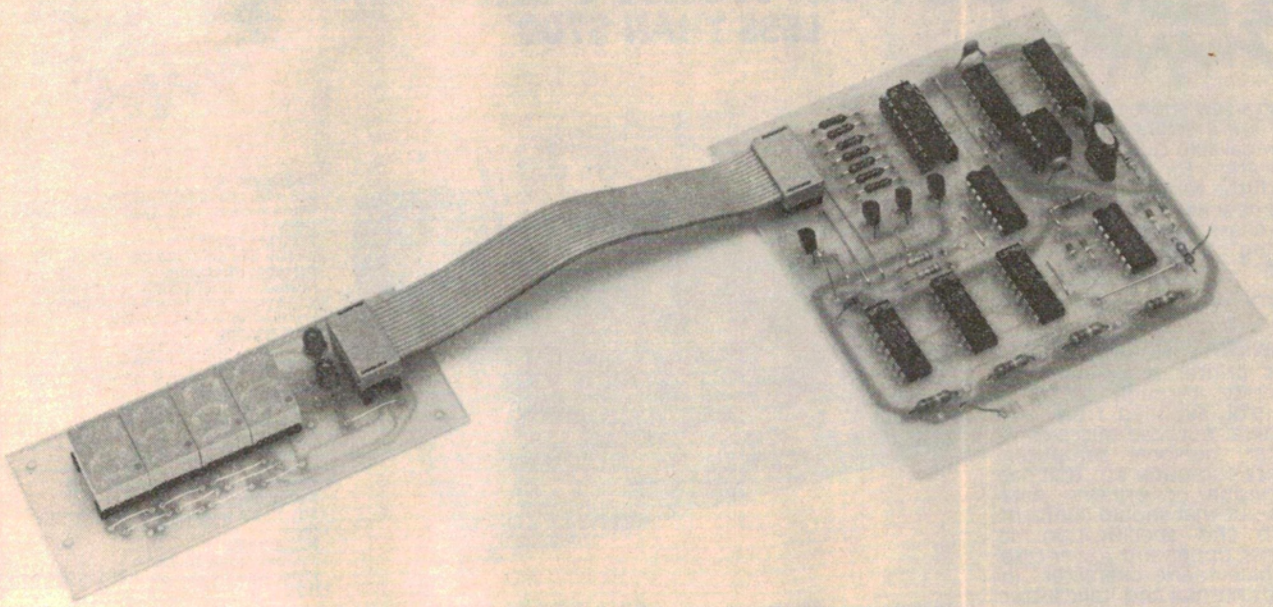


A laboratory standard function and pulse generator

Part 2.

This article covers the design and construction description of the frequency counter and power supply modules. Like the wideband amplifier (ETI-1520) module, these two can also be used in other applications.

