The assignment was plain enough. Get Radio-Electronics readers a versatile decimal counting module. Give them a basic block that counts from zero through 9 and indicates it. Make it resettable and cascadable, so any number of units can be placed side by side to obtain any desired accuracy.

Now readers would have the modular heart with which they could build their own electronic counters, digital voltmeters, frequency counters, electronic stopwatches, photographic shutter testers, electronic piano tuners, ballistic velocity meters, adding machines, computers. dragstrip speed measurers ... and heaven knows what else. Besides, there might be quite a bit to be gained simply by studying such a module, as its operating and service principles would be identical with much of the digital industrial electronic equipment in use today.

The trouble began when we started pinning down the specs on such a unit. It had to be small—not over 1" x 2" x 4", and a one-piece unit. It had to be near foolproof. It had to use integrated circuits—no neon bulbs, diodes, capacitors or critical pulse circuits allowed. It should be snappy, running anywhere from pushbutton speeds on up to 10 MHz. Less than 0.5 W per module of supply power would be nice. And, of course, it must be legible and easy to read, and must read out in plain numbers. Finally, if anyone was going to build one, it would have to cost less than $10 per decade—experimenter's single-quantity cost.

$10 per decade?

This was the stickler. Off to the catalogs. Let's see—Nixie tubes $8 each ... DTL integrated decade counters $10 each ... decoders $16 each. ... The IC boys are coming along just fine, but that's almost $35 per decade, and we're not through yet. No wonder the cheapest digital instruments start at $300 and work their way up—and up. ($600 is par for a good electronic frequency

---

**Build a $10 Experimenter's IC Decimal Readout Module**

By RALPH GENTER

---

The PC module is small (1" x 2" x 4") and mounts all readout components: decade counter, decoder/driver, and modified panel meter.
meter. But hang on—we’re going to show you the same thing for around $60! No, Nixies are out. So is DTL. Even the old Decatron counters top out above $20, and they can’t touch the speed we need. Besides, that bounding orange dot is hard to follow and harder yet to read. So we start from scratch and find a "new" way.

This is easy enough. Let’s draw the problem out in Fig. 1. We need three parts: an electronic decade or base-10 counter, a decoder and a readout. The counter has to work like a 10-position resettable stepper, only at a speed anywhere from dc to 10 MHz. Each individual input pulse has to advance the counter one, and only one, count. When the count gets up to 9, the next input pulse has to reset the counter to zero, and produce a carry pulse to hit the next decade over. We also have to be able to reset the counter to the zero state anytime we like. This gets our instrument reading 0000 at the start.

We obviously have to have a readout. This is something that brightly and unambiguously indicates the state the counter is in. We suspect that a binary counter that is tricked into thinking it is a decimal counter is a good route to follow. Somehow, we must decode the counter to find out what state it is really in. The decoded output is an electrical signal that lights up or moves the readout to indicate the proper count. So that’s it—we’ll need a counter, a decoder and a readout.

**The readout**

We already voted against Nixie tubes for their price. Ten light bulbs would be nice, but that’s at least $4 worth of driver transistors and $2 worth of lamps, jewels and panel work. This leaves little for the counter and nothing for the decoding.

How about a meter? For years, Hewlett Packard used ordinary milliammeters to indicate the least significant states on several of their larger industrial counters. The meters had special scales and the current through the meter was arranged so that the pointer could be only in one of 10 positions—but they were 3", $12 meters.

So, let’s update this proved technique. Back to the catalog—Emico's Model 13 horizontal panel meters. All plastic, 3/4" wide and less than $3 each, if we do not pick the most sensitive ones. Let’s take a 0–10 dc milliammeter and a special vertical 0–9 scale put on it with boxes for each number—no scale markings. Overlap the boxes to gain legibility. Now, put a bright pointer on the whole thing. We have a readout for $2 or so that’s as good as any vertical in-line readout going. And, yes, you can get them yourselves in single quantities—see the parts list.

