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# ham radio

magazine

JANUARY 1973

NETWORKS for TRANSMITTER MATCHING

## *this month*

- digital readout vfo 14
- fm repeater decoder 24
- phase-locked loop 40
- antenna tuning units 58

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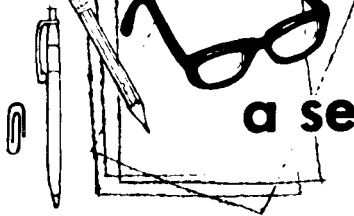
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## a second look

by Jim  
fisk

This is the time of the year when many high-school seniors are scurrying around, planning their future education, sending applications off to the college of their choice and taking entrance exams. Seniors who are also radio amateurs are probably considering a career in electronics. If they're lucky, they will have a knowledgeable guidance counselor who can steer them in the right direction; if not, they'll probably pick a school with a big name and work from there. Sometimes this works out and sometimes it doesn't — it depends entirely on what the student is looking for.

Electrical engineers who graduated before 1960 would probably not recognize the engineering curriculum now offered by their old alma mater because, during the past 15 years or so, engineering education has changed significantly. During this period (referred to by some as the post-Sputnik period), classical engineering education has tended to become less applied and more and more theoretically oriented. The backgrounds of some electrical engineering teaching staffs have changed from being primarily applied electronics to applied mathematics, and attempts to develop practical engineering programs have not been very successful.

In recent years the prestige of an engineering school has generally been gauged by the theoretical emphasis of its courses. Each school has tried to outdo the other in the theoretical sophistication of its curriculum. Unfortunately, the majority of the jobs in the sphere of electronics engineering do not require such an advanced mathematical sophistication as they do a "gut" understanding of electronics. If you talk to today's electrical engineering students, you will find that many of them do not know how to solve a simple steady-state ac problem, although they can invert a matrix and use state-variable techniques.

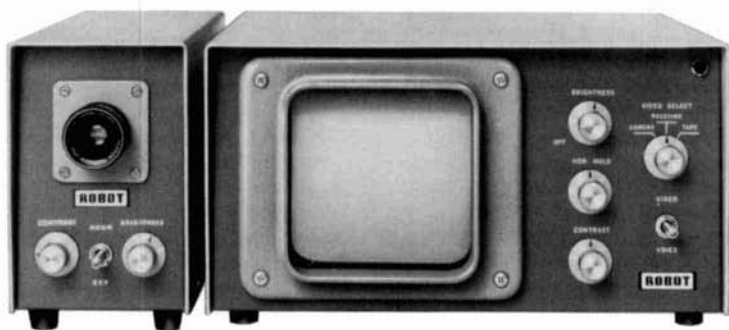
However, several colleges are now introducing four-year electronic technology programs in an attempt to get back to the old, practical engineering concept. The new Electronic Technology program at Trenton State College, for example, emphasizes electronics hardware and laboratory techniques as well as electrical theory. Unlike most engineering programs, at Trenton State the electrical courses begin in the first semester of the freshman year and continue right on through the senior year. And because of the applications orientation, graduates of two-year associate degree technician training programs can transfer into the B.S. program with little or no loss of credit.

The graduates of B.S. Technology programs have been pictured as fitting into the occupational spectrum somewhere between the technician and the engineer. However, many professors see technology graduates as having much wider employment opportunities. Actually, technology graduates should have many opportunities in areas of electrical applications and design traditionally occupied by engineering graduates, now vacated due to the change in emphasis of engineering education.

Students who are interested in this type of engineering education should be aware that there is a wide difference in B.S. programs offered under the title of "Technology." This condition is a result of the relative newness of the concept. Some programs are managerially oriented, others are applications and design oriented, while still others are little more than a two-year technician training program with added courses in the arts and humanities. Anyone desiring to enter this area should choose his school carefully to be sure he gets what he wants.

Jim Fisk, W1DTY  
editor

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# networks

## for transmitter matching

Complete data on  
building networks  
for matching the  
impedance of your exciter  
to the impedance  
of your  
power amplifier

Irvin M. Hoff, W6FFC, 12130 Foothill Lane, Los Altos Hills, California 94022

Most transmitters are designed for 50-ohm output loads and the use of 50-ohm coax cable has become quite standard on most antenna systems used by amateurs. As the typical transmitter these days has 100 to 175 watts output, it is often used as an exciter to drive a linear amplifier to higher output power. These units normally are cathode-driven and are characterized by an input impedance that falls in the region of 20 to 200 ohms. Although in many cases the exciter can drive such an amplifier directly with satisfactory results, the use of a properly-terminated matching network can be most beneficial in a variety of ways: It allows maximum energy transfer (most output), presents the best load to the exciter, minimizes harmonic radiation (tvi, etc.) and allows barefoot operation without retuning.

Perhaps other advantages will come to mind. Some exciters have only a 50-ohm output, and cannot be retuned for other impedances.

### input impedance

The input impedance of linear amplifiers is rarely the same from one band to another. Some amplifiers are not operated at zero-bias and actually drive the grid through a passive resistor. These systems, of course, usually present about the same impedance from one band to another, but are rarely 50 ohms to start with.

Formulas have been given to enable the calculation of the input impedance of a grounded-grid, cathode-driven amplifier. However, such formulas are all but worthless since they do not take the frequency into consideration. Measurements taken at the input of such amplifiers usually show a rather impressive variation from 10 to 80 ohms, indicating that a formula would be quite misleading. These variations are caused by the manner in which the rf is isolated from the filament transformer (and hence the house wiring). Two methods are used to accomplish this: filament chokes, such as bifilar-wound coils, or low-capacitance filament transformers.

The best uniformity is normally obtained with the low-capacitance filament transformer, but such a transformer is not always available, and in any event would need to be mounted within a few inches of the tube base. This is not always convenient, so filament chokes are more commonly used. These chokes range from commercially-available units to home-made — the latter usually being two number-12 double-enameled wires wound simultaneously around a round ferrite rod until 11 turns (you would count 22 with the two wires) are on the rod. With proper bypassing these chokes allow the 60-Hz filament current to pass, but do not allow the high-frequency rf signal into the filament transformer.

Factors which seem to contribute to variations in input impedance from band to band include the voltage on the final amplifier, the type of tube or tubes being used, the frequency involved and the type of rf chokes used.

## matching

I once had a Johnson Pacemaker 90-watt ssb transmitter. This unit could tune as high as 300 ohms on the output. I did not think any type of matching network to my linear was needed, but

one day, while operating on 10 meters, I got a bad rf burn on my mouth when I came too close to the microphone. This led to an investigation of the input impedance, and I found on that particular transmitter it was only 15 ohms on 28 MHz; the Pacemaker could not handle this low impedance at all. A simple

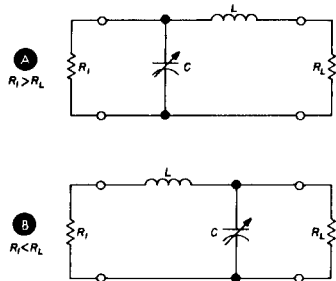


fig. 1. L-networks. The circuit in A is a step-down L-network; B shows a step-up L-network.

pi-network was used, and when incorporated for other bands, I found I not only had better output power, but could also then switch immediately from high power to barefoot, a distinct advantage over the previous system.

One company recommended that a particular length of coax should be used between the exciter and the amplifier. I personally always thought that this was a cop-out since it would be adequate (at best) on only one band!

Various articles have been written regarding the use of networks between the exciter and the linear, and this is now standard practice for most commercial units. These usually have input networks incorporated into the design, and are often adjustable if you wish to optimize them for your specific part of the band. They are usually switched automatically as you change the band selector.

Such networks are usually made up of pi-networks although a few use the more

simple L-network. The pi-network is usually preferred as greater control and uniformity are possible from band-to-band since the Q can be predetermined for consistent performance over a wider variety of impedances. The L-network is more simple, but at the same time it is somewhat more difficult to adjust for optimum swr.

## networks

L-networks have been covered adequately in other texts, including the

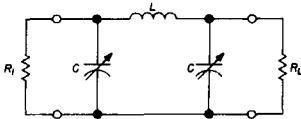


Fig. 2. A typical pi-network.  $R_i$  is the input load,  $R_L$  the output load.

ARRL Handbook, so only an example will be shown here (see fig. 1). Although this is a very simple circuit, it has several minor disadvantages.

For one thing, in the L-network Q cannot be controlled, and is usually very low. Also, if the network is used for all hf amateur bands, the capacitor often has to be switched from one end of the coil to the other. Further, the L-network has very little exciter loading due to the low Q and it offers very little harmonic suppression.

A typical pi-network is shown in fig. 2. It offers predictable performance as the Q may be preselected. It also offers additional harmonic suppression, presents a good load for exciter stability and can easily be used for all hf amateur bands.

## input impedance

The input impedance of the network may be determined by testing; use of formulas should be avoided because the calculations rarely approximate the observed results.

The easiest and quickest method of measuring input impedance would be to use a variable impedance bridge, such as

the long-since discontinued Heath AM-1. The ARRL Handbook also contains an excellent rf impedance bridge that may be easily built. These rf impedance bridges are basically a small swr bridge with a variable leg in the bridge so you can match the load impedance. Since an rf impedance bridge usually takes only a few milliwatts of power, they are easily driven from a grid-dip meter or ssb transmitter with the output cranked down.

Sufficient rf is introduced (with the load disconnected) to give either fullscale meter reading or nearly so. The load is then connected and the knob dialed for minimum meter reading. The impedance is then read directly from the calibrated dial. The high voltage must be running on the amplifier, and the meter hooked up close as possible to the place the network will be added.

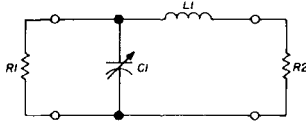
There are probably no typical impedances, but as a general rule I have found that most amplifiers I tested fell in to the neighborhood of 150 to 200 ohms on 80 meters, and around 15 to 30 ohms on 10 meters. The rest of the bands came somewhere in between. In many cases 20 meters offers a fairly decent match with no network at all.

