Counting with Class

— build this 500-MHz LSI frequency counter

After deciding that I could no longer do without a frequency counter, I began to look through my back issues of *73* for ideas. It seems that the accepted way to build a counter is by stacking together as many counter-latch-display driver sets as you want digits. Looking at the ads for today's commercially-built counters, it's obvious from size alone that this approach has become outdated. The way to go is LSI (large-scale integration).

The choice of ICs that are available is very broad. There are quite a few companies putting a lot of great circuits on LSI. After reviewing many data sheets, I decided that LSI Computer Systems LS7031 had everything I wanted. It's billed as a "6-decade MOS up counter with 8-decade latch and multiplexer."

What this means in an 8-digit counter is that it replaces six of the eight decade counters, all eight latches, and requires only one external decoder driver for the display. This is a savings of 21 standard TTL ICs. Other considerations which made it ideal were: TTL compatible I/O, single 5-V supply operation, and external decade-counter inputs for the first two digits. Due to the provision for external TTL decade counters, 1-Hz resolution can be obtained since it is not limited by the relatively slow MOS circuitry. The pinout given in the data sheet is included.

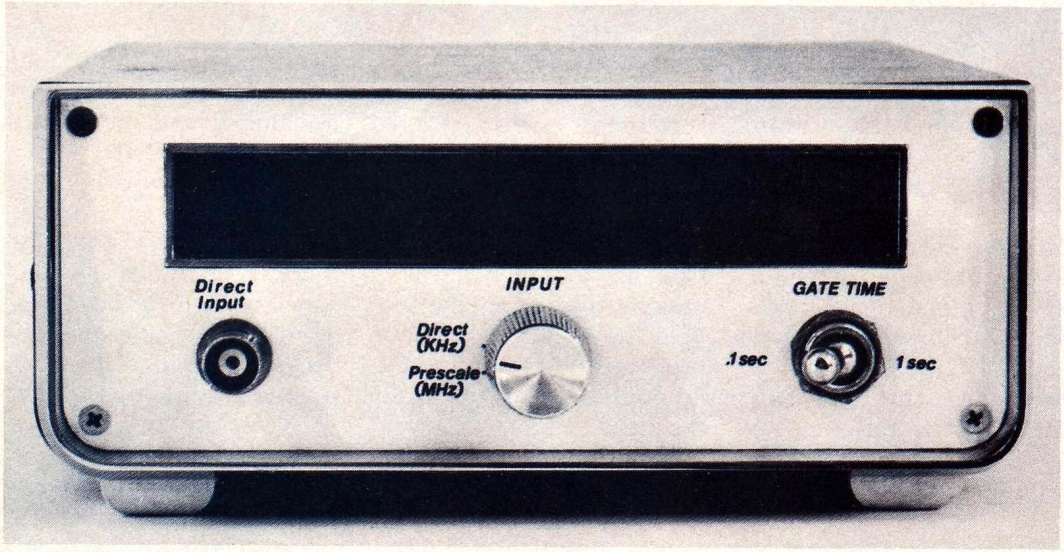

Photo A. Front panel.