Now, all we have to do is provide 10 discrete currents for the meter to indicate. These currents have to be pretty close—well under 5% if there is to be no question which number the meter is pointing to. We could start with 10 transistor switches, 10 resistors and a regulated power supply, perhaps as in Fig. 2. We’ll use an 18-volt supply, high enough that the saturated transistor drops and the drop across the meter will not bother us. Now, we make each resistor provide a suitable current, say 1.1 mA, 2.2 mA, 3.3 mA, and so on.

To go one step better, we provide a little more current for each step than we really need and shunt some of the extra current around the meter with a calibration pot that sets number and pointer positions exactly aligned.

Base current to any transistor provides the proper signal to allow the meter to indicate which transistor is receiving current, and our readout is complete. Of course, transistor Q, really isn’t doing anything, so we can leave it out entirely.

How about some of the other transistors? Can we...
Clever Kleps 30

Push the plunger. A spring-steel forked tongue spreads out. Like this. Hang it onto a wire or terminal, let go the plunger, and Kleps 30 holds tight. Bend it, pull it, let it carry dc, sine waves, pulses to 5,000 volts peak. Not a chance of a short. The other end takes it onto a test lead. Slip on a bit of shield braid to make a shielded probe. What more could you want in a test probe?

Available through your local distributor, or write to:
RYE INDUSTRIES INC.
130 Spencer Place, Mamaroneck, N.Y. 10543
Circle 23 on reader's service card

FREE
GIANT 1969
RADIO-TV ELECTRONICS CATALOG
228 GIANT VALUE-PACKED PAGES

YOUR BUYING GUIDE FOR TV, Radios, Recorders, Phonos, Amateur and CB equipment, electronic parts, tubes and test equipment, plus featuring BA's famous bargain packed section!

WRITE FOR YOUR FREE CATALOG TODAY!
BURSTEIN-APPLEBEE CO., DEPT. REW
3109 MERCIER ST., KANSAS CITY, MO. 64111

Name______________________________
Address____________________________
City______________________________
State______________________________
Zip Code____________________________

Circle 24 on reader's service card.
Fig. 5—Waveforms needed on driver bases for correct count.

take out the meter and decoder/driver circuitry. Take out one more dollar for a circuit board, and that leaves $4.80 for a 1-2-2'-4' coded decimal counter. This is easy—we use RTL microcircuits. Two dual flip-flops and a dual gate, and we're home free. Now, all we have to do is figure out how to hook up the counter.

Suppose we take four JK flip-flops and connect them as shown in Fig. 6. This gives us a four-stage binary divider that takes two dual IC's to count to 16. The trick is to somehow convince this type of circuit that it is really a base-10 counter and make it forget the other six states it once knew. We might first note that this connection

Fig. 6—Four JK flip-flops form a binary divider for a 16 counter.

Fig. 7—Connection provides 1-2-2'-4 circuit, but only 8 count.

Fig. 8—Hookup inhibits 2' circuit and corrects 2 and 2' count.

Fig. 9—AND gate inhibits 2 counter for all counts but zero.

ARE YOU A WINNER?

DEALER APPRECIATION CERTIFICATE

Serial Number:

Receiving Tubes You Can Trust
This certificate has no cash value, but the radio/television service dealer in possession of this certificate may be a winner in Raytheon's 1968 Dealer Appreciation Program which ends September 30, 1968.

YOU ARE

—If you have a Raytheon Dealer Appreciation Certificate bearing any one of these 104 numbers:

1680 10050 12390 15092 18079
2070 10053 12574 15145 18168
4637 10129 12780 15151 18200
8100 10134 12863 15245 18210
8181 10558 12919 15555 18247
8226 10791 12994 15610 18309
8237 10810 13075 15905 18377
8290 10845 13269 15935 19025
8319 10930 13370 16000 19229
8555 10997 13526 17005 19300
8600 11035 13704 17073 19327
8723 11091 14007 17199 19423
8939 11111 14019 17231 20292
8981 11215 14101 17329 30897
9009 11380 14123 17362 33261
9048 11577 14179 17440 33397
9333 11607 14749 17600 35785
9650 11776 14797 17619 36900
9899 11888 15000 17706 37877
9958 12009 15037 18007 38088

New! Ask your distributor about Raytheon's Stanley tools for box tops promotion!