If the input impedance is measured directly at the filament of the power tube it will be considerably less than 50 ohms on ten meters, and considerably more than 50 ohms on 80. The data shown below is for my own 4-1000A linear with

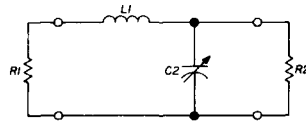
	impedance at tube base (ohms)	impedance at network (ohms)
80 meters	180	100
40 meters	155	60
20 meters	75	22
15 meters	50	40
10 meters	40	65

6000 volts on the plate. The amplifier uses a low-capacitance filament transformer. The first column of figures is the impedance measured right at the tube base; the second column shows the impedance at the end of a 6-foot piece of

**table 1. L-network component values. Data is for matching a 50-ohm transmitter to a cathode-driven amplifier. The Q is set by the ratio of the input and output impedances and is shown for approximately the middle of each amateur radiotelephone band. The Q at the top of the band would be slightly less, at the bottom of the band it would be slightly greater.**



R1	F	C1	L1	C2	R2	'Q'	R1	F	C1	L1	C2	R2	'Q'
OHMS	MHZ	PF	UH	PF	OHMS	QUAL.	OHMS	MHZ	PF	UH	PF	OHMS	QUAL.
50	1.9	4188	2.89	--	10	2.0	50	1.9	3420	5.13	--	30	0.8
50	5	2094	1.05	--	10	2.0	50	5.8	1710	2.56	--	30	0.8
50	7.2	1105	0.55	--	10	2.0	50	7.2	902	1.35	--	30	0.8
50	14.2	560	0.28	--	10	2.0	50	14.2	458	0.69	--	30	0.8
50	21.2	375	0.19	--	10	2.0	50	21.2	306	0.46	--	30	0.8
50	28.5	279	0.14	--	10	2.0	50	28.5	226	0.34	--	30	0.8
50	1.9	3420	3.42	--	20	1.2	50	1.9	4188	0.38	--	40	0.5
50	3.8	1710	1.71	--	20	1.2	50	3.8	2094	0.49	--	40	0.5
50	7.2	902	0.90	--	20	1.2	50	7.2	1105	2.21	--	40	0.5
50	14.2	458	0.46	--	20	1.2	50	14.2	560	1.12	--	40	0.5
50	21.2	306	0.31	--	20	1.2	50	21.2	375	0.75	--	40	0.5
50	28.5	228	0.23	--	20	1.2	50	28.5	279	0.56	--	40	0.5



50	1.9	--	11.24	3746	60	0.4	50	1.9	--	9.04	1129	160	1.5
50	3.8	--	5.62	1873	60	0.4	50	3.8	--	4.52	565	160	1.5
50	7.2	--	2.97	989	60	0.4	50	7.2	--	2.38	298	160	1.5
50	14.2	--	1.50	501	60	0.4	50	14.2	--	1.21	151	160	1.5
50	21.2	--	1.01	336	60	0.4	50	21.2	--	0.81	101	160	1.5
50	28.5	--	0.75	250	60	0.4	50	28.5	--	0.60	75	160	1.5
50	1.9	--	9.27	2649	70	0.6	50	1.9	--	9.19	1081	170	1.5
50	3.8	--	4.64	1324	70	0.6	50	3.8	--	4.68	541	170	1.5
50	7.2	--	2.45	699	70	0.6	50	7.2	--	2.43	285	170	1.5
50	14.2	--	1.24	354	70	0.6	50	14.2	--	1.23	145	170	1.5
50	21.2	--	0.83	237	70	0.6	50	21.2	--	0.82	97	170	1.5
50	28.5	--	0.62	177	70	0.6	50	28.5	--	0.61	72	170	1.5
50	1.9	--	8.65	2163	80	0.8	50	1.9	--	9.55	1059	180	1.6
50	3.8	--	4.33	1081	80	0.8	50	3.8	--	4.68	519	180	1.6
50	7.2	--	2.28	571	80	0.8	50	7.2	--	2.47	274	180	1.6
50	14.2	--	1.16	289	80	0.8	50	14.2	--	1.25	139	180	1.6
50	21.2	--	0.78	194	80	0.8	50	21.2	--	0.84	93	180	1.6
50	28.5	--	0.58	144	80	0.8	50	28.5	--	0.62	69	180	1.6
50	1.9	--	8.43	1873	90	0.9	50	1.9	--	9.51	1001	190	1.7
50	3.8	--	4.21	937	90	0.9	50	3.8	--	4.76	501	190	1.7
50	7.2	--	2.22	494	90	0.9	50	7.2	--	2.51	264	190	1.7
50	14.2	--	1.13	251	90	0.9	50	14.2	--	1.27	134	190	1.7
50	21.2	--	0.76	168	90	0.9	50	21.2	--	0.85	90	190	1.7
50	28.5	--	0.56	125	90	0.9	50	28.5	--	0.63	67	190	1.7
50	1.9	--	8.38	1675	100	1.0	50	1.9	--	9.67	967	200	1.7
50	3.8	--	4.19	838	100	1.0	50	3.8	--	4.84	484	200	1.7
50	7.2	--	2.21	442	100	1.0	50	7.2	--	2.55	255	200	1.7
50	14.2	--	1.12	224	100	1.0	50	14.2	--	1.29	129	200	1.7
50	21.2	--	0.75	150	100	1.0	50	21.2	--	0.87	87	200	1.7
50	28.5	--	0.56	112	100	1.0	50	28.5	--	0.64	64	200	1.7
50	1.9	--	8.41	1529	110	1.1	50	1.9	--	9.83	937	210	1.8
50	3.8	--	4.21	765	110	1.1	50	3.8	--	4.92	468	210	1.8
50	7.2	--	2.22	404	110	1.1	50	7.2	--	2.59	247	210	1.8
50	14.2	--	1.13	205	110	1.1	50	14.2	--	1.32	125	210	1.8
50	21.2	--	0.75	137	110	1.1	50	21.2	--	0.88	84	210	1.8
50	28.5	--	0.56	102	110	1.1	50	28.5	--	0.66	62	210	1.8
50	1.9	--	8.58	1416	120	1.2	50	1.9	--	9.99	909	220	1.8
50	3.8	--	4.25	708	120	1.2	50	3.8	--	5.00	454	220	1.8
50	7.2	--	2.24	374	120	1.2	50	7.2	--	2.64	240	220	1.8
50	14.2	--	1.14	189	120	1.2	50	14.2	--	1.34	122	220	1.8
50	21.2	--	0.76	127	120	1.2	50	21.2	--	0.90	81	220	1.8
50	28.5	--	0.57	94	120	1.2	50	28.5	--	0.67	61	220	1.8
50	1.9	--	8.61	1324	130	1.3	50	1.9	--	10.15	883	230	1.9
50	3.8	--	4.30	662	130	1.3	50	3.8	--	5.08	441	230	1.9
50	7.2	--	2.27	350	130	1.3	50	7.2	--	2.68	235	230	1.9
50	14.2	--	1.15	177	130	1.3	50	14.2	--	1.36	118	230	1.9
50	21.2	--	0.77	119	130	1.3	50	21.2	--	0.91	79	230	1.9
50	28.5	--	0.57	88	130	1.3	50	28.5	--	0.68	59	230	1.9
50	1.9	--	8.74	1249	140	1.3	50	1.9	--	10.31	859	240	1.9
50	3.8	--	4.37	624	140	1.3	50	3.8	--	5.16	430	240	1.9
50	7.2	--	2.31	330	140	1.3	50	7.2	--	2.72	227	240	1.9
50	14.2	--	1.17	167	140	1.3	50	14.2	--	1.38	115	240	1.9
50	21.2	--	0.78	112	140	1.3	50	21.2	--	0.92	77	240	1.9
50	28.5	--	0.58	83	140	1.3	50	28.5	--	0.69	57	240	1.9
50	1.9	--	8.88	1185	150	1.4	50	1.9	--	10.47	838	250	2.0
50	3.8	--	4.44	592	150	1.4	50	3.8	--	5.24	419	250	2.0
50	7.2	--	2.34	315	150	1.4	50	7.2	--	2.76	221	250	2.0
50	14.2	--	1.19	159	150	1.4	50	14.2	--	1.40	112	250	2.0
50	21.2	--	0.80	106	150	1.4	50	21.2	--	0.94	75	250	2.0
50	28.5	--	0.59	79	150	1.4	50	28.5	--	0.70	56	250	2.0



RG-58A/U where my matching network is placed.

You can instantly see the futility in trying to cut a piece of coax to just the right length to provide proper matching on a number of different bands. This table also illustrates how unpredictable it would be to try to use a formula to find the impedance!

In one rig I built, using a pair of 813s and a commercial FC-30 filament choke, the impedance varied widely, from 12 ohms on ten meters to over 200 ohms on 80 meters. Replacing the commercial filament choke with a homemade bifilar-wound unit gave results that varied much less, from about 30 ohms minimum on one band to 130 ohms on 80 meters. These figures are given only to illustrate the wide impedance variations possible from 3.5 through 29 MHz, and are unlikely to be typical of what you may experience with your own particular amplifier.

### wattmeter method

The majority of you will not have access to an rf impedance bridge. You can still match the exciter to the amplifier, but it will take longer. The name of the game is low swr between the two units, so a wattmeter makes a good trial-and-error method of initially tuning the network. Once the settings have been found, you can mark them on the box and paste on tabs or use the sheet of paper I use.

In this case you observe, from the computer charts, the approximate inductance and capacitance, and start out by setting the inductance somewhere near what you think would be appropriate. With about half-power on the transmitter, rotate the variable capacitors while observing the reflected power. If it does not go to zero, tap up or down on the inductor and try again (the tap on the coil should be temporary until properly selected). This same technique is used on each different band.

### using a swr bridge

This is the least desirable of the

various methods. It will usually work, but is the most time-consuming of all and can be misleading. If you think you have gotten it just right, switch to the exciter barefoot and see if the antenna presents approximately the same load, plate current, output power, etc. without returning the exciter. This will provide a check on your accuracy, and is, of course, the desired end result anyway — the ability to switch from antenna to amplifier with similar results.

### network placement

In commercial rf power amplifiers the matching network is usually quite near the tubes in the amplifier, and usually there is a separate network for each band. The appropriate network is switched in automatically with the band-selector knob.

It is not at all necessary to have the networks in the same cabinet with the rest of the transmitter. You may find it considerably more convenient to have it a few feet away from the amplifier where a simple network can be changed quickly whenever you bandswitch. This is the

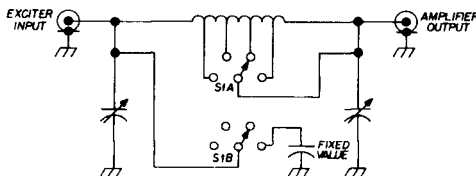
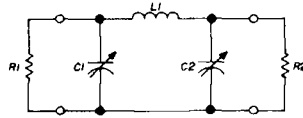


fig. 3 A typical pi-network for transmitter matching. The switch selects the proper tap for the various bands; the second switch section may be used to switch in parallel fixed values on the lower frequency bands.

arrangement I have used successfully for a number of years. I have a short piece of coax connecting the network minibox to the input of the amplifier. The length of the coax is in no way critical, but once the network is adjusted, of course, the coax length should then remain the same.

A piece of paper was temporarily placed on the front panel of the minibox, the correct settings for the various bands found and the paper marked. Then a

table 2. Pi-network component values. Data is for matching a 50-ohm transmitter to a cathode-driven amplifier. The Q has been chosen quite low to obtain broadband characteristics. The Q figure in the last column shows the worst-case condition at the bottom of the band using the inductance value shown.