David Tilbrook

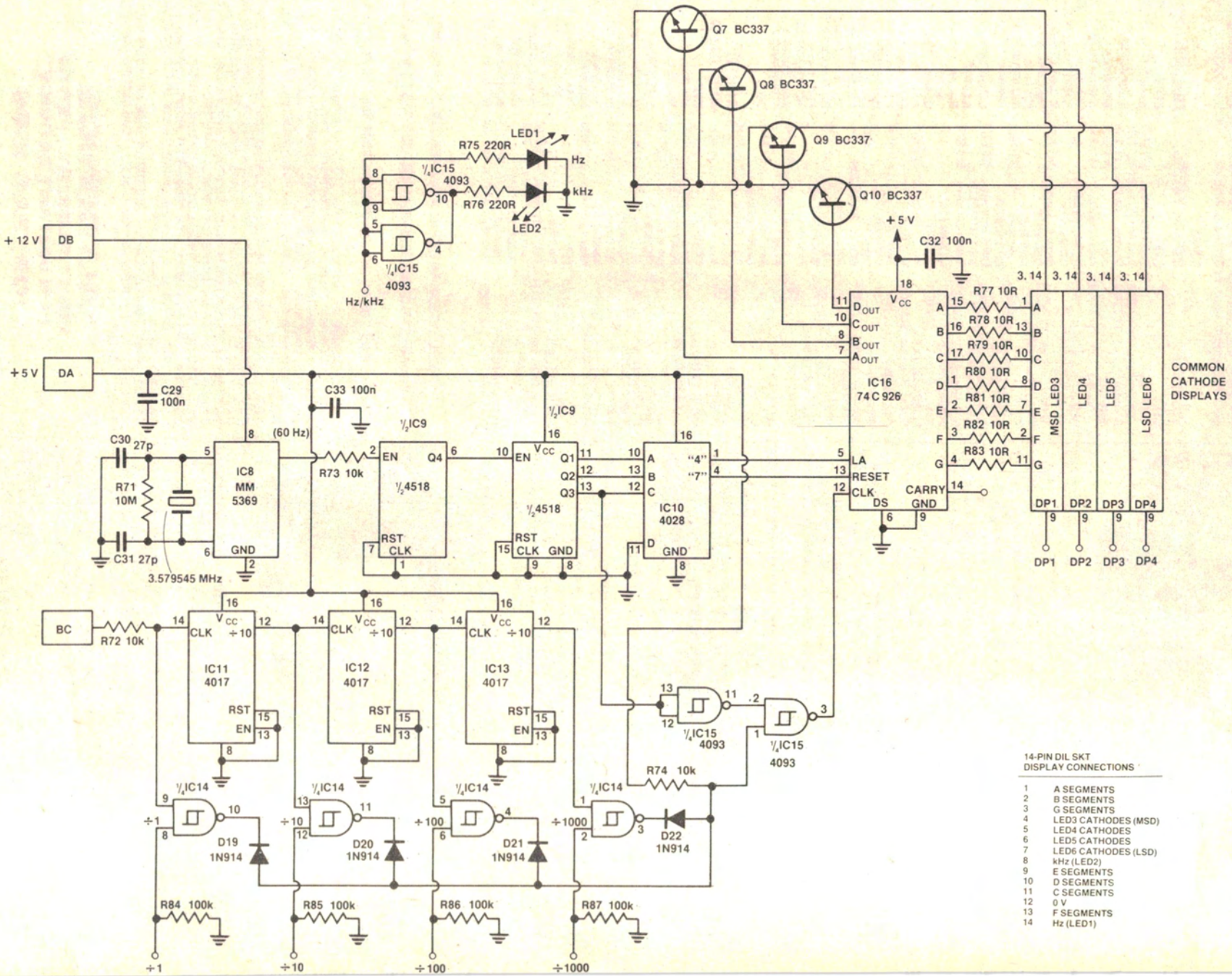
THE TWO MODULES to be described here, the frequency counter and power supply sections of the Function/Pulse Generator, can be used in applications aside from this project. For the moment, we'll leave the details to you and get on with the project in hand. Both modules have been designed to do the job required, yet keep costs low. No really 'specialised' components have been employed and constructors should have little difficulty obtaining kits or individual parts.

FREQUENCY COUNTER

This is housed on two boards — one containing the counter electronics, the other containing the 4-digit 7-segment LED display and Hz/kHz indicators. The counter board measures 95 x 105 mm, while the display board measures 40 x 100 mm. Spacious component layout is employed on each, easing construction.

A total of nine ICs are employed, but they're all off-the-shelf types and the reference is derived from a low-cost common crystal. The displays finally selected, after a great deal of shopping around, are high-efficiency Stanley types, the NK#-163 series. The # letter signifies the colour — A for amber, R for red, etc. We used the amber displays because they are very 'visible', easy on the eyes and the red displays were unobtainable! (Grr ... Ed.). Litronix LT-547 displays are physically identical, but do not feature the high efficiency LED segments. ▶

Project 166b,c,d function/pulse generator



14-PIN DIL SKT
DISPLAY CONNECTIONS

1	A SEGMENTS
2	B SEGMENTS
3	G SEGMENTS
4	LED3 CATHODES (MSD)
5	LED4 CATHODES
6	LED5 CATHODES
7	LED6 CATHODES (LSD)
8	kHz (LED2)
9	E SEGMENTS
10	D SEGMENTS
11	C SEGMENTS
12	0 V
13	F SEGMENTS
14	Hz (LED1)

Design

The heart of this counter is a 74C926 counter/display driver IC. A 1 Hz gate period is derived from a 3.579545 MHz crystal using an MM5369A oscillator/17-stage divider IC, which provides a 60 Hz output, followed by a 4518 dual 4-stage counter, half of which divides the 60 Hz to 6 Hz, the other half dividing this to 1 Hz. A 4028 BCD-to-decimal decoder provides the appropriate gating signals to the 74C926.