Just take your prize-winning certificate to your Raytheon distributor. He'll make all arrangements to get your prize—whether a color TV set, golf clubs, savings bond, or one of many others—promptly to you.

Lucky you! You're always a winner with reliable Raytheon receiving tubes. Raytheon Company, Receiving Tube Operation, Fourth Avenue, Burlington, Massachusetts 01803.

Remember to ask "What else needs fixing?"
would be a 1-2-4-8 type of deal, so we might rearrange the flip-flops in a 1-2-2'-4 circuit like Fig. 7. Right now, this circuit can count only to 8 and the 2 and 2' flip-flops are apparently doing the exact same thing.

Now comes the black magic. By lifting some of the grounds on the inputs of the 2 and 2' flip-flops and by replacing these grounds with signals that change from count to count, we can inhibit the operation of these two flip-flops. Look at the timing diagram. We want to inhibit the 2' flip-flop only when the 2 flip-flop is up, so we add a wire jumper as shown in Fig. 8. That's half the problem. Next, we want to inhibit the 2' counter except for count 0.

We note that both the 2' and 4 flip-flops are up simultaneously on counts 8 and 9 and thus will still be up while awaiting the next count 0. We can add an AND gate to allow this signal to inhibit the 2 counter for every count except count 0. Now, we simply combine both circuits, and out comes our complete 1-2-2'-4 counter in Fig. 10.

You'll find the complete schematic in Fig. 11. IC1 and IC2 are the counter. As these IC's also have a preset

Fig. 11—Complete schematic of the counter module. IC1 and IC2 are the two dual JK flip-flops and IC3 is the AND gate. Collector resistors on Q1-Q5 determine weighted current to the meter. Count pulses must have full time less than 100 μsec.

![Complete Schematic of the Counter Module](image)

<table>
<thead>
<tr>
<th>PARTS LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1, IC2—MC790P dual JK flip-flop (Motorola)</td>
</tr>
<tr>
<td>IC3—LS194 dual two-input gate (Fairchild)</td>
</tr>
<tr>
<td>Q1, Q2, 3, Q4—MPS2923 or similar NPN silicon transistor (Motorola)</td>
</tr>
<tr>
<td>Note: Data sheets and distributor lists are available from the following respective sources: Motorola Semiconductor Box 9-5 Phoenix, Ariz. 85001 Fairchild Semiconductor 313 Fairchild Drive Mountain View, Calif. 94041</td>
</tr>
<tr>
<td>R1—10,000-ohm, 1/4-watt carbon resistor</td>
</tr>
<tr>
<td>R2, R3, R4—470-ohm, 1/4-watt carbon resistor</td>
</tr>
<tr>
<td>R5—9,100-ohm, 5%, 1/4-watt carbon resistor</td>
</tr>
</tbody>
</table>

R6, R7—4870-ohm, 1/4-watt, 1% resistor |
R8—2430-ohm, 1/4-watt, 1% resistor |
R9—potentiometer, 350 ohms, CTS No. U201-251 or similar |
M1—0-10 dc vertical milliammeter |
Circuit board—1/16" x 1/16" single-sided PC board |
MISC: PC terminals (6); wire jumpers (3); No. 6 spade bolts and No. 6 nuts (2); solder |
*Note: The following are available from Southwest Technical Products Inc., 217 West Rhapsody, San Antonio, Tex. 78216. Etched and drilled PC-1 $1.00; meter M1 with special scale $2.25; complete kit of all parts $10.00; postpaid in US. |
input, we bring out a common lead that gives you the reset terminal that automatically resets the counter to 0. IC3 is the AND gate. Transistors Q1 through Q4 drive the meter through weighted precision resistors R5 through R8. R1 had to be a bit bigger than the other base-driving resistors to eliminate a loading problem on IC1.