R1	F	C1	L1	C2	R2	Q'	R1	F	C1	L1	C2	R2	Q'
OHMS	MHZ	PF	UH	PF	OHMS	QUAL.	OHMS	MHZ	PF	UH	PF	OHMS	QUAL.
50	1.8	4909	1.85	7612	10	3.6	50	1.8	1959	6.54	1488	130	3.3
50	3.5	2608	0.94	4153	10	3.8	50	3.5	1052	3.32	708	130	3.4
50	7.0	1179	0.49	1678	10	3.3	50	7.0	453	1.74	338	130	3.0
50	14.0	579	0.25	801	10	3.2	50	14.0	220	0.87	175	130	3.0
50	21.0	364	0.16	528	10	3.2	50	21.0	146	0.58	117	130	3.0
50	28.0	300	0.12	459	10	3.4	50	28.0	109	0.44	87	130	3.0
50	1.8	3828	2.56	4992	20	3.3	50	1.8	1887	6.82	1410	140	3.3
50	3.5	2028	1.30	2679	20	3.4	50	3.5	1015	3.46	747	140	3.4
50	7.0	928	0.68	1157	20	3.0	50	7.0	434	1.81	339	140	3.0
50	14.0	451	0.34	562	20	3.0	50	14.0	210	0.91	166	140	3.0
50	21.0	300	0.23	372	20	3.0	50	21.0	139	0.61	110	140	3.0
50	28.0	234	0.17	298	20	3.1	50	28.0	104	0.46	83	140	3.0
50	1.8	3403	3.08	3978	30	3.3	50	1.8	1821	7.09	1542	150	3.3
50	3.5	1802	1.56	2120	30	3.4	50	3.5	981	3.60	710	150	3.4
50	7.0	817	0.82	940	30	3.0	50	7.0	417	1.88	322	150	3.0
50	14.0	401	0.41	459	30	3.0	50	14.0	201	0.95	158	150	3.0
50	21.0	266	0.27	305	30	3.0	50	21.0	133	0.63	105	150	3.0
50	28.0	208	0.20	241	30	3.1	50	28.0	100	0.47	79	150	3.0
50	1.8	3090	3.54	3310	40	3.2	50	1.8	1757	7.56	1279	160	3.3
50	3.5	1636	1.79	1757	40	3.3	50	3.5	949	3.73	678	160	3.4
50	7.0	742	0.94	790	40	3.0	50	7.0	400	1.95	307	160	3.0
50	14.0	364	0.47	387	40	3.0	50	14.0	193	0.98	151	160	3.0
50	21.0	242	0.32	257	40	3.0	50	21.0	128	0.66	100	160	3.0
50	28.0	189	0.23	202	40	3.1	50	28.0	96	0.49	75	160	3.0
50	1.8	2872	3.95	2872	50	3.2	50	1.8	1697	7.62	1223	170	3.3
50	3.5	1521	2.00	1521	50	3.3	50	3.5	918	3.86	648	170	3.4
50	7.0	690	1.04	690	50	3.0	50	7.0	384	2.02	294	170	3.0
50	14.0	339	0.53	339	50	3.0	50	14.0	185	1.02	144	170	3.0
50	21.0	225	0.35	225	50	3.0	50	21.0	122	0.68	96	170	3.0
50	28.0	176	0.26	176	50	3.1	50	28.0	92	0.51	72	170	3.0
50	1.8	2689	4.35	2542	60	3.2	50	1.8	1641	7.88	1173	180	3.3
50	3.5	1427	2.20	1346	60	3.3	50	3.5	890	3.99	621	180	3.4
50	7.0	643	1.15	611	60	3.0	50	7.0	369	2.08	282	180	3.0
50	14.0	315	0.58	300	60	3.0	50	14.0	178	1.05	136	180	3.0
50	21.0	209	0.39	199	60	3.0	50	21.0	117	0.70	92	180	3.0
50	28.0	157	0.29	149	60	3.0	50	28.0	88	0.53	69	180	3.0
50	1.8	2559	4.68	2306	70	3.3	50	1.8	1589	8.12	1127	190	3.3
50	3.5	1361	2.37	1221	70	3.4	50	3.5	863	4.12	597	190	3.4
50	7.0	609	1.24	554	70	3.0	50	7.0	355	2.15	271	190	3.0
50	14.0	298	0.62	272	70	3.0	50	14.0	170	1.08	133	190	3.0
50	21.0	198	0.42	181	70	3.0	50	21.0	113	0.72	88	190	3.0
50	28.0	148	0.31	135	70	3.0	50	28.0	84	0.54	66	190	3.0
50	1.8	2432	5.01	2104	80	3.3	50	1.8	1538	8.37	1085	200	3.3
50	3.5	1295	2.54	1114	80	3.4	50	3.5	837	4.24	575	200	3.4
50	7.0	576	1.33	506	80	3.0	50	7.0	342	2.21	261	200	3.0
50	14.0	281	0.67	248	80	3.0	50	14.0	163	1.11	128	200	3.0
50	21.0	187	0.45	165	80	3.0	50	21.0	108	0.74	85	200	3.0
50	28.0	140	0.34	124	80	3.0	50	28.0	81	0.56	64	200	3.0
50	1.8	2319	5.34	1939	90	3.3	50	1.8	1512	8.58	1054	210	3.4
50	3.5	1237	2.71	1027	90	3.4	50	3.5	824	4.35	558	210	3.5
50	7.0	546	1.42	466	90	3.0	50	7.0	335	2.27	253	210	3.1
50	14.0	267	0.71	229	90	3.0	50	14.0	160	1.14	124	210	3.0
50	21.0	177	0.48	152	90	3.0	50	21.0	105	0.76	83	210	3.0
50	28.0	133	0.36	114	90	3.0	50	28.0	79	0.57	62	210	3.0
50	1.8	2216	5.66	1799	100	3.3	50	1.8	1515	8.75	1035	220	3.4
50	3.5	1184	2.87	953	100	3.4	50	3.5	826	4.43	548	220	3.6
50	7.0	520	1.50	432	100	3.0	50	7.0	335	2.32	249	220	3.1
50	14.0	253	0.76	212	100	3.0	50	14.0	160	1.17	122	220	3.1
50	21.0	168	0.50	141	100	3.0	50	21.0	106	0.78	81	220	3.0
50	28.0	126	0.38	106	100	3.0	50	28.0	79	0.58	61	220	3.0
50	1.8	2120	5.96	1679	110	3.3	50	1.8	1518	8.91	1016	230	3.5
50	3.5	1135	3.02	889	110	3.4	50	3.5	828	4.52	538	230	3.6
50	7.0	495	1.58	405	110	3.0	50	7.0	335	2.36	244	230	3.2
50	14.0	241	0.80	198	110	3.0	50	14.0	160	1.19	120	230	3.1
50	21.0	160	0.53	131	110	3.0	50	21.0	106	0.79	80	230	3.1
50	28.0	120	0.40	99	110	3.0	50	28.0	79	0.60	60	230	3.1
50	1.8	2036	6.26	1577	120	3.3	50	1.8	1520	9.08	999	240	3.6
50	3.5	1092	3.17	833	120	3.4	50	3.5	829	4.60	529	240	3.7
50	7.0	473	1.66	379	120	3.0	50	7.0	335	2.41	240	240	3.3
50	14.0	230	0.84	186	120	3.0	50	14.0	160	1.21	118	240	3.2
50	21.0	152	0.56	123	120	3.0	50	21.0	106	0.81	78	240	3.2
50	28.0	114	0.42	93	120	3.0	50	28.0	79	0.61	59	240	3.2

nicer looking paper was drawn up with markings for those settings, typewritten with the band-markings, and attached to the minibox. This allows very rapid setting of the box whenever I bandswitch, yet only one coil and two variable capacitors are used.

Other methods may come to mind that will work adequately for your purpose. Trying to put the networks into the amplifier usually makes additional problems with regard to space, synchronizing with the bandswitch, etc. Thus, the remote minibox idea may appeal to some of you who do not have space in the amplifier or the technical capability of providing mechanical selection when the bandswitch is rotated.

### components

Even with 100 watts output, there is only about 1.4 rf amps flowing. Consequently, rather small inductors, such as B&W stock can be used successfully. B&W type 3018 comes in 4-inch lengths, 8 turns per inch; the full 4 inches is 9.4 microhenries. Price is well under \$2. B&W type 3014 is also 8 turns per inch, 3-inches long, and 4.8 microhenries; cost is approximately \$1.50. These should give you ideas, and a wide variety of similar inductances are available.

Even with 100 watts output, the voltage across 50 ohms is only about 70 rms. Almost any type of variable capacitor, including the common 365 pF broadcast type will be more than adequate. You can easily find these for free from junker a-m radios of another era, and usually in gangs of two or three on the same shaft.

You will probably want a bandswitch for the network. Any type of switch capable of handling small amounts of rf will be adequate, and the additional pole/poles may be used to switch in fixed values for the lower frequencies, if desired. Ceramic or steatite switches are recommended.

Fixed capacitors should be rated for at least 150 or 200 volts, and capable of handling rf currents. Mica transmitting types are excellent. Low-cost door-knob

capacitors are also good and are usually capable of handling kilowatt outputs.

Some commercial amplifiers use fixed capacitors and a slug-tuned variable inductor. Unless you have some means of determining the actual impedance to be matched, tuneup could be very time consuming, and fairly costly unless a large supply of capacitors suitable for rf is available. Also, many of the available slug-tuned inductors will not handle the amp or two of rf current without damage.

### summary

Some method of matching the 50-ohm output impedance to the input of a linear amplifier should be offered. A good, simple but effective method is to build a single, variable pi-network and place it in a convenient place a few feet from the amplifier. A rf wattmeter may be used for initial tuneup, and simple markings placed on the box containing the network so rapid band changes can be made. Tables are included for both pi-networks and L-networks. These were computer-derived and include values for 1.9 through 29.7 MHz.

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# digital readout variable-frequency oscillator

This digital readout  
vfo covers the range  
from 5.0 to 5.5 MHz  
and costs less  
than \$100  
to build

Frequency counters have been around for some time, but only recently has the market become abundant with suitable parts and components making it possible to build a digital frequency station readout in a few evenings for under \$100.00. The counter described here measures the frequency of the transceiver vfo or any other piece of equipment. It is designed for the Heath-kit HW100 which has a 5 to 5.5 MHz variable oscillator and requires a downcount for proper frequency reading. However, the design can easily be changed to accommodate other equipment.

Gerd H. Schrick, WB8IFM, 4741 Harlou Drive, Dayton, Ohio 45432

The prototype was built into an external vfo which in turn is connected to my HW100. However, since it is very compact it can be incorporated into almost any existing equipment. The digital dial reads the frequency of the oscillator, indicating hundreds, tens, ones and a decimal of kilohertz. You have to remember the band, which in many cases is required anyway, for dial reading. A switch makes it possible to start reading at either 000.0 or at 500.0, taking care of the 75- and 10-meter bands which start out at 500.0. Another switch makes it possible to correct for errors that are introduced by inaccurate crystals.

The entire project (without power supply) consists of only 13 integrated circuits, four numerical readout ICs, two surplus crystals and a few resistors and



Front dial of the digital readout vfo.

capacitors. The following paragraphs will describe the various functions of the counter. The actual hardware consists of only three parts: a 3.75 x 6-inch Vero-board with the ICs and crystals, the 1 x 2-inch readout panel, which can be

cycle. A complete schematic of the time-base circuit and the times involved can be seen in fig. 4.