The incoming frequency to be displayed is gated through to the 74C926 clock input, only for the period for which the counter/display is enabled so that a steady display results.

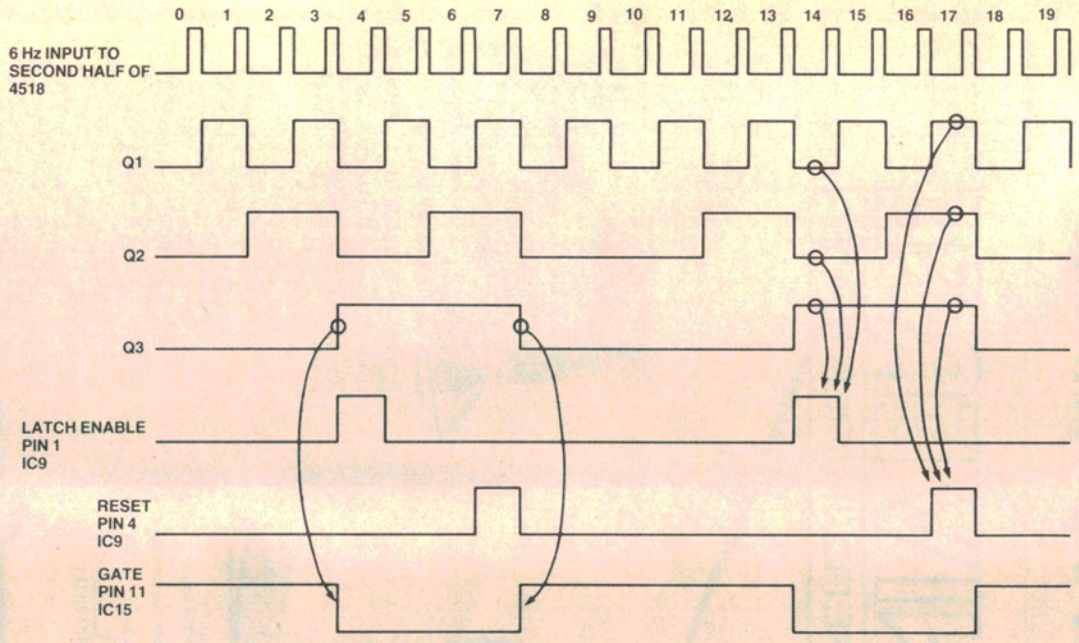
The output of one of a series of 4017 dividers, driven by the input signal, can be selected to provide divisions of 10,100 and 1000. The counter can display input frequencies to 2 MHz, limited by the speed of the CMOS circuitry. Decimal point switching and divider selection is arranged by an external switch — the range switch of the main oscillator. The Hz/kHz indicator switching is also provided by the generator's range switch.

Note that the 74C926 multiplexes the displays. This chip's 'carry' output is brought out to a pad on the counter board so that this module can be used stand-alone as a $4\frac{1}{2}$-digit counter.

Construction

The first thing you should do is check your pc boards, no matter whether you've bought them or made them yourself. Check the tracks for minute 'bridges', particularly where they run between IC pins, and also that there are no minute cracks — many of the tracks are quite fine. See that all the holes are correctly drilled. Fix any problems before proceeding.

Tackle the counter board (ETI-166b) first. The component overlay shows the overall arrangement. Install all the resistors and capacitors first. Mount the capacitors with as short leads as possible. Install the nine links next. Note that one solders to a lead of resistor R74 (near the location of the crystal). ▶



HOW IT WORKS — ETI 166b

The frequency reference is derived from a 3.579545 MHz crystal and a MM5369 oscillator/divider. This combination produces a crystal-locked 60 Hz output which is further divided to provide a 1 Hz gating signal accurate enough to ensure that all displayed digits are meaningful.

A ceramic resonator may have also have sufficed since only four digits are displayed.

