New design has LCD and counts to 19,999!

A general-purpose 4½-digit event counter

Looking for a general-purpose event counter that's easy to build? This design features a 4½-digit liquid crystal display, low power consumption, and a maximum count of 19,999. It is battery powered and uses only a handful of components.

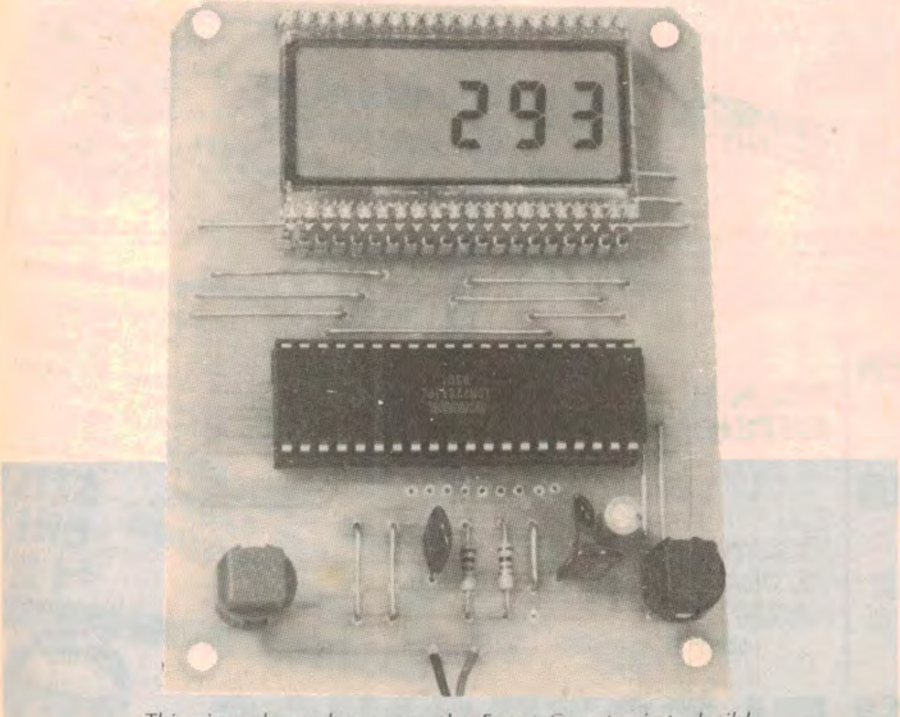
by JOHN CLARKE and GREG SWAIN

So what does an event counter do? Well, as its name implies, an event counter is a circuit that counts the number of times a particular event takes place and displays the result. Typical applications include counting the number of objects on a production line, a lap counter for a slot car or model train set, or even counting the number of sheep through a race.

Other possible uses include a coil winding counter, a turnstile counter, a lap counter for sports events, or counting the number of people that enter and exit through a doorway. One staff member even suggested that the Event Counter could be used by prisoners to count off the days! That would certainly be within the capabilities of this unit, since 19,999 days is almost 55 years!

Practical operation of the Event Counter is simple – the device is incremented by one each time the clock input is pulled low. We used a momentary contact pushbutton switch to trigger the prototype, but you can use virtually any trigger input that's convenient. For batch counting on a production line, for example, the Infrared Light Beam Relay described in April 1981 would provide an ideal trigger input.

Alternatively, you can trigger the Event Counter using relay contacts, reed switches, microswitches, or CMOS switches. Logic signals may also be used, provided they are compatible with the supply rail of the Event Counter.



This view shows how easy the Event Counter is to build.

The Event Counter is reset to zero simply by pressing the reset switch. As before, we used a momentary contact pushbutton switch, but the reset function can also be carried out automatically using any of the above methods if you wish.

But that's not all this versatile module can do. In addition to event counting, it can also form the heart of a very effective digital frequency meter (DFM). Next month, we intend to describe a compact module which, when teamed with the Event Counter, will form a compact 2MHz DFM that should prove very attractive to the hobbyist.