### mixer

The 5- to 5.5-MHz output of the vfo is

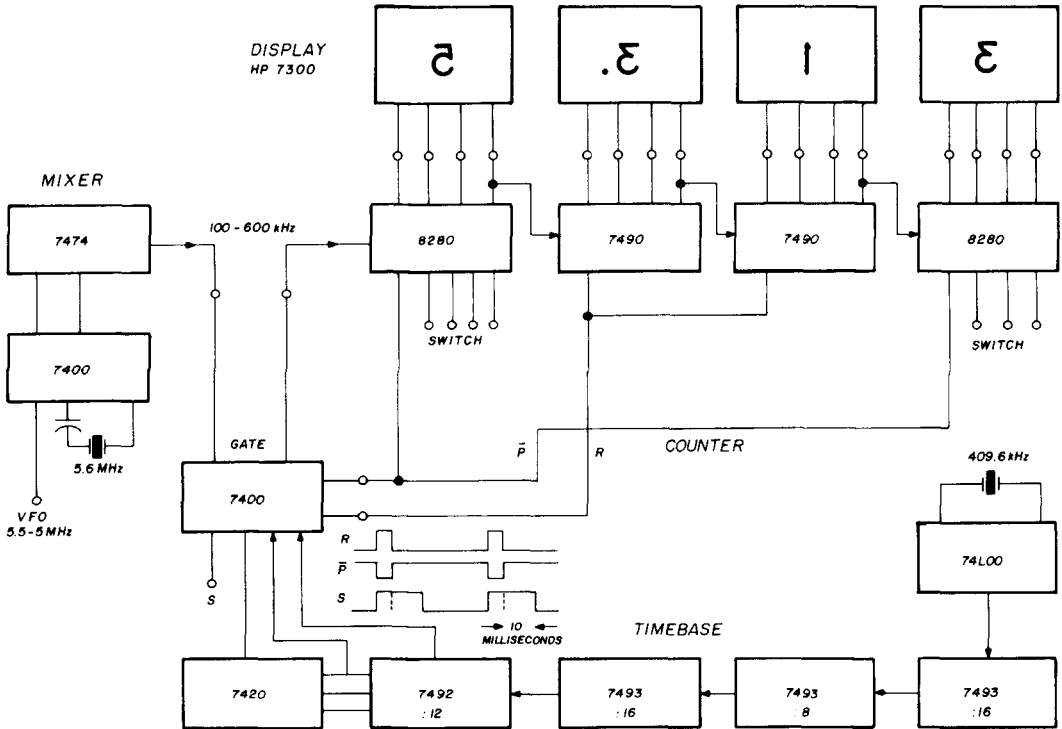


fig. 1. Block diagram of the digital readout vfo. All interconnections are shown except supply leads, grounds and switches.

mounted somewhere on the front panel of the equipment, and the power supply. The power supply described here uses an IC for regulation; however, any power supply of similar design can be used.

The oscillator uses a 74L00 IC, followed by three 7493 ICs and one 7492 IC connected as dividers (see fig. 1). The 7492 divide-by-12 IC plus two multiple-gate ICs (7420 and 7400) are used to derive the time-base functions:  $\bar{P}$  (present), R (reset) and S (suppress). The bar over the P indicates a negative-going pulse. The suppress function turns the readout numbers off briefly and permits counting during the last two-thirds of the

not measured directly, but is mixed with another crystal oscillator. This not only reduces the accuracy requirements for the timebase; the entire counting process is relaxed since the actual frequency being measured is now only in the hundreds of kHz. Also, it is possible to choose the right crystal for the particular vfo and up or down counting scheme without changing anything else in the counter.

A rather unknown type of mixer using a D-type flip-flop (7474) is used (fig. 2). With this mixer there is no need for any external filter components whatsoever; moreover, there is no loss involved and consequently no need for amplification.

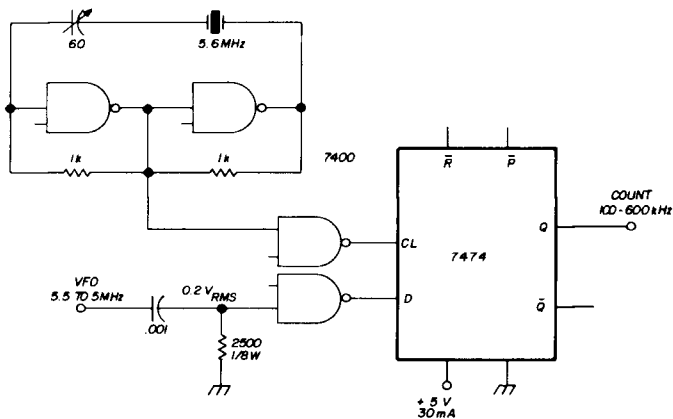


fig. 2. Digital mixer uses D-type flip-flop.

The oscillator uses a surplus 5600-kHz crystal and a 7400 IC to beat the 5- to 5.5-MHz vfo down to 100 to 600 kHz. The crystal oscillator can be adjusted with a trimmer capacitor to within  $\pm 300$  Hz, so it can take care of some of the various band crystal frequency offsets.

### counter

The counter is a simple ripple counter consisting of four individual decade counter ICs, fig. 3. The first and last ICs are 8280s or 74196s, and the two middle ones are 7490s. Each counter has a four-line (ABCD) output leading directly

to the respective numeric indicators.

The first counter, which provides the last digit or hundreds of Hz, can be preset by properly grounding the four data lines  $D_A$ ,  $D_B$ ,  $D_C$  and  $D_D$  to any number from 0 to 9, thus permitting a correction (by separate switch) for individual bands. The last counter can be preset by switch to read from either 000.0 to 500.0 or from 500.0 to 1000.0. The middle counters have only normal reset capability. The individual counting process takes 10 milliseconds (1/100 of a second) and is repeated about 17 times per second, causing a slight flicker like a home movie.

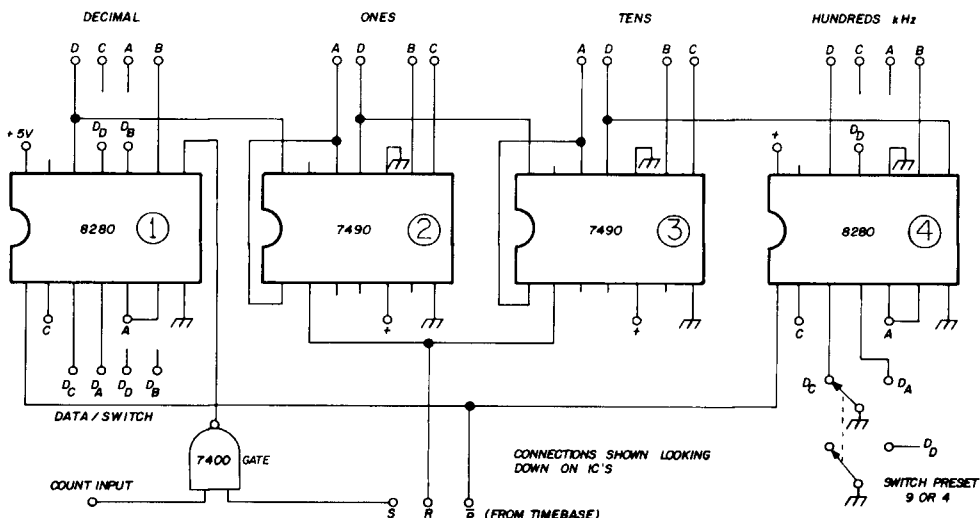


fig. 3. Four-stage ripple counter.



However, this is not at all annoying and indicates that the counter is operating properly. If, for instance, the flicker is not visible, the time base might be oscillating at a harmonic, thus giving an erroneous reading.

### correction switch

The switch for correcting frequency

Short pieces of wire are inserted between contacts according to the offset to be corrected and the BCD-code depicted in fig. 5.

### power supply

This is a straight-forward power supply design. However, many similar schemes can be used. You might want to extract

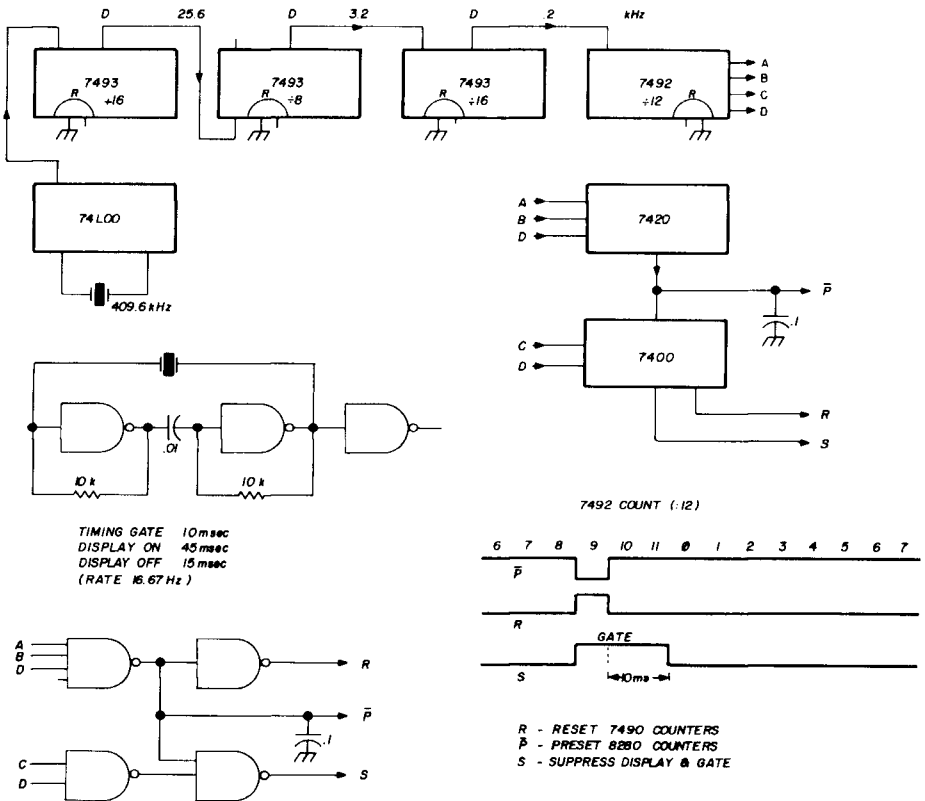


fig. 4. Complete timebase circuit for the digital readout vfo.

offsets of inaccurate band crystals is a five-position, four-contact switch. The contacts correspond to the  $D_A$ ,  $D_B$ ,  $D_C$  and  $D_D$  data lines leading to the first counter chip, and the five positions correspond to the 75- through 10-meter amateur bands. Some people might want to use more positions to cover other 10-meter segments. The contact leads are brought out to a long socket capable of accepting double-sided circuit boards.

the power from 6.3-V filament winding. Approximately 600 mA at 5 V is required. An IC is used for regulation. This IC now costs about \$2.00, looks and mounts like a T03 transistor and regulates any supply having between 7 and 25 V input to 5 volts output. Make sure you use several thousand microfarads for the filtering capacitor. The 2N3719 PNP-transistor (or similar) is used for switching the display. A separate ze-

ner-regulated voltage is available for an external transistor vfo.