The technique of using a mains derived 50 Hz signal instead of a crystal was not used since the short term accuracy of the mains is not sufficient to ensure that all digits displayed are valid.

The output of the MM5369 is fed to one half of a 4518 dual BCD up-counter which is used to divide the input 60 Hz signal by ten. This provides a 6 Hz signal which is used as the input to the second half of the 4518.

This stage, in combination with the 4028 BCD decimal decoder, generates latch-enable, gating and reset signals which are required by the 74C926 seven-segment display driver.

The timing diagram shows the relationship between the control signals and the 6 Hz input to the second stage of the 4518.

Since the 6 Hz signal is derived from the Q4 output of the first stage of IC9, it has a 2:8 mark/space ratio. This input frequency is counted by the second stage of IC9 which provides a BCD output corresponding to the count at any given time.

Notice that the Q3 output is low for exactly six cycles of the input clock i.e: low for one second. This signal is inverted by one gate of IC15 (4093) and used as an accurate 1 Hz gating signal.

This signal is NANDed with the input signal, to be measured in another gate of IC15 so that the input frequency (signal at pin 1, IC15) is counted by the 74C926 for a period of one second. At the end of this time gating stops.

The output of the 4518 is decoded by the 4028 and the '4' output is selected as the latch-enable line. As can be seen from the timing diagram, this line goes high immediately counting ceases and the measured frequency is displayed.

The displayed frequency will not change again until a completely new measurement is carried out one second later.

A short time after the latch-enable signal, the '7' output of the 4028 goes high and this is used to reset the counter within the 74C926, in preparation for the new measurement.

The 74C926 automatically counts the input frequency, converts it to seven-segment code and drives the seven-segment displays. The displays are multiplexed by the 74C926 so that only one is on at any given time to decrease current consumption and power dissipation.

We tried a variety of seven-segment displays and finally chose the Stanley NKA163-B since it is considerably brighter than any other display tried. The pinout on these displays is the same as that on a variety of displays so availability should not be a problem.

The remaining section of the frequency meter is formed by IC11, IC12, IC13 and IC14. This circuitry divides the input by 1, 10, 100 or 1000 to provide range switching. IC11, IC12 and IC13 are decade counters, each providing a ÷10 function. The outputs of the counters are fed to the inputs of successive counters and to the inputs of the NAND gates (IC14).

The desired input prescaling is obtained by taking the other input of the gates to +5 V. The resistors R84, 85, 86 and 87 are used to hold these gates at ground potential unless driven.

The maximum frequency that can be measured is around 2 MHz and this is determined by the first decade counter IC11. If a high frequency is required simply incorporate a TTL ÷10 stage before the input with a 1k pull-up resistor on its output to the +5 V rail. This would enable the meter to measure to around 20 MHz.

PARTS LIST — ETI-166b,c

FREQUENCY COUNTER

Resistors ..... All ¼W, 5% unless noted
- R71 ..... 10M
- R72, 73, 74 ..... 10k
- R75, R76 ..... 220R
- R77-83 ..... 10R
- R84-87 ..... 100k