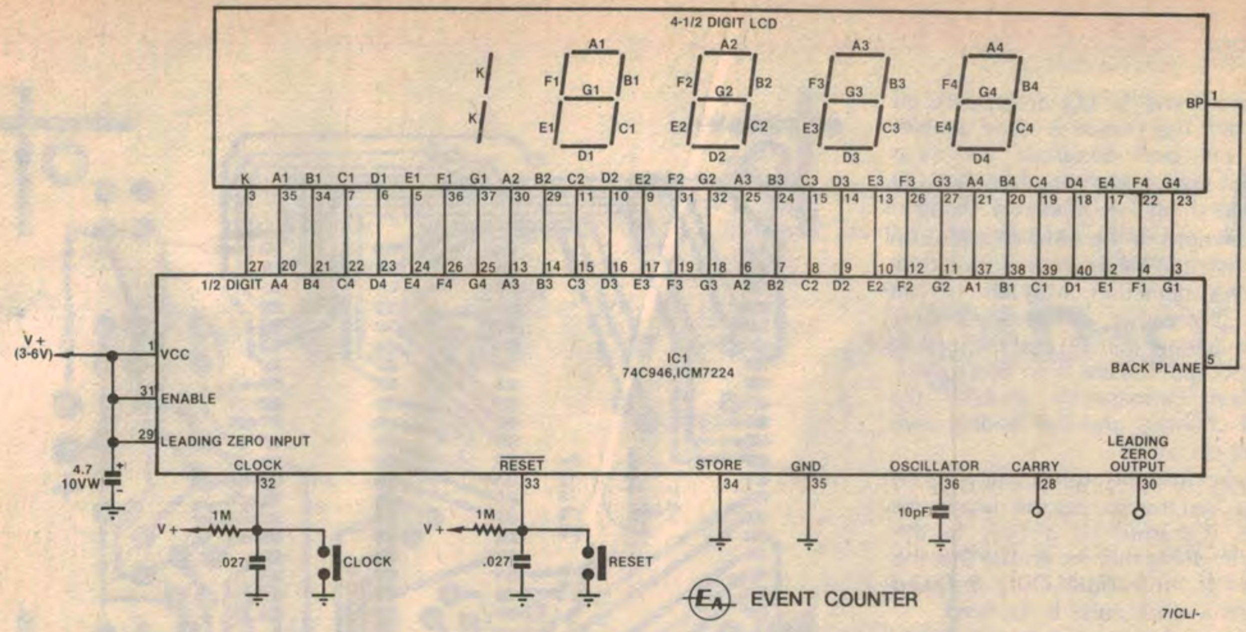
On board the add-on module will be an input preamplifier and prescaler stage, a timebase, and housekeeping circuitry to provide the reset and latch enable signals required by the counter module. But enough of this for the time being – we'll give you all the details next month.

Design features

Apart from the LCD, our new Event Counter uses just one IC and a few minor components. The parts are all contained on a small printed circuit board (PCB) that can be easily assembled into a plastic zippy case. Power is derived from four 1.5V penlite cells which provide a 6V supply, thus making the unit completely portable.

One very worthwhile feature of the display is leading zero blanking. In addition to providing a more attractive display, this also means that the display is completely blanked whenever the reset button is pressed. No on/off switch has been provided – with a power consumption of just 20μA, the circuit doesn't need one!

As can be seen from the photograph, we mounted the clock and reset switches directly on the PCB. However, the switches can be mounted remotely if



The circuit uses a single 4½ digit counter IC to direct-drive a liquid crystal display.

this is more convenient, or you can replace the switches with any of the trigger inputs described above. The main thing to watch out for here is that voltages from the external trigger source do not exceed the +6V supply rail.