Hewlett-Packard type 5083-7300 numerical indicators were used in the unit.\* These display numbers by utilizing a 4 x 7 light-emitting diode dot matrix. They accept a four-line BCD code from the actual counter. They also have a memory capability which is not being used in this counter.

Although each digit is only 0.2 by 0.3 inch, they are rather bright and can be

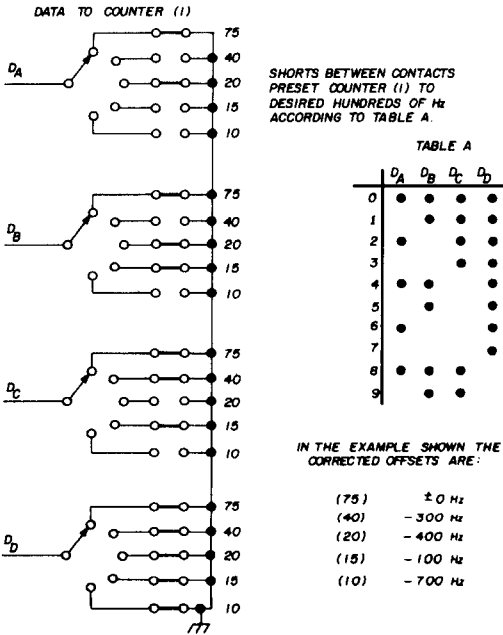


fig. 5. Bandswitch for correcting slight crystal frequency offsets.

seen clearly from up to 10 feet away. A missing dot, if it should occur, does not give an erroneous reading as would a missing section of a seven-segment readout. No extra power supply is required, nor is a decoder, as would be needed for almost all other designs.

\*The Hewlett-Packard 7300 light-emitting digital display ICs are available from any H-P Sales Office. To find the address of your local Sales Office, look in the Yellow Pages, or write to Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304.

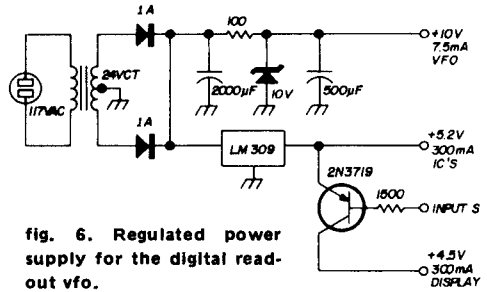


fig. 6. Regulated power supply for the digital readout vfo.

The Hewlett-Packard light-emitting readouts are somewhat more expensive than Nixie tubes, but they offer enough advantages to be well worth the price difference (the cost for one 7300 is \$14.50). The readout can be mounted with a 36-pin IC socket, resulting in a rather flat, 1 x 2-inch display.

### timebase

A frequency counter has to derive a gate from some standard, which is pretty much the same as using a crystal calibrator, except that the final result with the counter is a readout every 100 Hz and you do not have to search and zero beat those frequency marks.

This particular timebase starts off with a surplus crystal at 409.6 kHz and then, using a divide-by-two scheme, arrives at a gate which is 10 milliseconds wide (fig. 4). The number of Hz measured with this gate gives frequency directly with the last digit being in hundreds of Hertz. Other crystals and dividers can be used, providing you build an accurate 10-millisecond gate.

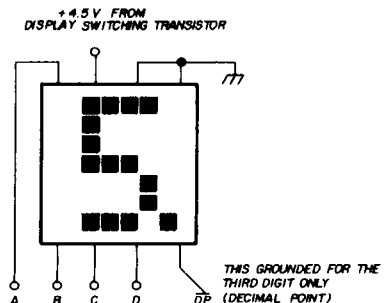


fig. 7. Wiring of light-emitting displays.

Although it is quite helpful to understand digital ICs, it is not absolutely necessary for this project. No special wiring diagram or printed circuit layout has been attempted. However, from the figures and schematics accompanying this article it should be relatively easy to perform the wiring chore; it can be done in two evenings.

It is recommended that you make major interconnections with IC socket pins and pieces of wire. Multicolor, no. 24 telephone wire is best suited; it should not be difficult to obtain scrap pieces.

sideband as used in Heathkit equipment?

## conclusion

The counter was first shown at the Dayton Hamvention in April, 1972, and has been in use ever since. You very soon become accustomed to reading the numbers, and although my vfo used the excellent Drake SPR4 dial, I hardly look at it any more. Quick departure from the operating frequency is possible. To look for a clear frequency, for example, and in an instant you can be back within a 100 Hertz of the old frequency, almost

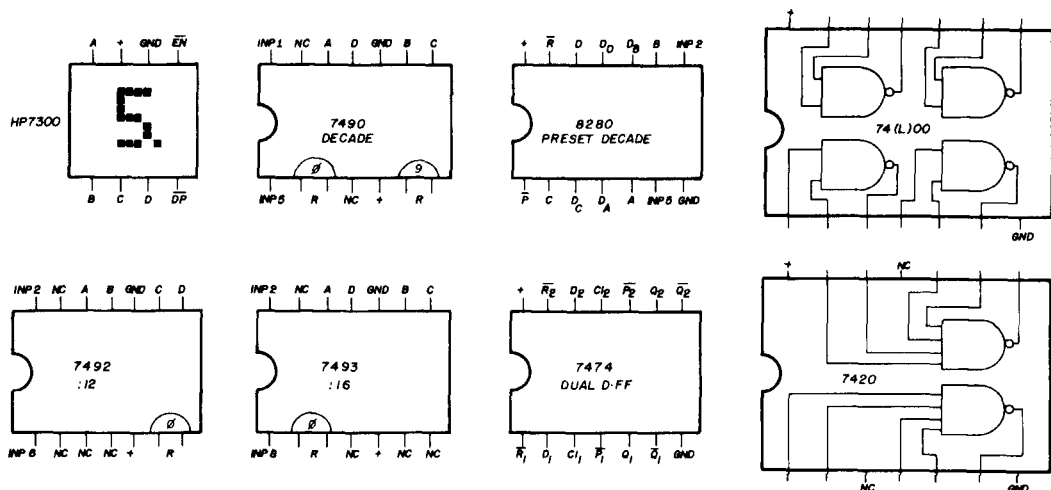


fig. 8. Base connections of the ICs used in the digital readout vfo (top views).

Great care must be exercised to ensure correct connections; every wire is important, components are rather small and IC lugs are spaced only 1/10 inch.

## calibration

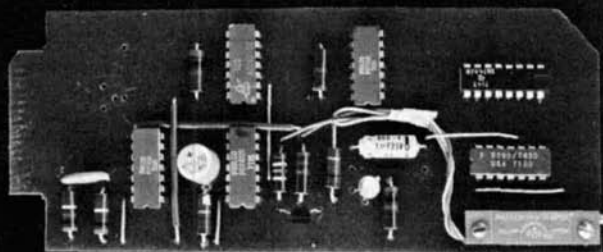
In the question of calibration a detailed procedure is being worked out. There are problems with the accuracy of the customary 100-kHz crystal and problems in detecting a beatnote on an ssb receiver that attenuates frequencies below 300 Hz. Also, there is the question of what exactly is the frequency of an ssb signal; is it, as the FCC questionnaire implies, the carrier frequency, which of course is never transmitted, or is it a nominal center frequency in the middle of the

making the external vfo scheme or the clarifier obsolete.

One final comment about the improvement in frequency reading. First: Once the counter is checked out and calibrated there is no need for recalibration since only crystals are used for reading the frequency. Second: Compared to the  $\pm 1$  kHz of the Drake dial the accuracy is now  $\pm 0.1$  kHz, a ten-fold improvement over the very good Drake dial.

This counter exhibits the usual  $\pm 1$  ambiguity in the last digit. However, this can be avoided by synchronizing the gate with the incoming frequency. A conversion taking care of this problem will be forthcoming.

ham radio



## automatic line feed for RTTY

This low-cost,  
all solid-state  
automatic line-feed  
prevents end-of-line  
print garble  
and overprinting

Bert Kelley, K4EEU, 2307 South Clark Avenue, Tampa, Florida

When an RTTY transmission begins, there is no assurance that the receiving printer will start on the same line as the transmitting printer. Sometimes the line feed character is garbled, occasionally it's not even sent — these are all causes for loss of copy (or a "black box" of overstrikes on the right margin).

When no line feed is received, the printer runs up to the right margin and stops there, overprinting characters until a valid line-feed signal is received. This copy may be missed even if the operator is present, because attempts to manually inject a line-feed signal through the local loop may fail due to incoming signal interference.

An automatic RTTY line-feed system greatly improves the quality of the received copy, and is a definite operating convenience. There are various mechanical line-feed systems available, but they are unreliable and sometimes difficult to adjust.<sup>1,2</sup> The all solid-state system described here has proved to be very reliable, requires only one simple adjustment, and doesn't cost an arm and a leg.

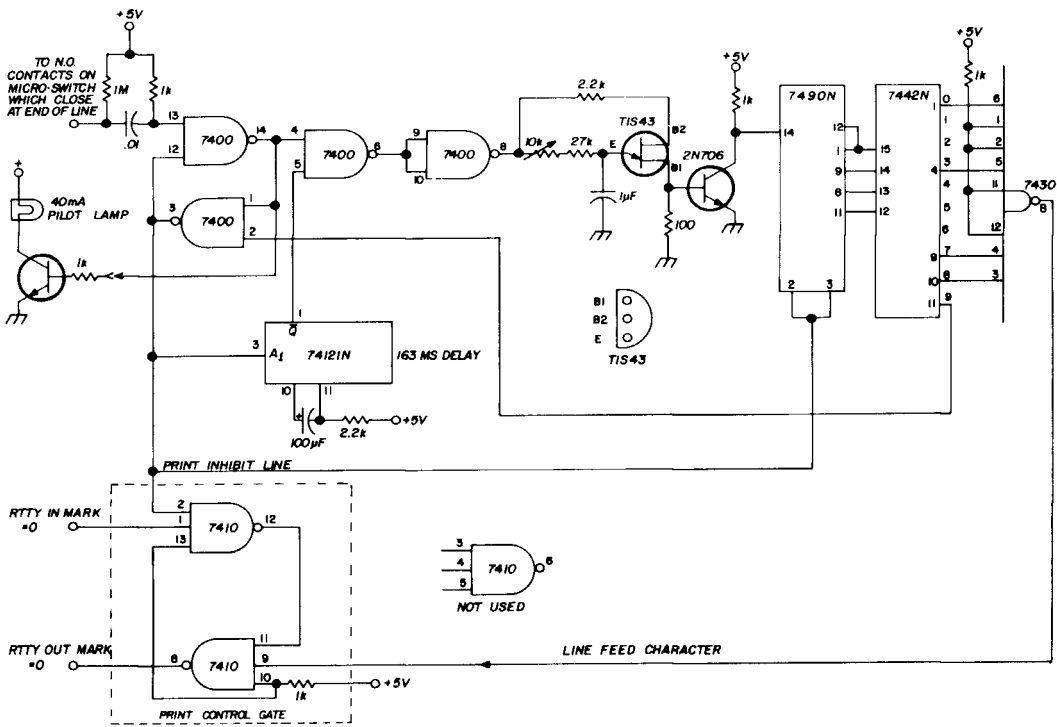


fig. 1. Logic for the RTTY automatic linefeed circuit.