Two power supplies are required, a regulated 18 volts at 10 mA and a ripple-free +3.6 volts at 100 mA for the IC's. Your count signal should normally be positive, say from +1.5 to +4 volts, and abruptly drop to zero whenever a count is desired. This signal MUST come down only once per count and MUST come down faster than 100-nsec fall time. If you want to count anything but good square waves, you'll have to "process" your input signals in some simple circuitry we'll talk about later. You'll also find that pushbuttons and mechanical contacts will have to be made bounceless. Once again, this is easily accomplished in a simple circuit.

The carry output of any decimal counting module will directly drive the count input of the next module down the line, and you simply cascade as many counting units together as you wish. Four is typical, and allows measurement from 0.1% to 0.01% accuracy.

The reset input is normally left grounded. To reset the counter, simply apply +1.5 to +4 volts of dc to this input.

The integrated circuits used are guaranteed to operate at an 8-MHz rate, but all the modules we have tested go well beyond 10 MHz. You'll find the meter movement's inertia automatically-blanks any high-speed counting, eliminating the need for the strobe or storage circuitry often used in fancier industrial designs.

Construction

Your decimal counting module can be built onto a 1½" square printed-circuit board that mounts directly on the meter terminals. You can buy this circuit board ready to go, but if you prefer, you can lay out, drill and etch your own circuit card, simply by following the layout guide in Fig. 12. Three wire jumpers are needed as shown. The

(continued on page 94)
Why is a Vectorscope essential for Color TV servicing?

1. Check and align demodulators to any angle ... 90°, 105°, 115° ... accurately and quickly. No guesswork. New color sets no longer demodulate at 90°. Only with a Vectorscope can these odd angles be determined for those hard-to-get skin tones.

2. Check and align bandpass-amplifier circuits. Eliminate weak color and smeared color with proper alignment. No other equipment required. Only a V7 Vectorscope does this.

3. Pinpoint troubles to a specific color circuit. Each stage in a TV set contributes a definite characteristic to the vector pattern. An improper vector pattern localizes the trouble to the particular circuit affecting either vector amplitude, vector angle or vector shape. Only a V7 Vectorscope does this.

LECTROTECH V7
color vectorscope/generator

EXCLUSIVE FEATURES:
Color Vectorscope: Until now, available only in $1500 testers designed for broadcast use. Accurately measures color demodulation to check R,Y and B,Y, for color phase and amplitude. A must for total color and those hard-to-get skin tones. Self-Calibrating. Adjust timing circuit without external test equipment. Dial-A-Line. Adjust horizontal line to any width from 1-4 lines. Solid State Reliability in timer and signal circuits. Plus: All Crosshatch, Dots, Vertical only, Horizontal only and Keyed Rainbow Patterns. RF at channels 3, 4 or 5. Video Output (Pos. and Neg. adjustable) for signal injection trouble-shooting. Red-Blue-Green Gun Killer. All transistor and timer circuits are voltage-regulated to operate under wide line voltage ranges. Lightweight, compact—only 8¼ x 7½ x 12½". NET 189.50

ONE YEAR WARRANTY

V6-B New, improved complete color bar generator with all the features of the V7 except the Vectorscope. Only 99.50

For the full story, see your distributor or write for literature. Dept. RE-11

LECTROTECH, INC.
1221 W. Devon Ave., Chicago, Ill. 60626
Circle 127 on reader's service card

BUILD A $10 READOUT MODULE
(continued from page 69)

Fig. 13—Component placement and input connections.

Component layout is in Fig. 13. IC1 and IC2 go in with their code notch in the direction shown, while the flat side identifies IC3. Two No. 6 spade bolts secure the circuit card to the meter, giving you a rugged, one-piece assembly.

Testing
You can test your unit with two D-cells and a 22½V battery, connected as in Fig. 14. Build up the bounceless pushbutton circuit shown for the input. To calibrate the unit (temporarily, of course, since you'll later be switching to a regulated meter supply), reset the counter and run the count up to 9. Now adjust R9 to set the pointer precisely to 9. Your counter is complete, and you should be all set to build any of a number of digital instruments at a tiny fraction of their normal cost.

Fig. 14—Test setup for the module uses battery supply for 22.5V and 3.6V. Input (temporary) uses pushbutton circuit.