Construction project:

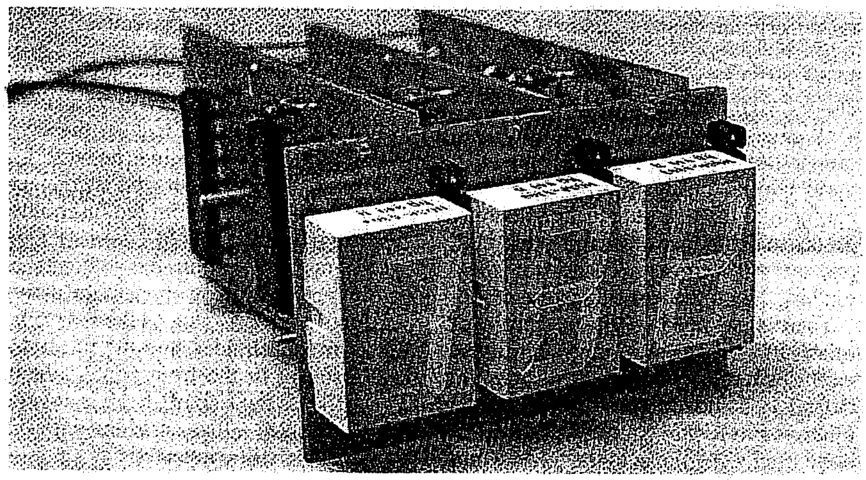
FLEXIBLE COUNTER MODULE

If you've ever wanted to fit a digital readout to your latest project, or needed a flexible counter module that could be easily expanded and modified to suit, then this little project should fit the bill nicely. Using a simple 'sandwich' technique, this counter module takes up a minimum of space on the front panel, and you can extend the count to as many digits as you like by simply adding extra units.

by GRAHAM CATTLEY

It's been quite a while since we've presented a general purpose counter unit, and looking back at past designs we realised that there wasn't really anything that offered a degree of flexibility in the number of digits, while also providing an aesthetically pleasing display. Most designs provide three digits, but if you wanted to add more, there was no way to link on the next unit and still maintain an equal spacing between each of the displays.

To make matters worse, supplies of the much-loved 74C926 counter and seven-segment driver IC that was used in a lot of earlier designs have dried up, leaving many previous designs now unbuildable. All of this highlighted the need for a flexible counter module that was small and expandable, but still offered a goodly number of control inputs to make it easy to adapt to new and existing designs.



Although a little unconventional in design, this counter module can be easily expanded to as many digits as required. A full range of control inputs is available as well, making this module suitable for use in existing designs.

Features

With this new design, each digit is completely independent of any other digit, and so the modules can be cascaded to give anything from three to 30 digits, and can even be cut down to give two digits (or even one) if required.

Each digit has a full complement of control inputs, including lamp test, blanking, output latching, up/down counting, input gating, reset and clock. As well, the design uses standard CMOS, and so will run off a wide range of supply voltages.

With minimal additional circuitry the counter could be expanded to count up to millions of events, or with a suitable front end and gating circuit it could be the basis of a simple frequency meter.

The circuit

As you can see from the schematic, the circuitry behind each of the three digits is identical, and so I'll just cover the operation of the first digit here, based around IC1 and IC2.

Most of the work in this circuit is done by the 4029 counter IC. This IC is very flexible, and can be configured to count in a number of different modes by tying the relevant control pins high or low. IC1 drives the right hand (least significant) digit on the display, and clocks on a rising edge from whatever circuitry is driving the counter. If the counter is to be clocked mechanically (a switch contact or pressure mat for example) the incoming signal driving the counter should be suitably de-bounced, and its peak voltage should be clamped so that it doesn't exceed the counter's supply rails.

IC1's output is a four-bit binary word, which (depending on the configuration) will count to a maximum of 15 before resetting back to zero.

In this application we only want it to count up to nine before resetting, and so the counter's BIN/DEC input (pin 9) is held permanently low, selecting a decimal rather than binary counting mode.