How it works

It's a long time since we've published a circuit simpler than this one. Most of the work is performed by integrated circuit IC1, a 74C946 device made by National Semiconductor. Intersil make a pin compatible device designated the ICM7224, but the National Semiconductor device is slightly cheaper. Each will do the job equally as well.

A word of warning: do not use the Intersil ICM7224A chip. This device is a seconds/minutes/hour counter with a maximum count of 15,959. It is NOT equivalent to the ICM7224.

National Semiconductor describe the 74C946 as a "4½-Digit Counter/Decoder/Driver for Liquid Crystal Displays". This 40-pin LSI device has a four-decade counter plus all the circuitry necessary to direct-drive the LCD. This circuitry includes BCD to 7-segment decoders, output latches, segment drivers, count inhibit, and a backplane oscillator.

In addition, the chip contains circuitry for leading zero blanking, and a D-type flip-flop and latch to drive the half-digit segments on the LCD. A Schmitt trigger is provided on the clock input to allow operation in noisy environments or with slowly changing input signals.

Although the 74C946 and ICM7224 devices are pin compatible, there is a wide discrepancy in the maximum clock frequency specified for each device. National Semiconductor specify the maximum clock frequency for the 74C946 as typically 2MHz, while Intersil guarantee the ICM7224 to 15MHz with typical operation to 25MHz. This discrepancy is of no consequence in this project, however. Nor is it of any consequence in the DFM to be described next month, since the prescaler circuitry divides the input frequency by 100 and the display overranges at 2MHz.

A feature of LCDs is that their response time is too slow to permit multiplexing. As a result, each segment of the display must be driven separately and, for a 4½-digit display, this means 29 segment connections plus the backplane signal connection. The 74C946 thus has 29 segment driver outputs and these are labelled A1 – G1 for the least significant digit through to A4 – G4 for the digit-4 segments. Pin 27 drives the two ½-digit segments.

So why are the segment connections

Pin connections for the 74C946

Backplane In/Out – When the oscillator pin is grounded this pin is an input allowing an external device to generate the backplane waveform. When the oscillator pin is left open this pin is an output supplying backplane drive for an LCD.

Oscillator – The oscillator frequency may be lowered by tying a capacitor between this pin and ground. If this pin is grounded the backplane pin becomes an input.

Store Input – This controls the latches. When low, the latches are in flow-through mode (latch outputs follow counter), but when taken high data on counter outputs is stored in latches and displayed.

Reset Input – When low, counters are reset to zero.

Clock Input – Advances counter on negative edge.

Enable Input – When low, halts counter operation.

Leading Zero Input (LZI) – When high, enables leading zero blanking.

Leading Zero Output (LZO) – This signal goes high when counter equals zero and LZI is high.

Carry Output – Goes high for one clock period when count of 9999 is reached.

A1-G1 – Digit 1 segment outputs.
A2-G2 – Digit 2 segment outputs.
A3-G3 – Digit 3 segment outputs.
A4-G4 – Digit 4 segment outputs.

½-Digit Output – Goes high when count goes from 9999 to 0000 and stays high until Reset goes low.

We estimate that the current cost of components for this project is approximately

$32

This includes sales tax.

between IC1 and the LCD transposed on the circuit? The reason is quite simple: the IC pin outs designate the most significant digit as digit-1, while the LCD designates them the other way round.

The functions of the remaining pins on IC1 are listed in Table 1 which should be read in conjunction with the circuit diagram. Note that, in this application, the enable input (pin 31) and the leading zero input (pin 29) are both tied to Vcc. This step permanently enables the internal counters and the leading zero blanking circuitry.

Note also that the store input (pin 34) has been tied low so that the data in the counters is transferred directly to the latches. By doing this, we ensure that the display is immediately updated whenever a clock pulse is received.