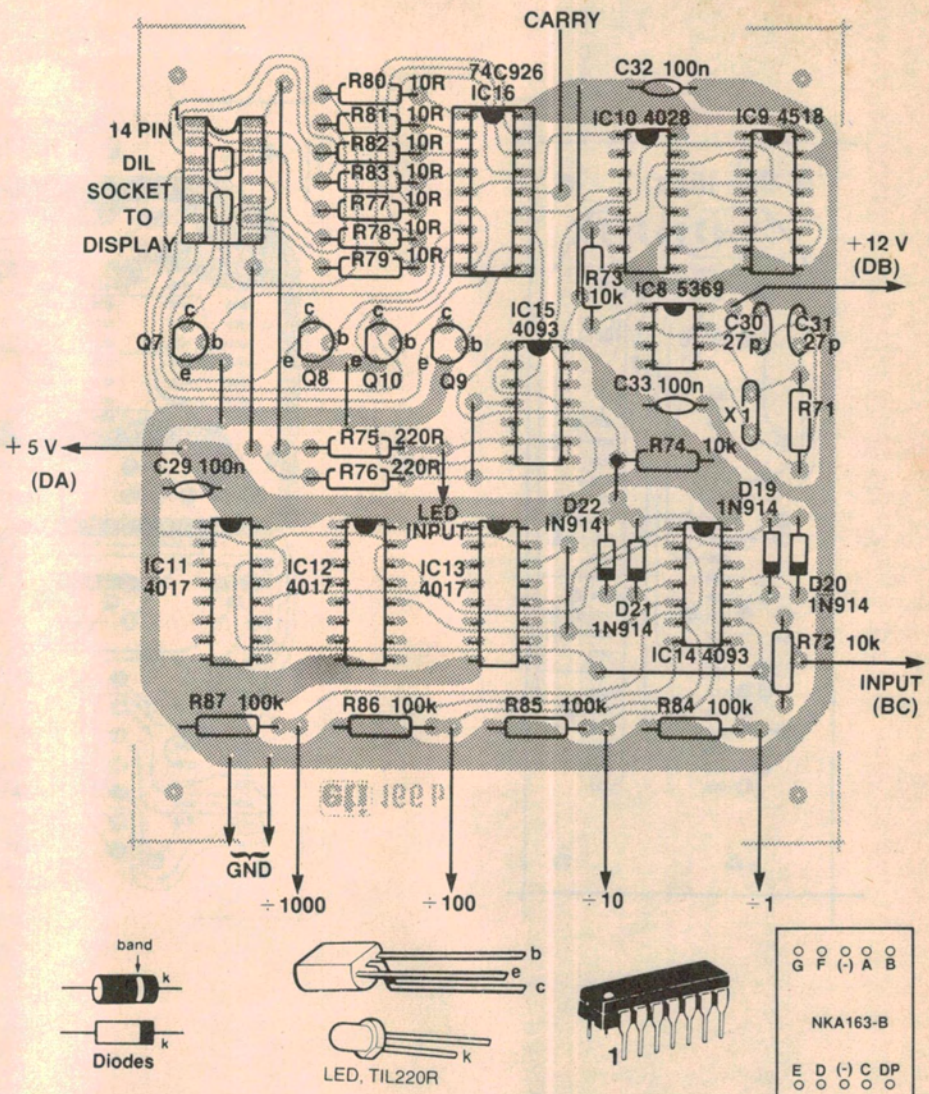
Capacitors
- C29, C33 ..... 100n
- C30, 31, 32 ..... 27p

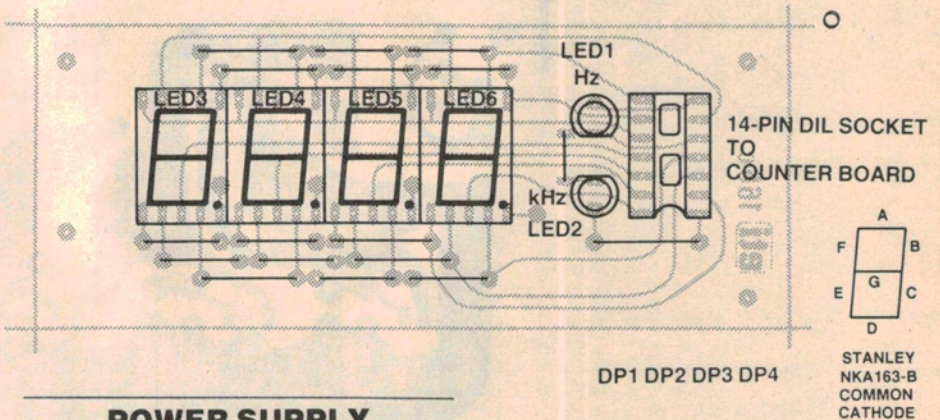
Semiconductors
- D19-22 ..... 1N914, 1N4148
- IC8 ..... MM5369AA (60 Hz model)
- IC9 4518
- IC10 4028
- IC11, 12, 13 4017
- IC14, IC15 4093
- IC16 ..... 74C926
- LED1, LED2 ..... TIL220R
- LED3-LED6 ..... Stanley NKA-163-B, Litronix LT-547R or similar common cathode 7-segment display with DP.
- Q7-10 ..... BC337-BC338

Miscellaneous
- X1 ..... 3.579545 MHz crystal, HC18/U can.