Operation

An 8-digit counter which I designed around the

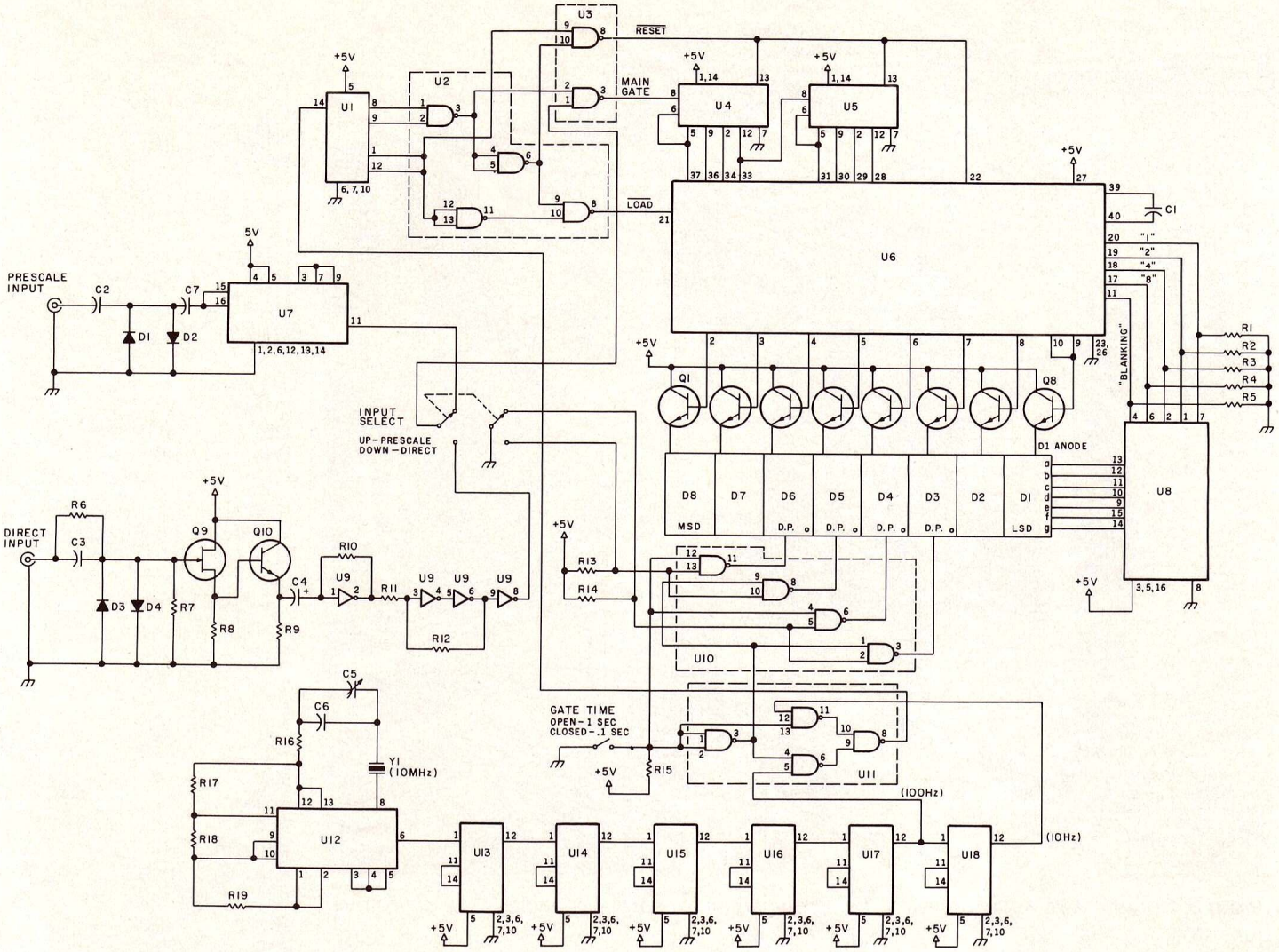

Fig. 1. Schematic. For U2, U3, U9, U10, U11, and U12, Vcc = pin 14 and ground = pin 7. Note: Two gates in U3 and two inverters in U9 are not used; ground all unused inputs.

LS7031 is described below. It has 1-Hz resolution on direct or 10-Hz resolution on prescale using 1-second gate time, or 10-Hz resolution on direct and 100-Hz resolution on prescale using .1-second gating. The direct input is good to at least 50 MHz, and the prescaled input should exceed 500 MHz. The counter has leading 0 blanking, and, if turned on with no input signal, will just display a 0 at the least significant digit position along with the decimal point to remind you what range you are on. In the direct mode, the decimal point is placed to read in kHz; in the prescale mode, the display is in MHz.

Circuitry

As can be seen in the block diagram, the LS7031 greatly simplifies the circuitry. The prescaler is an 11C90 ECL IC which divides the input signal by 10 and outputs in TTL. The direct input preamp was taken from "The Latest in Counters" by WA1UFE, in the December, 1976, issue of *73*.