The BCD output feeds into IC2, a 4511 BCD to seven segment decoder driver IC, which decodes the four bit word and outputs the correct display code for each count. Resistors R6 to R13 limit the current to each segment to around 20mA, which gives a nice bright display.

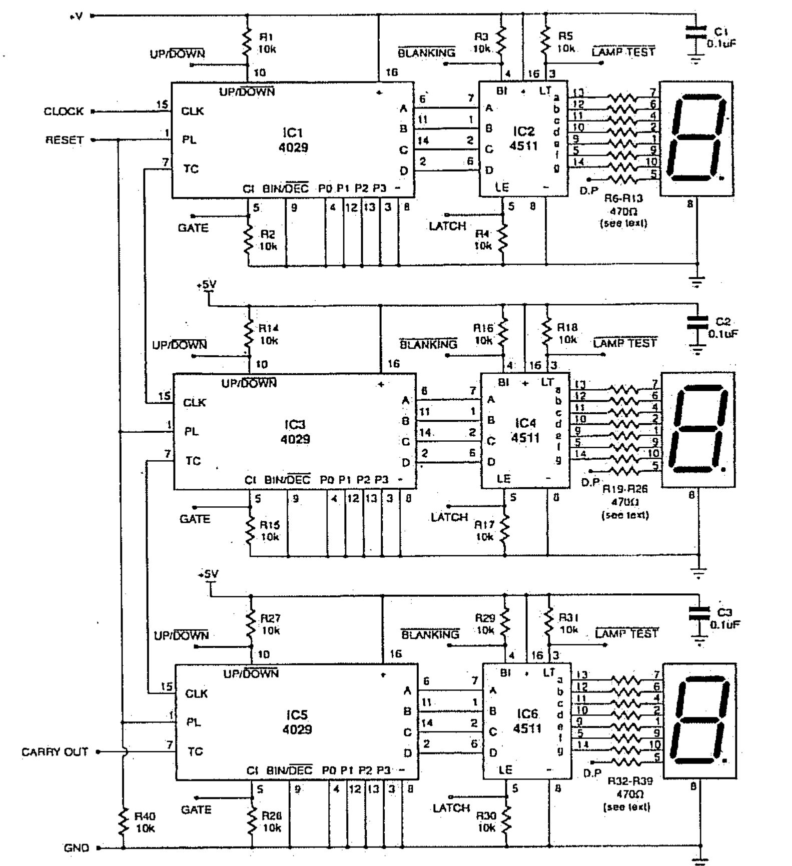
Both IC1 and IC2 support a total of five control inputs, and these are all held in their inactive or 'normal' states by the five 10k resistors R1 to R5. The following list describes the function and effect of each of these inputs.

- **Up/Down**
  High — counts up from 000;
  Low — counts down from 000.
- **Latch**
  High — freezes the display only, with the counter still enabled;
  Low — display updated with each count.
- **Blank**
  High — digit turned on;
  Low — digit turned off, counter still enabled.
- **Lamp test**
  High — no effect;
  Low — all segments of digit turned on, counter still enabled.
- **Gate**
  High — counter enabled;
  Low — counter stopped.

As well as the five inputs listed above, each digit has a clock and reset input as well as a carry-out output. Carry-out is connected to IC1's TC (Terminal Count) pin, which pulses low every time the counter reaches nine (when counting up) or zero (when counting down). This output is used to clock the next counter in the module (here shown as IC3) and acts as a carry out for each digit. By chaining the clock input of each module to the carry-out output of the proceeding digit, any number of counter modules can be added.

One aspect of the counter's operation that may not be immediately apparent is the reset circuit. The 4029 doesn't have a reset as such, and instead this function relies on one of the more specialised features of the IC. It's called *parallel load*, and the idea is that the counter can be pre-loaded with a value, and counting will continue from there. In this case, all the parallel load inputs (or 'jam' inputs as they are known) are tied to ground, and the parallel load input (pin 1) is used as a reset as it simply loads a value of zero into the counter. The reset control line is tied low (inactive) by R40.