ETI-166b and c pc boards; 2 x 14-pin IC sockets (others if required); 2 x 14-pin IDC plugs; length of 14-way ribbon cable; tinned copper wire; pc stakes, etc.

Price Estimate $42-$48





Solder the four diodes and four transistors in place next. Note their orientation before installation; each set faces the same way.

The ICS can be installed next. The 74C926 (IC16) requires a socket. This is to provide some heat dissipation for it as there is insufficient copper in the tracks around it on the board to provide enough heatsinking. There are no objections to using IC sockets for the rest of the ICs if you so wish. Note that all the ICs face the same way. Install a 14-pin IC socket for the display interconnection.

The crystal should be soldered in place last of all. Mount it right down on the board — it's not good to have it flapping around in the breeze — and take care not to apply too much heat or hold the iron on the leads for longer than about 10 seconds.

The display board can be assembled next. Install the 17 links first. I used a 40-pin IC socket for the displays and this should be installed next, followed by the 14-pin socket for the interconnection from the counter board. Solder the two LEDs in place next, mounting them so that their bases are 9-10 mm above the board. Then plug the four 7-segment displays into the 40-pin socket.

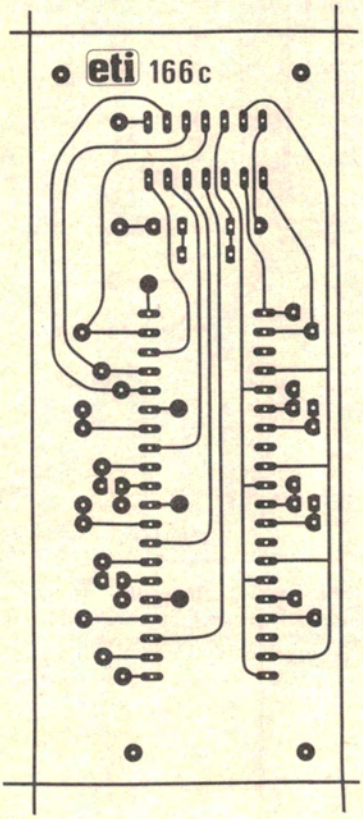
Strip a short length of ribbon cable to leave 14 wires and cut it to a length of at least 125 mm. Install 14-pin insulation displacement connector (IDC) plugs on each end and the counter is ready!

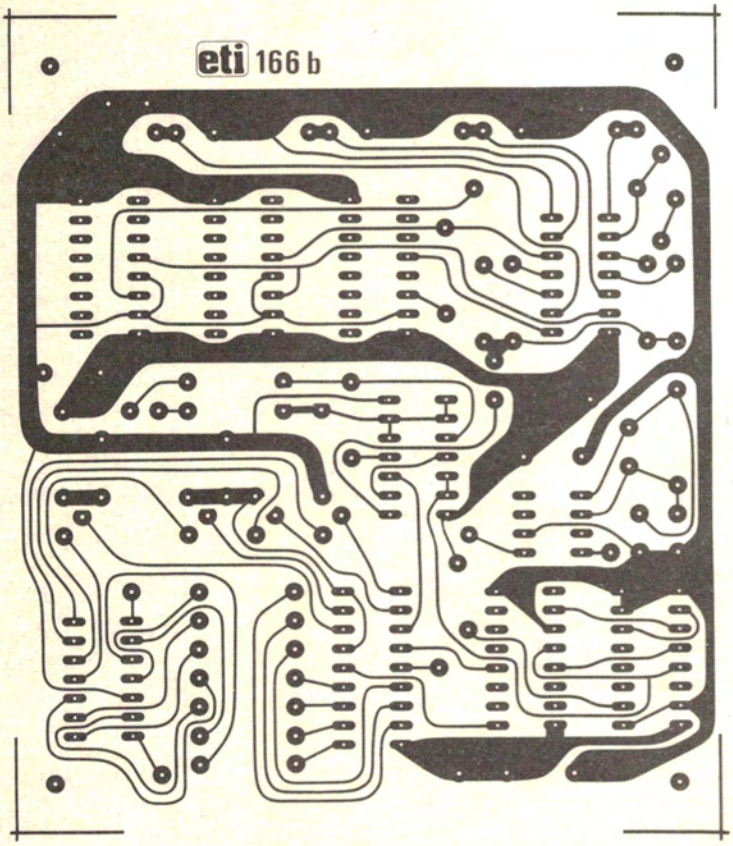
POWER SUPPLY

The power supply board is quite straightforward. It has been designed to use a transformer delivering 15-0-15 Vac at around 1 A and provided three regulated rails — +5 V, +12 V and −12 V.