The input-select switch chooses the source. This signal is gated by U3 during the 0 to 9 counts of U1. At count 10, the Load input to U6 goes low, latching in each digit's value and displaying it, and at count 11, the Reset line goes low, resetting to 0 all the counters, both internal and external. Then it begins to tabulate a new value during the

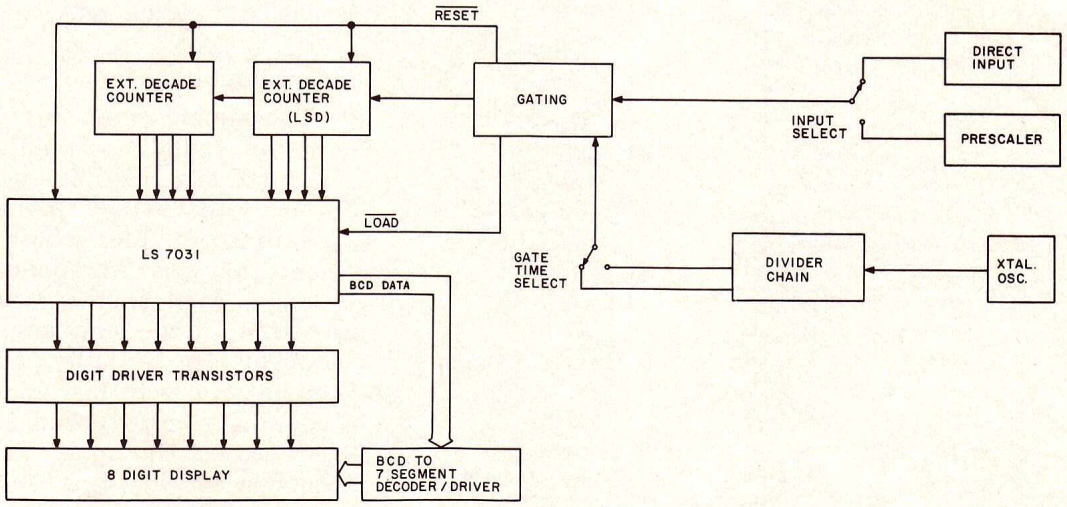

Fig. 2. Block diagram of LSI-based counter.