### the circuit

This automatic line-feed system uses six TTL integrated circuits and two transistors to generate a line-feed character locally and insert it into the loop. A microswitch is mounted on the frame of the printer so that it is actuated by a projection on the type carriage when the printer reaches the end of a line (see photo). Two gates then act as electronic switches to shutoff print, insert the line-feed character, and restore print. The entire sequence happens very quickly, and only three characters are lost in the copy, even at full machine speed. However, in practice, only one or two characters are lost as few RTTY operators actually type at 60 words per minute (the auto-line feed occurs at full machine speed).

Normally, the output of the TTL NAND gate is at logic 1. The output of the two-input gate will be zero if, and only if, both inputs are logic 1. A 7400 IC is used as a start/stop latch, with the output at pin 14 normally logic zero.

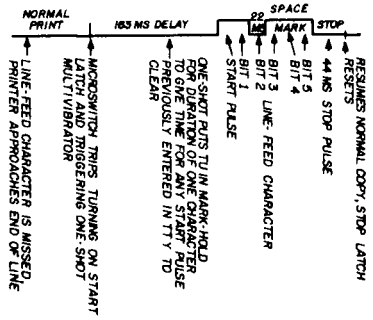


fig. 2. Timing sequence of the automatic line feed.

When the line-feed microswitch closes, the start/stop latch trips, pin 14 goes to logic 1 and pin 3 goes to logic zero, triggering a 74121 monostable multi-vibrator.

the length of one RTTY *bit*. The 7442 decoder IC is connected to an eight-input 7430 gate so that decimal zero is mark-hold, decimal one is the start pulse, and the remaining bits follow in order

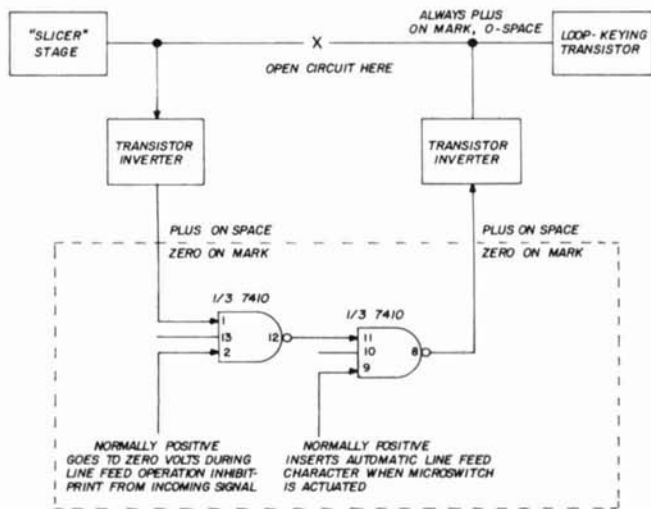


fig. 3. The automatic line feed may be used with most solid-state RTTY demodulators as shown here.

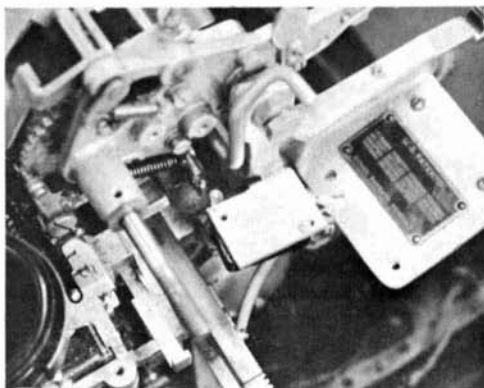
At rest, pin 5 of the 7400 is at logic 1; with pin 14 at logic 1, pin 6 would be at logic zero except that the 74121 has been triggered and the output of the one-shot is low for about 163 milliseconds. This gives the printer time to clear any parts of an incoming signal (print is inhibited by the 7410 gate as soon as the voltage at pin 3 of the 7400 falls to logic zero).

After the one-shot pulse is completed, pin 5 of the 7400 goes high, and since the start latch has tripped, pin 4 is also high, meeting the condition for a logic zero at pin 6. The next 7400 section is used as an inverter and is at logic 1; this is about 4 volts. The 1- $\mu$ F capacitor in the unijunction emitter circuit starts to charge, and fires the unijunction transistor, generating a sawtooth wave at a frequency of 45.5 Hz. The 2N706 transistor is used as an interface between the unijunction transistor and the 7490 TTL decade counter.

The 7490-7442 counter-decoder combination converts the 45.5-Hz sawtooth to a series of 22-millisecond pulses, each

through the sequence until the stop pulse is reached on pins 9 and 10 (decimal seven and eight).

Both pins 9 and 10 of the decimal decoder are connected to the gate, giving a 44-millisecond stop pulse. When the counter reaches decimal nine, pin 11 goes low, immediately resetting the flip-flop to



Line-feed microswitch is actuated by a projection on the type-carriage arm that mounts the margin-bell pawl.

standby and restoring print. The 7490 is simultaneously reset to zero, ready for the next microswitch closure.

The same circuit could be used to generate any RTTY character by proper connections to the 7430 gate. In this circuit only the line-feed character is generated, and it is assumed that the printer is already modified for non-overline; that is, it is only necessary to send a line-feed signal to obtain both carriage return and line feed (kits are available for this\*).

## installation

The automatic line-feed system described here is compatible with most solid-state transistor or IC RTTY demodulators. However, proper signal polarity must be observed, and the input to the TTL IC must not exceed 5 volts (a zener diode will take care of this). Fig. 3 shows the general interconnection of the automatic line-feed; fig. 4 shows how the ST-3 and ST-4 RTTY demodulators may be adapted, and fig. 5 shows the ST-5.

Power for the automatic line-feed circuit can usually be taken from the demodulator. The logic requires about 80 mA at 5 volts. An LM309K voltage-regulator IC is the most convenient way to obtain the proper voltage from an unregulated demodulator positive supply.

The microswitch is mounted on the teleprinter as shown in the photographs. To prevent ground loops it's necessary to

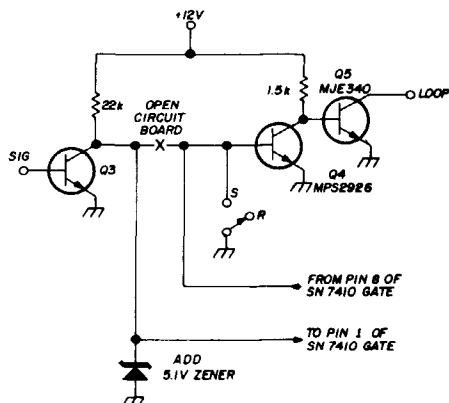


fig. 4. Connecting the automatic line-feed circuit to the ST-3 and ST-4 demodulators.

use shielded wiring between the micro-switch and the logic. In my unit, I used printed-circuit sockets and phono connectors for easy servicing.

The only adjustment required is that

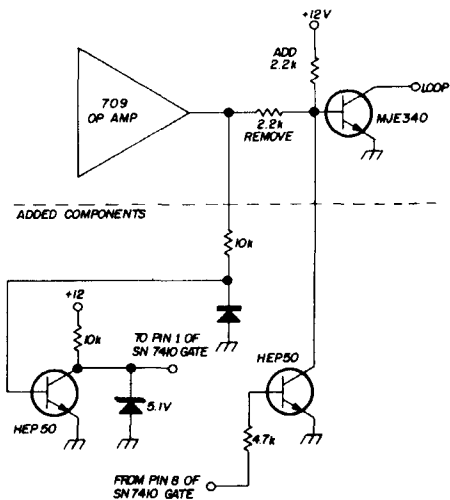


fig. 5. Proper connections for using the automatic line feed with the ST-5 demodulator.

of setting the clock frequency to 45.5 Hz. There are two ways of doing this. One is to temporarily disconnect the reset line at pin 11 of the 7442 decoder; this makes the clock run continuously so its frequency can be measured with a digital frequency counter. If the 10k potentiometer will not reach the proper setting, change the 27k resistor to another value to compensate for wide tolerances in the electrolytic capacitor. If you do not have access to a frequency counter, simply adjust the clock for proper line-feed operation while manually actuating the microswitch.

\*Modification kits for non-overline are available from several sources, including Typetronics, Box 8873, Fort Lauderdale, Florida.

## references

1. Irving M. Hoff, W6FFC, "Simplex Auto CR-LF," *RTTY Journal*, July, 1968.
2. J. Struder, W9RY1, "Modification for the Simplex," *RTTY Journal*, May, 1971.

ham radio



# multi-function fm repeater decoder

This multi-function  
Touchtone-actuated  
repeater decoder  
provides over  
3500 different functions  
with a 16-button pad

A **repeater** usually has some sort of simple control system that requires, perhaps, one tone to turn the repeater on and a timer to shut it off. Some of the more elaborate systems use Touchtone coding which allows the users 12 different functions (or maybe 16) by using the pad from a Touchtone telephone. These functions may be: repeater on; repeater off; tight squelch; open squelch; 450 link on; 450 link off; etc. The system described here is the next step forward. It uses a three-digit combination that provides facilities for up to 810 functions using a ten-button Touchtone pad, up to 1464 functions with a 12-button Touchtone pad, and up to 3616 functions using a 16-button pad.

In developing this system, the intention was not to start off with a full 3616 function decoder, but to build a unit so that functions could be added to the decoder in modules as more and more functions were required. It was decided that it would be easiest to add functions in modular groups of ten. In the decoder

described here, up to ten of these modules (100 functions) can be added to the basic decoder. By adding four more integrated circuits, another ten modules can be added (a total of 200 functions). Still another set of ICs will expand the system to 1000 functions.

This article describes a basic 20-function decoder that can easily be expanded to 100 functions. Instructions for further expansion are also included. The decoder consists of many subsystems, some of which may be eliminated or replaced with an existing design. Each subsystem is a distinct entity and may be useful for other purposes apart from this particular decoder.

In addition to the three-digit decoder, which consists of a memory unit and function modules, this system includes a base tone decoder, two different pre-filtering systems and a display. Either of the two prefiltering systems may be used to increase the differential tone input range to the tone decoders. The display converts Touchtone coding to binary, and then uses a seven-segment display and binary decoder/driver to display 16 different characters, corresponding to the 16 buttons.

## basic touchtone decoder

There are several reasons for using phase-locked loops for tone decoders: their small size, excellent bandwidth, relative immunity to bandwidth with level changes and their ability to decode Touchtone signals when the levels of the two tones differ by as much as 6 dB. However, they are expensive — about \$9.00 apiece, and there are eight required for 16 digits, seven for 10 or 12 digits.