I might just note that I have shown separate pull up/down resistors for all the control inputs for each digit. As most of these inputs are paralleled in normal operation, resistors 14, 15, 17, 18, 27, 28, 30 and 31 are not installed in the standard three-digit assembly. They would normally only be fitted to one digit logic board.



As you can see, the circuitry for each digit is practically identical. Note that the pull up/down resistors have been shown on every control input for clarity. Only one set should actually be installed.

Construction

The photos give a pretty good idea of the construction technique, with the three logic boards mounted on edge behind the main display board. This system is perhaps a little unconventional, but it results in a compact unit with only a 0.1" gap between each of the displays.

While the counter isn't difficult to assemble, it's worth following the order of construction described here, as it can be a bit tricky getting into the logic boards once they have been soldered in to position.

To start, you will need the small main display PCB as well as three of the slightly longer logic boards. (I am assuming that you will be building the three-digit counter as shown in the photos. I'll cover the construction of modified boards for different numbers of digits later on...)

Although the three logic boards are identical, only one set of 10k resistors is needed per counter, and you'll only need PCB terminal pins on one of the boards as well.

With this in mind, the best place to start is by installing the components common to all boards. Start with the link, the 0.1uF monoblock and two PCB pins — one for blanking (located in the centre of the board) and the other for each display's decimal point. If you are going to perform blanking on an individual digit basis (leading zero blanking for example), you should also install R3, R16 and R29 as these will aid testing of the counter module as it is being constructed.

You can now mount the eight dropper resistors on each of the three logic boards — Table 1 lists the correct value to use for whatever supply voltage you'll be using. Lastly, install all the ICs, with the 4511 mounted next to the column of resistors, and the 4029 at the end of each board.

Table 1

Resistor values

5V	220Ω
9V	470Ω
12V	560Ω
15V	680Ω

Now select one of the boards, and mount on it the five remaining 10k resistors. Pick another board and install the five PC pins for V+, reset, clock, gate and ground. Note that this leaves the carry-out pad free, along with a couple of extra pads for power and reset.

You can now move on to the display board, where it is probably easiest to start by installing the three nine-way SIL header strips. These can be cut down from one 28-way strip, and are inserted 'upside down' in the PCB so that around 4mm of pin protrudes from the copper side of the board. This leaves the plastic strip and the short ends of the pins sticking up on the component side of the board, but these won't be noticed once the displays are soldered in.

Once the SIL strips are installed, you can mount the displays. These should just fit nicely between the plastic pin header strips, but before soldering them in, double check that they are the right way up — the decimal points sit at the bottom, with each of the header strips to the *right* of each display.

Now comes the fun bit — soldering each of the logic boards to the display board. Before we do that though, we'll need some lengths of tinned copper wire to run between the boards. You'll need seven 50mm lengths of straight bare wire, and these are inserted from the copper side of the logic board that contains the extra resistors. Leave around a millimetre protruding out of the component side of the board, and solder them to the following (unoccupied) pads: Up/down, Latch, Lamp Test, V+, Reset, Gate and Ground.

If your application is going to support leading zero blanking, it would be a good idea to attach leads to the 'Blank' pin on each board now, as it's a little difficult getting to this pin once all the boards have been soldered together.

With the tinned copper wires poking up from the bottom of the first logic board, position the nine copper fingers along one edge of the board so that they line up with the nine pins belonging to the *left hand digit* of the display board.

Just tack solder a couple of the pins, and then check that the two boards are correctly aligned, and are sitting at 90° to each other. Also double check that you have actually connected it to the left hand (most significant) digit, otherwise you'll find it rather difficult to solder in the remaining two boards...