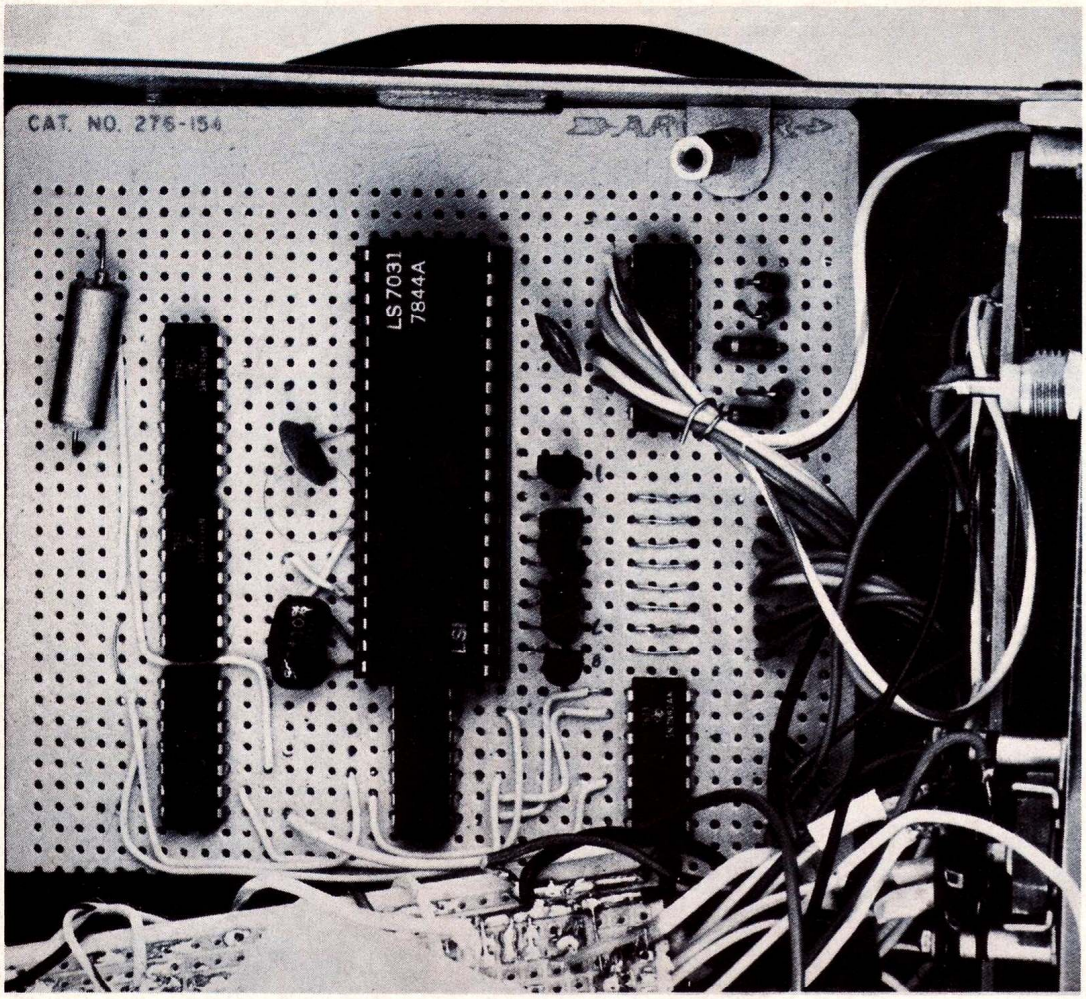

Photo B. Count/gate/display board, showing placement of parts—especially the digit-driver transistors.

0 to 9 count of U1, but the display keeps the old value until a new one is available, making a nice, steady display.

The crystal oscillator and divider chain provide 100 Hz or 10 Hz to U1 for .1- or 1-second gating, respectively. U10 places the decimal point in the proper place depending upon the gate time and input chosen. All of the cathodes for each segment should be wired together from display to display, except for the decimal point cathodes which go to U10 for D3 through D6. U8 takes the BCD data from U6 and drives these segment buses. C1 on U6 provides the display multiplexing rate.

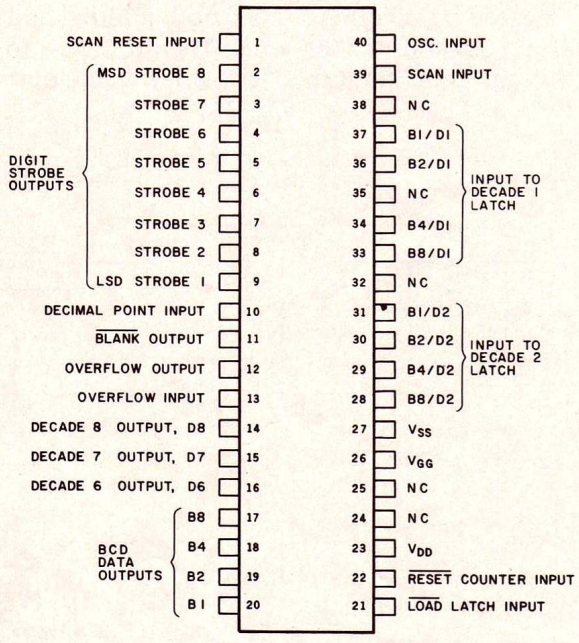

Fig. 3. Top view, pinout for LS7031.

Construction

I assembled the counter on two Radio Shack multipurpose edge card boards. One board was used for the oscillator-divider chain, prescaler, and direct input preamp, and another was used for all the other components. For the latter, the board style with two voltage source buses etched on it was used. This made connection to U6 easier and provided a neat layout for the display driver transistors, where the bases went to the U6 lands, the collectors soldered directly to the 5-V bus, and the emitters spanned across to their own land for easy connection of wires to the display.