The tone decoder circuit in **fig. 1** is typical. Proper resistor values for each of

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eight tones are included. Audio, on the order of 200 mV rms is applied to the input of the IC. Each chip has its own RC combination for timing, and will respond only to the tone that it is timed for. Each IC produces a low output when its tone is being received and rests at +5 V. Bandwidth for these decoders with 200 mV rms input and the filtering capacitors shown in the schematic is on the order of 70 Hz.

The decoder, as shown in the schematic, requires the level of the two different tones (differential tone level) to be within 6 dB of each other. This level imposes a fairly stringent requirement on the audio response of the repeater receiver and the repeater users transmitter. Rather than requiring all users to clean up their transmitters, it may be easier to build a pre-filter to increase the differential response of the decoder.

### prefilters

Two different prefilter systems were built and tried; both will be described here. One filter system is completely passive. It has two bandpass filters, one for the high group frequencies, the other for low group frequencies. These filters

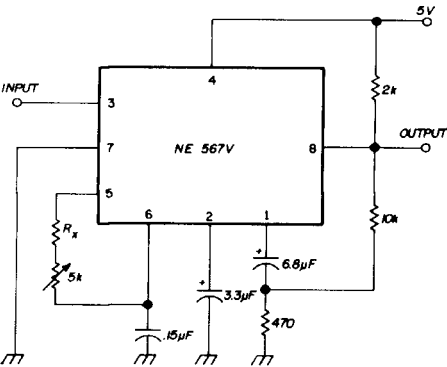


fig. 1. Circuit for the IC tone decoder. One decoder is required for each tone used in the system. The value of Rx determines the Touchtone frequency to which the tone decoder is sensitive.

frequency (Hz)	Rx (ohms)
697	6800
770	6200
852	5100
941	4700
1209	3000
1336	2400
1447	2000
1633	1500

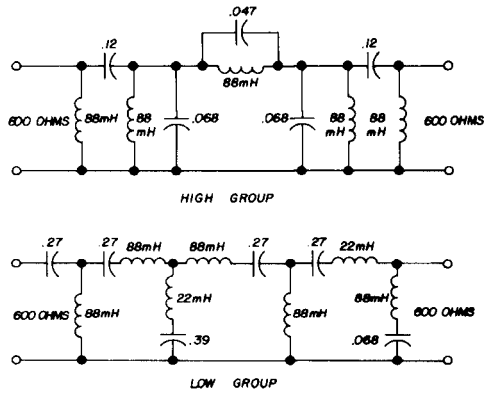


fig. 2. Passive bandpass filters for high- and low-group tones.

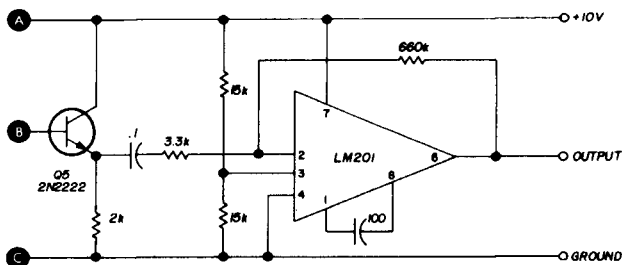
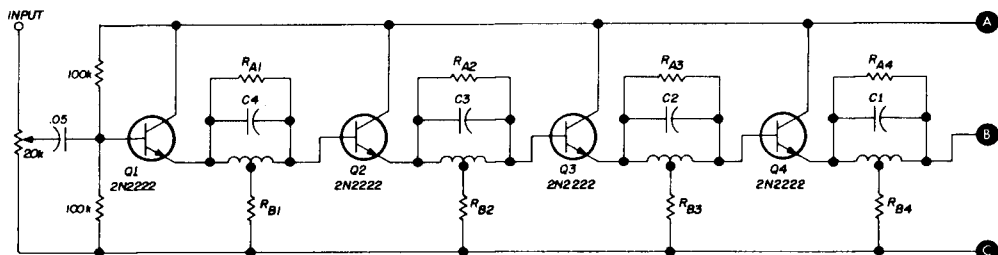
are built from standard 88-mH toroids and off-the-shelf capacitors and require no tuning. Schematics for these two filters are shown in fig. 2.

The other filter system is considerably more elaborate. It basically consists of notch-filters cascaded together with an active limiter at the output and is used for band-reject filtering at the input to the tone decoders. Consequently, all the high-group tones are rejected at the input to the low-group decoder and vice-versa. The schematic for this filter is shown in fig. 3. Tune-up instructions for these filters will be discussed under construction. The passive bandpass filter furnishes an additional 16-dB minimum isolation between the decoders while the active band-reject filters supply a minimum of 20 dB. This allows a total differential tone range of 22 dB for the passive filters and 26 dB for the active filters.

The advantage of the notch-filters over the bandpass filters is that with the notch-filter, the input of the tone decoder is looking at the entire audio spectrum except for the tone that is notched out. This requires that the overall signal-to-noise ratio be better than 6 dB for the decoder to function. With the bandpass filters, the input of the tone decoder looks at a very narrow portion of the spectrum, and the unit will work with very marginal signal-to-noise ratios.

The schematic for the display is shown in fig. 4. Notice that DTL logic is used instead of TTL. This is so that wired-OR can be used at the input to the inverters driving the binary to seven-segment display driver (MSDO47). If TTL logic is to

the decoder. This single-digit Touchtone command resets the counter and enables the system to store the next three digits in the memory. After the next three digits are sent, the unit produces an output to tell the function modules that



	low group	high group
C1	.68	.22
C2	.5	.18
C3	.39	.15
C4	.33	.1

fig. 3. Active band-reject filter. All inductors are 88-mH toroids. Resistor  $R_A$  is between 5600 and 22k ohms,  $R_B$  is 1000 to 3000 ohms (see text).

be used, all gates with the exception of U1 must have open-collector outputs and associated pull-up resistors. Another factor to be considered is that the display logic requires positive logic while the Touchtone decoder shown here furnishes negative logic. For operation directly from the decoder, inverters will have to be used between the decoder outputs and the display logic inputs. A Monsanto MSDO47 decoder-driver was chosen; however, an SN7447A could be used in place of the Monsanto unit.

### memory unit

The operation of the memory unit requires some explanation. Basically, it consists of a *recognizer* (which recognizes legitimate Touchtone signals and not noise), an *access system* which has access to the memory, a counter to count digits and the memory itself (see fig. 5).

Essentially, the memory unit works as follows. The *access* command is sent to

there is a command in memory (*command enable*), and to shut the access to the memory down until the next access command is sent. It is possible to use single row or file accessing, as is common on the West Coast, with minor circuitry changes.

The four high-group tone decoders are applied to the clock on one set of four lines, while the four low-group tone decoders are applied on another (fig. 6). Each group of lines is *looked* at by a set of exclusive OR gates (U7 and U8). These gates produce an output only when one of the four lines goes low. These two exclusive OR sets are NANDed together and applied to an integrator. This integrator will only start to discharge when *one* of the high-group lines and *one* of the low-group lines go low. This happens only when a legitimate Touchtone command is being sent.

Since this integrator has a 100-ms time constant, the 311 comparator will fire

only if the command is present for more than 100 ms. The output of the comparator is connected to a one-shot so that a pulse is produced when the comparator fires. This 7-ms pulse is produced 100 ms after a button is pushed on the pad. This

mer. This NOR gate output goes high when the *access* digit is being sent. The output of the access programmer resets the four-bit counter, resets the access flip-flop (U15), and starts the NE555V timing. The Q output of the access

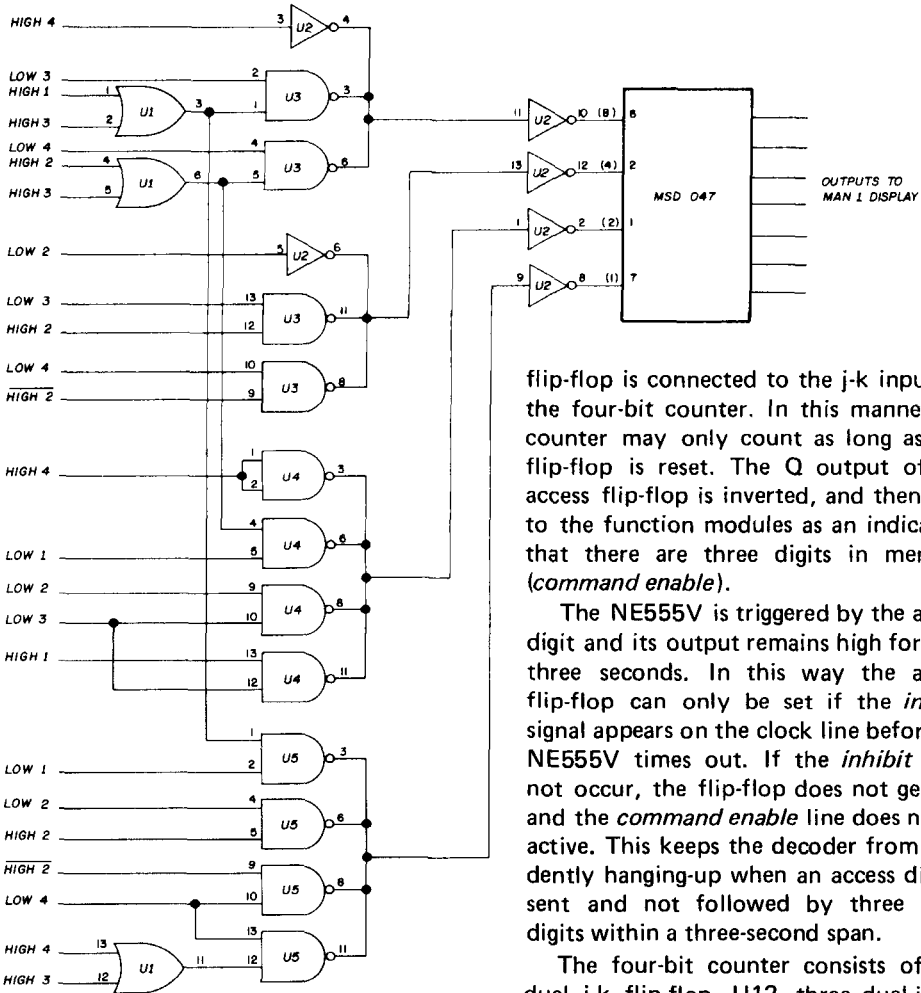


fig. 4. Display logic. U1 is a MC1809P; U2 is a MC837P; and U3, U4 and U5 are MC846Ps.

pulse is fed to one input of a two-input NAND gate while the other input is connected to the input of the integrator. If the command is still present when the one-shot produces its pulse, the output of this gate will produce the *digit* present pulse which drives the four-bit counter.