Operation of the circuit is as follows: normally, the clock and reset inputs (pins 32 and 33) are held high by 1MΩ pull-up resistors. The counter is incremented by one each time a negative going signal appears on the clock input (ie, pin 32 pulled low) and the total count displayed for as long as the reset input remains high. Pressing the reset switch pulls pin 33 low, resetting the counter to zero and blanking the display.

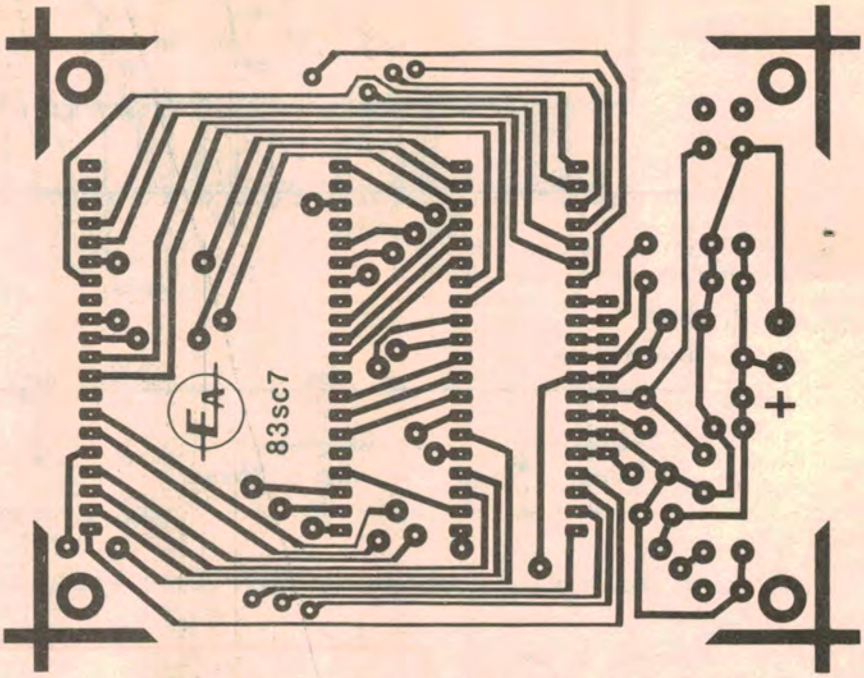
The two .027µF capacitors in parallel with the clock and reset switches provide switch debouncing. In addition, a 4.7µF capacitor has been connected to Vcc to provide supply decoupling.

The backplane signal is derived from an on-chip RC oscillator. This oscillator normally free runs at approximately 16kHz and is divided by 128 to provide a 125Hz output at pin 5. In this circuit, however, the backplane signal has been reduced to around 40Hz by connecting a 10pF capacitor to the oscillator terminal, pin 36.

Incidentally, the backlane and segment drive signals are 180° out of phase and have matched rise and fall times. This is done to eliminate any DC component in the driving waveforms which would otherwise degrade display life.

Before leaving the circuit description, it's worth noting that the 74C946 includes a carry output (pin 28) so that the device can be easily cascaded in 4-digit blocks. This pin goes high for one clock period when a count of 9999 is reached and then goes low for the next count. Also provided is a leading zero output (pin 30) which allows correct leading zero blanking when two or more devices are cascaded.

Finally, the backplane driver can be disabled by grounding the oscillator pin, thus allowing the device to be slaved to a master backplane signal. While this master backplane would typically be provided from one of the cascaded



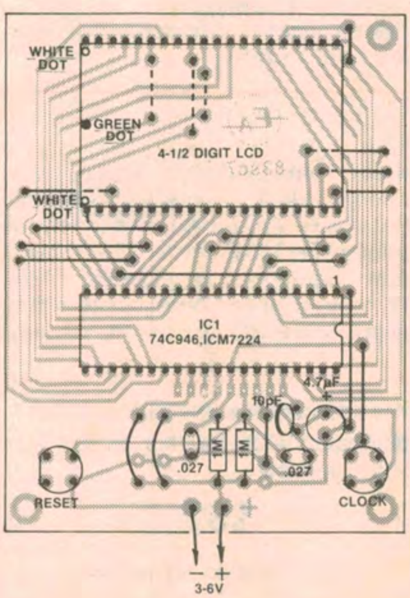
Above is an actual size reproduction of the PCB artwork.