A 6672 transformer is ideal to drive it. This has a multi-tapped secondary delivering an overall 30 V, tapped at 15, 17.5, 20, 24 and 27.5 volts. The 0, 15 and 30 volt taps are used, the 15 V tap being the centre-tap ('C.T.'). It is rated at 1 A.

Apart from its application in this project, this power supply could be used with many microprocessor and digital or digital/analogue circuits. ▶


eti 166c

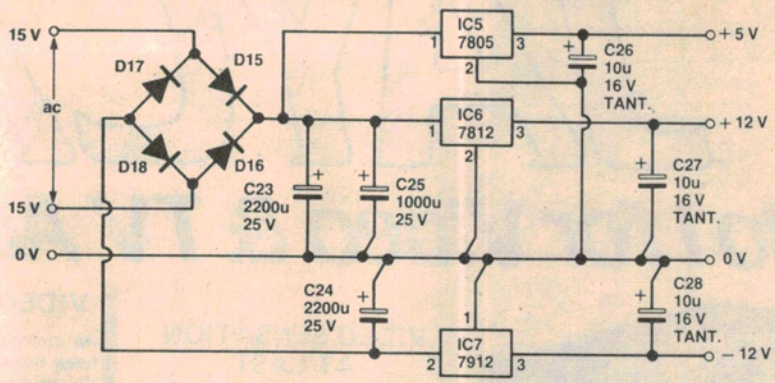

eti 166b


eti
166d

Construction

Simple! However, check the board first — mainly to see that all the holes are correctly drilled. Solder the four diodes and three tantalum capacitors in place first. See that they are correctly orientated — check with the overlay diagram.

All external connections to and from the board are made via pc stakes and these should be installed next. Follow by installing the three 3-terminal regulators. Last of all, solder the three electrolytic capacitors in place, making sure you get them the right way round. Mount them right down on the board, it's not good to have them waving around on their leads. ●



PARTS LIST — ETI-166d

POWER SUPPLY

Capacitors

C1 ..... 1000u/25 V single-ended electro.
C2, C3 ..... 2200u/25 V single-ended electro.
C4, 5, 6 ..... 10u/16 V tantalum

Semiconductors

D1-4 ..... 1N4001, 1N4002, EM401, etc
IC1 7805
IC2 7812
IC3 7912

Miscellaneous

ETI-166d pc board; small heatsinks for TO-220 devices (e.g.: Thermalloy 6073B or similar; pc stakes, etc.)

Price Estimate $14-$16

HOW IT WORKS — ETI-166d

POWER SUPPLY

The power supply comprises fullwave positive and negative capacitor-input rectifiers followed by three, three-terminal regulators developing a +5 V rail, a +12 V rail and a -12 V rail.

The positive rectifier consists of diodes D2 and D3 plus capacitors C1 and C2. With an input from a transformer secondary delivering no greater than 15-0-15 V at 1 A, the voltage developed across C1-C2 is about 21-22 V under load.

IC1 regulates this to +5 V and a load no greater than 250 mA can be drawn without IC1 being mounted on a larger heatsink. Capacitor C4 lowers the regulator's output impedance and maintains its stability.

IC2 regulates the positive rectifier output to +12 V and a load of up to 500 mA can be drawn without IC2 being mounted on a larger heatsink. Capacitor C5 fulfils the same role as C4 does for IC1.

The negative rail rectifier consists of diodes D1 and D4 plus capacitor C3. This also develops around 21-22 V across C3 (negative with respect to the 0 V rail) with 15-0-15 V ac applied to the rectifiers' input.

IC3 regulates the negative rail to -12 V and its load can be no greater than 500 mA without the IC being mounted on a larger heatsink. Capacitor C6 lowers the output impedance of IC3 and maintains stability.

The sum of the load currents on the three supply rails should not exceed the current rating of the transformer.