Testing, testing

If all's well, you can fully solder all the pins, and the first digit should be complete. As a test, try applying power to the logic board and checking that it lights up correctly, and counts at around 50Hz if the clock input is touched with a wet finger (you can, of course, use a signal generator instead, but wet fingers are usually closer to hand, so to speak).

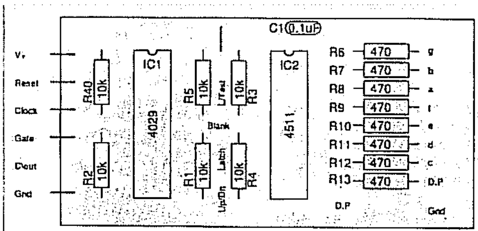
With the left-hand digit working, you can now mount the second logic board to drive the middle digit. Carefully thread the board over the tinned copper wires, making sure that each wire goes through the correct hole — some holes are unused on the second and third boards, so it pays to be careful.

Position the fingers with the pins as before, and again check that everything is at right angles before soldering it in place permanently.

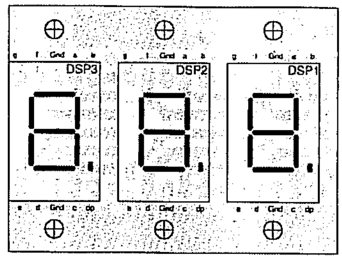
Check again that this second digit counts in the same way as the first, and then link this second board's carry-out pad to the first board's clock pad with a short length of tinned copper wire. You should now find that you can clock the middle digit at 50Hz as before, and the first digit will clock at a tenth of the speed (5Hz). It's a good idea to follow this check-as-you-go procedure, as finding faults after all the boards have been wired together can get a bit fiddly.

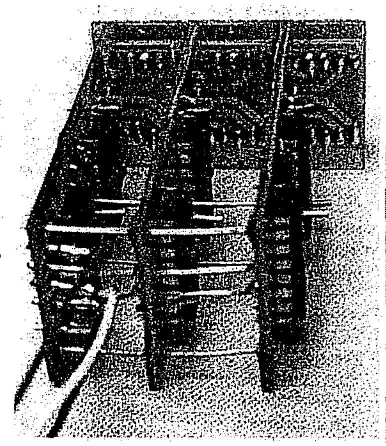
The last board is connected in the same way as the second; this one should have the extra PC pins on it, and once it has been connected to the display board and the feed throughs soldered in you can then connect its carry out to the clock input on the middle board.

All three digits should now light up when power is applied, and they should count from 000 to 999, with the last (left) digit incrementing every 0.5Hz, or once every two seconds.



Component overlays for both the logic board (above) and the display board at bottom.





This shot shows how feed through links are used to connect between boards. All off-board connections are made to the board driving the right hand digit.

PARTS LIST

Resistors

R1-R5,R40 10k
R6-R13, R19-R25, R32-R39 470 ohms (see text)

Capacitors

C1-C3 0.1uF monolithic

Semiconductors

IC1,3,5 4029 CMOS BCD counter
IC2,4,6 4511 CMOS 7-segment decoder/ driver
DSP1,2,3 FND500/5303 or equiv. 13mm common cathode display

Miscellaneous

PCBs — 1 x 98cm01a (46 x 28mm), 3 x 98cm01b (56 x 28mm); 1 x 28-way SIL header strip; 9 x PC pins; 400mm tinned copper wire; hookup wire, solder etc.

Extra digits

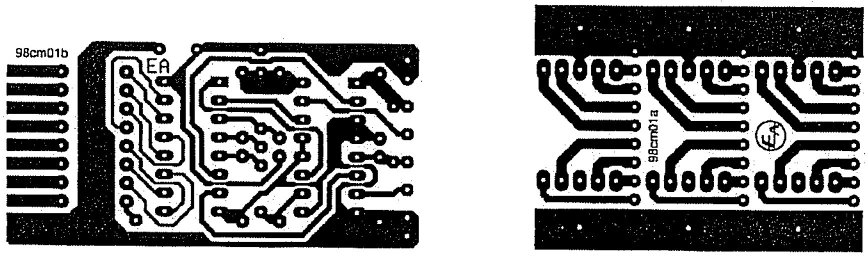
If you want to extend the counter to give four, five six or more displays, then it is a simple matter to repeat the above procedure for as many digits as you want. You can trim off any excess display board and mount the extra module(s) to the right of the original displays. You may find it easier to construct and test each module as a separate unit, and then wire them together with hookup wire, rather than trying to construct a 'mini skyscraper' on the bench...