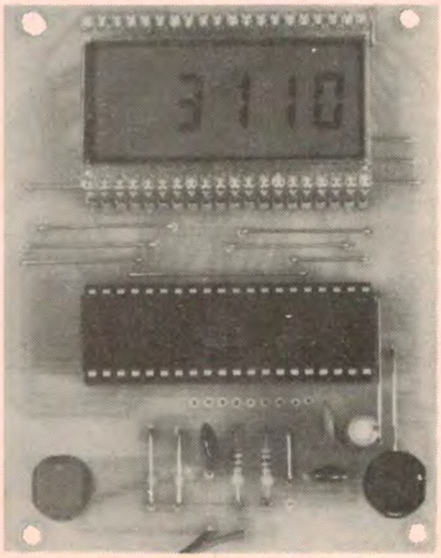
PARTS LIST

- 1 printed circuit board, code 83sc7, 78 x 102mm
- 2 momentary contact pushbutton switches (click action type)
- 1 battery clip
- 1 4-way AA battery holder
- 4 1.5V size AA batteries
- 1 40-pin DIL IC socket
- 1 48-pin Molex IC socket strip
- 1 4½-digit liquid crystal display (Dick Smith Catalog No. Z-4175 or equivalent)
- 1 74C946 or ICM7224 4½-digit counter/display driver
- 1 4.7µF/10VW electrolytic capacitor
- 2 .027µF metallised polyester capacitors (greencap)
- 1 10pF ceramic capacitor
- 2 1MΩ resistors (¼W, 5%)

MISCELLANEOUS

Tinned copper wire, solder, case to suit (optional), machine screws and nuts, etc.





Compare this photograph with the parts layout diagram at left.

devices, an external source should be used if more than four devices are to be cascaded.

Construction

Construction is straightforward with all parts mounted on a small PCB coded 83sc8 and measuring 78 x 102mm. Install the wire links first, followed by the resistors and capacitors. There are 20 wire links in all, several of which mount underneath the display. These latter are shown dotted on the parts overlay diagram.

The IC is mounted using a 40-pin DIL socket, while two 20-pin Molex IC socket strips are used to mount the LCD. Solder each socket strip to the PCB, then snap off the two carrier strips so that each pin connector is separated from its neighbour. This done, the LCD can be carefully installed on the board.

The LCD used in the prototype is a 4½-digit type sold by Dick Smith Electronics (catalog No. Z-4175). Other parts retailers will doubtless have a pin-compatible device available by the time this article appears in print.

It is important that both the LCD and IC be correctly oriented. Pins 1 and 40 of the LCD are identified by small white dots, and these go towards the left. Our sample display also had a green dot between pins 1 and 40 on one end of the glass envelope (see parts overlay diagram). Different devices from different manufacturers may use variations on the above theme, however.

Pin 1 of the IC is identified by a small notch at one end of the device. This mounts towards the right. Note that the IC is a CMOS device and can be easily damaged by static electricity. Do not remove it from its protective foam package until you are ready to install it, and then avoid touching the pins.

The clock and reset switches are both good quality momentary contact types that feature a positive click action. Do not use cheap pushbutton switches here, otherwise you could experience switch bounce problems. We elected to mount the switches on Molex IC pins to keep them on the same plane as the surface of the LCD.

Connect up the battery clip, give the circuit a final check over, and apply power. The display should now increment by one each time the clock switch is pressed and reset to zero (ie, display blank) when the reset switch is pressed.

We're sure that you will discover many potential applications for your Event Counter. Watch out for our article next month describing construction of the 2MHz DFM.