Parts List

ICs	
U1	7492
U2	7400
U3	74LS00
U4,U5	74196
U6	LS7031
U7	11C90
U8	7447
U9	74LS04
U10,U11	7400
U12	74LS00
U13-U18	7490
LM309K	
Transistors	
Q1-Q8	2N3704
Q9	MPF102
Q10	2N708
Diodes	
D1-D4	1N914
D5-D8	1N4001
Resistors (all ¼ Watt)	
R1-R4	1k
R5	560
R6	100k
R7	1 meg
R8	4.7k
R9	220
R10	560
R11	470
R12	15k
R13-R15	1k
R16	220
R17	1.8k
R18	220
R19	560
Capacitors	
C1	500 pF
C2, C7	.01 uF
C3	68 pF SM
C4	47 uF, 10 V
C5	20 pF trimmer cap
C6	15 pF
Pwr. Sup.	2500 uF, 15 V
	1 uF, 6 V tantalum
Displays	
D1-D8	FND-507 or any other common-anode display

Misc.
Y1—10-MHz crystal
Gate time switch, SPST
Input select switch, DPDT
On/Off switch, SPST
BNC or SO-239 connectors for inputs
40-pin DIP socket

A 40-pin socket must be used for the LS7031, and be careful not to touch the pins when you insert the chip, as MOS is static-sensitive.

If you use FND-507 ½" displays, there's an excellent mounting technique I thought of which you may wish to use. Since these displays have their pins in a horizontal DIP configuration, they can be mounted as if they were ICs. Both CSC and Radio Shack offer an experimenter's PC board which is etched to match a protoboard-type breadboard socket. It just so happens that eight FND-507s fit perfectly on one of these boards.

Before installing them, use bare wires as jumpers on the component side of the board, and wire together all the segments (all "a" segments together, all "b", etc.). There are ten holes in each column; subtracting two for the display, that leaves room for the seven horizontal bus lines to be run on the component side. Two of these will be under the display, so wire them first. Now solder on the displays, and you have an instant display multiplexing board. One final construction note: Make sure that you use a 560-Ohm resistor for R5.

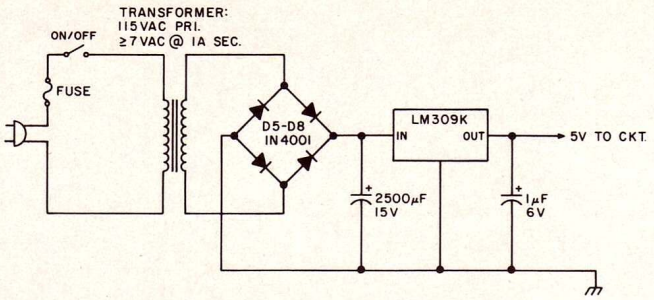

Fig. 4. Power supply for frequency counter.

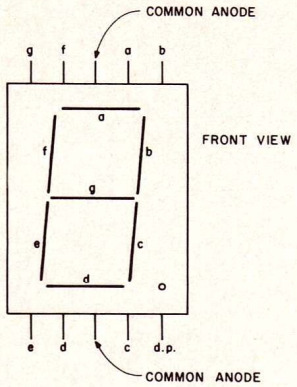

Fig. 5. Pinout for FND-507 or -510 common-anode display.

Parts

All of the parts except the 11C90 prescaler and the LS7031 are extremely common and inexpensive. The LS7031 can be bought from the manufacturer: LSI Computer Systems, Inc., 1235 Walt Whitman Road, Melville NY 11746. The 11C90 can be ordered from a number of *73* advertisers.

Conclusion

I used an old cabinet from a Lafayette low-band police monitor and even used the SO-239 connector on the back and some of the switches. The opening for the dial accommodated the display perfectly.

This is a good project to customize with, as no placement or other problems are important. I happened across a crystal oven for mine, but accuracy without it is completely acceptable (depending, of course, on the crystal used). It's fun to use LSI, and the fewer parts, the less room for error. ■