Only one set of pull up/down 10k resistors will be needed no matter how many digits you have, so it's probably best to leave them on the first module and omit them from all the others.

To make it easier to physically align more then one display board, the top and bottom edges of each of the display boards have a wide copper track running along them. This track can be used to hold a 10mm long piece of stout wire soldered between the two adjoining display boards, which will keep them lined up.

To mount the display in your case, you are probably best off enlarging the mounting holes on the top and bottom of the display board to accept some M3 x 15mm countersunk screws. You can then use four 10mm spacers to mount the module behind a rectangular cutout in the front panel, covered with clear red perspex or other suitable filter material. ❖

Full sized artwork for both boards. You will need one logic board (below) for each digit in the display, making a total of four boards per module.



Construction Notes

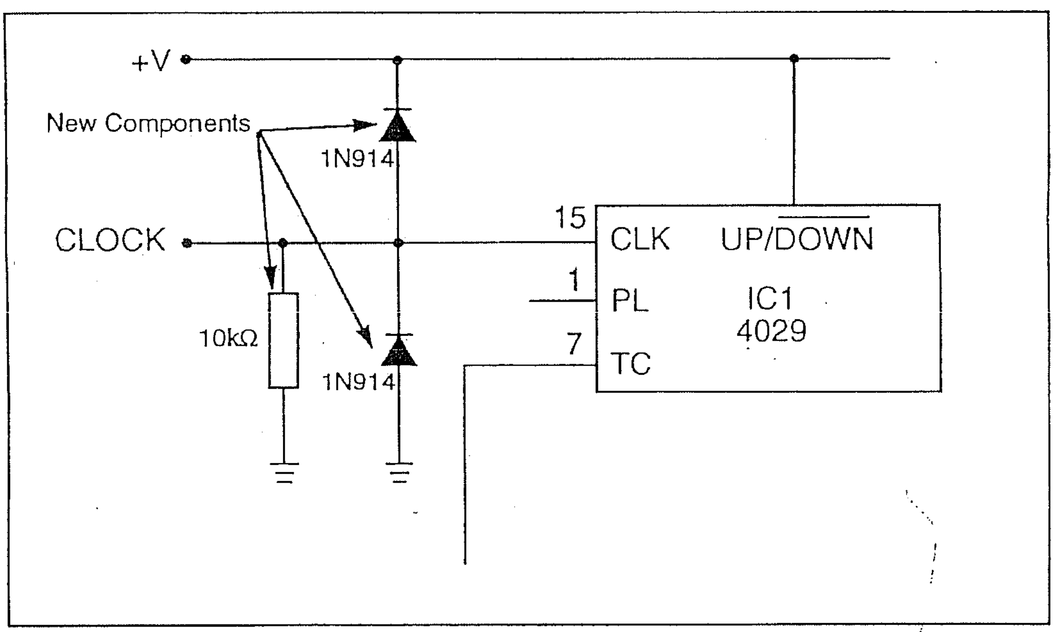
K 2505 3 Digit Counter Module Kit

Dear Customer

We have introduced a small modification to the input circuitry for the K 2505 to enable it to better cope with inputs that are not CMOS in nature. The circuit is a form of "limiter" which will protect the 4029 IC from damage to it's CLOCK input.

The modified schematic is shown below, and the components may be soldered underneath the PCB, on the copper side of the board.

We have included the components for this modification at no extra cost.



Happy Constructing!

Kit Department