Gate 2 serves as the access program-

mer. This NOR gate output goes high when the *access* digit is being sent. The output of the access programmer resets the four-bit counter, resets the access flip-flop (U15), and starts the NE555V timing. The Q output of the access

flip-flop is connected to the j-k inputs of the four-bit counter. In this manner the counter may only count as long as this flip-flop is reset. The Q output of the access flip-flop is inverted, and then sent to the function modules as an indication that there are three digits in memory (*command enable*).

The NE555V is triggered by the access digit and its output remains high for only three seconds. In this way the access flip-flop can only be set if the *inhibit* signal appears on the clock line before the NE555V times out. If the *inhibit* does not occur, the flip-flop does not get set, and the *command enable* line does not go active. This keeps the decoder from accidentally hanging-up when an access digit is sent and not followed by three more digits within a three-second span.

The four-bit counter consists of one dual j-k flip-flop, U12, three dual-input NOR gates and a two-input NAND gate (fig. 7.). The counter is programmed so that when it is reset, output 1 is high, outputs 2 and 3 are low, and output 4 is high. Output 1 occurs when the counter is reset by the access command. Output 1 is connected to the first digit memory (1st digit memory enable). This high input to these two memory units allows them to look at their input and remember what it was when this line goes low again.

If a *digit present* pulse appears at the input to the counter, the counter will advance, making output 1 low and output 2 high with no change in outputs 3 or 4.

Thus, the digit that was present when the *digit present* pulse occurred is stored in the first digit memory, and the second digit memory is ready to accept a digit. When the next digit is sent, another *digit present* pulse is produced, locking this digit in the second digit memory and allowing the third digit memory to accept

For single rank or file accessing (i. e., single-tone produced by pushing two adjacent buttons on the pad), the following addition must be made. For single-tone, low-group accessing, a four-input NAND gate is installed between gate 2 and the high-group tone decoder inputs. The output of this added gate is connected to pin 12 of gate 2, and the inputs are connected to the high-group tone decoder inputs. This gate functions as a NOR gate in this configuration, and gate 2 will now

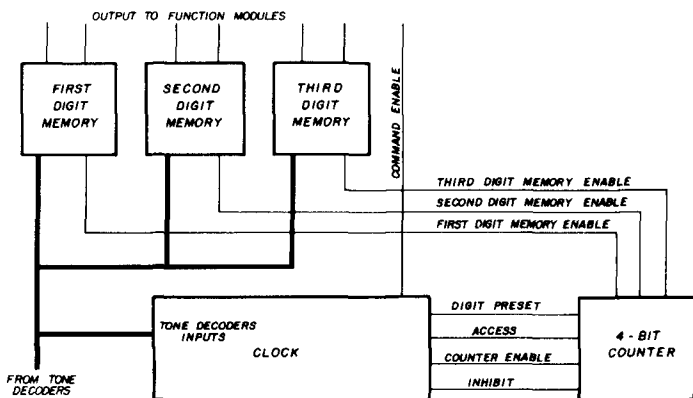


fig. 5. Block diagram of the memory.

a digit. The same thing happens when the third digit is sent, except that output 4 now goes low which sets the *access* flip-flop so that no more *digit present* pulses may get to the four-bit counter unless it is accessed again. The access flip-flop can be set only if the NE555V has not timed out. Therefore, output 4 of the counter must occur within 3 seconds after *access* or the access flip-flop will stay reset.

The memory consists of two SN7475 quad latches for each digit (fig. 8). The output of the memory to the function modules is from the Q outputs. The unit is so constructed that resending the *access command* at any time resets the four-bit counter and reaccesses the counter input, as well as restarting the NE555V. Thus, the *access command* can be sent at any time to restart the decoder. By the same token, this *access digit* cannot be used as a digit in the three-digit command.

produce an output only when none of the high-group tones are present and when the low-group tone, to which the other input of the access programmer is strapped, is present. For single-tone, high-group accessing, put the added gate between the low-group decoder inputs and pin 11 of gate 2.

### function modules

The function modules are built in groups of ten. One pair is shown in fig. 9. Each pair of functions are electrically the same, except for programming. Each group of ten functions is prefaced by hex-inverters on the memory output lines for fan-out; this is why the number 10 was chosen for a group of functions. Each function module is an eight-input NAND gate, followed by a two-input NAND gate. One of the eight inputs is permanently tied high, so the gate functions as a seven-input gate.



to substitute values for any of the capacitors, otherwise you may have bandwidth and/or temperature stability problems.

The best way to set the center frequency of each decoder is to connect a counter to pin 5 of the decoder being aligned and adjust the pot for the proper center frequency.

For use without prefiltering, all inputs to the decoders are tied together and a 1  $\mu$ F coupling capacitor is used to connect this common input to the audio input. When using either of the prefilters, the audio inputs of the four low-group decoders are tied together and called the low-group audio input; the four

that is available is a speaker line, use an output transformer backwards to jack the impedance up.

The active prefilters are built on two identical PC cards, one for the high group, the other for the low group. It is easier to begin tuning this filter before it is constructed. Temporarily connect C1 across an 88-mH toroid. Install the combination in the test fixture shown in fig. 11. Measure the resonance point of the combination. This is indicated by a peak on the voltmeter. Chances are, the peak will not correspond with the needed frequency. For low-group, C1 should produce resonance at 697 Hz, C2 at 770 Hz, C3 at 852 Hz, and C4 at 941 Hz. For high-group, C1=1209 Hz, C2=1336 Hz, C3=1447 Hz and C4=1633 Hz.

In all cases, the resonance should be lower in frequency than desired with the capacitors called for in fig. 3. To tune the combination to the proper frequency, start removing turns from the toroid. Remove turns equally from both windings. After tuning, install this LC combination on the circuit board. Connect C2 across another toroid, install in the jig, and continue as above, tuning the combination for 770 Hz. Do the same for C3 and C4.

Temporarily install 2000-ohm resistors at RB2, RB3 and RB4. Do not install RA1, RA2, RA3 or RA4 at this time. Connect an audio oscillator and counter to the input of the filter board. Check the resonant frequency and notch depth of first tuned circuit by connecting an ac voltmeter to the emitter of Q2. Use a decade resistance box for RB1 to determine the correct resistance for the deepest notch (typically 50 dB). It may be necessary to add or subtract turns from the toroid to finalize the frequency of the notch.

Install a fixed resistor for RB1 and connect the decade box where RA1 should be. Determine the value of RA1 required to broaden the notch to  $\pm 10$  to 15 Hz. This should bring the notch depth to about 20 dB. Permanently install RA1, and continue on to the next frequency by removing the temporary RB2 and replac-

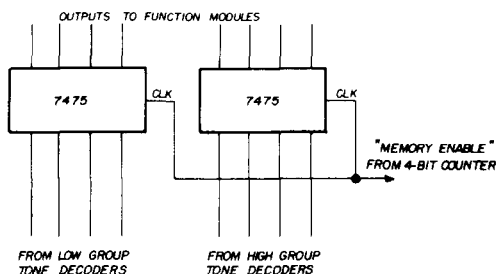


fig. 8. Memory (typical of three).

high-group decoder audio inputs are tied together and called the high-group audio input. When using the passive prefilters, both the low-group audio input and the high-group audio input will require a 680-ohm resistor to ground to normalize its impedance to 600 ohms, and each of these inputs is connected directly to the output of its filter. When using the active prefilter, both the low-group audio input and the high-group audio input are connected to the output of its filter through a 1- $\mu$ F capacitor.

When building the passive prefilter shown in fig. 2 it is essential that the capacitor values be exactly as shown. There is no tuneup necessary for these units. However, the input and output impedances are critical. Each filter must see 600 ohms at both input and output. Connect the filters as shown in fig. 10. If a 600-ohm line is available for use, the 600-ohm resistor can be removed. If all



ing it with the decade box and moving the voltmeter to the emitter of Q3.

### access programming

Pick one of the digits on the Touch-tone pad for access. Let's use 0 as an

digit combinations, pick three digits (except for the *access* digit). Let's use 159. Referring to table 1, digit 1 is high-group 1, low-group 1. Run jumpers from the first digit memory outputs *high 1* (1H1) and *low 1* (1L1) to two of the inputs on an

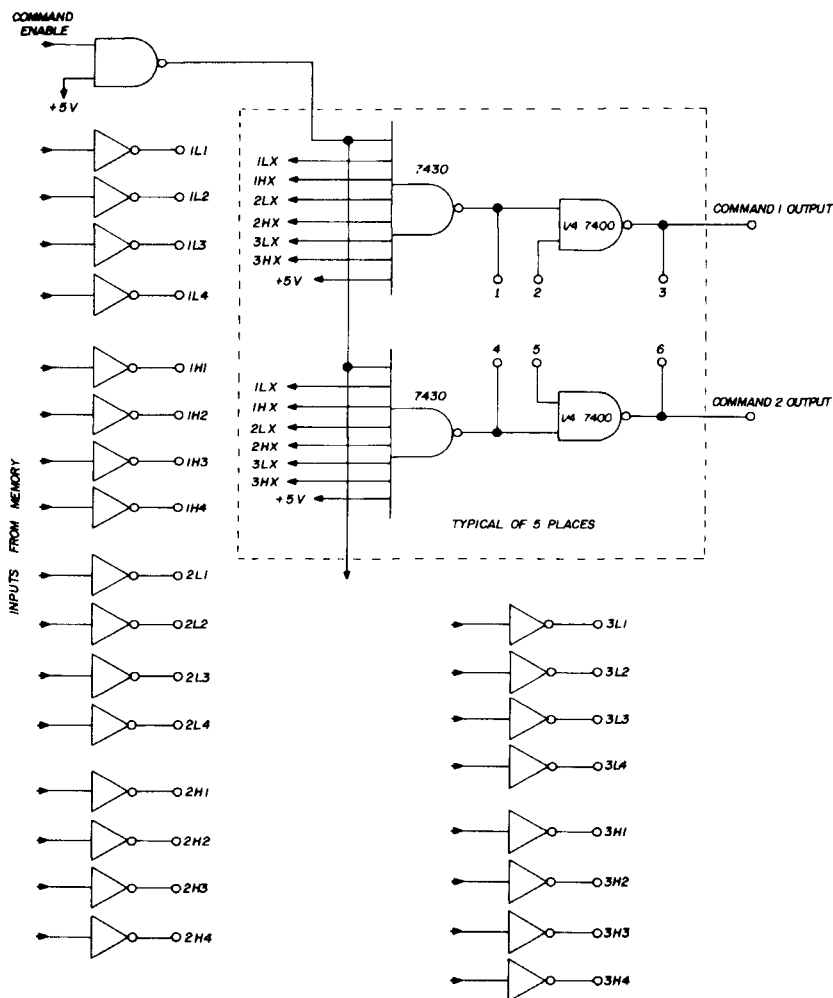


fig. 9. Function module board.

example. Referring to table 1, digit 0 is low-group 4 and high group 2. Run jumpers from high-group tone decoder 2 (1336) and low-group tone decoder 4 (941) to the two-input NOR gate used for access. This is all that is required for access programming.

To program the decoder for specific

the eight-input gate. This programs first digit one.

Referring again to table 1, digit 5 is high-group 2 and low-group 2. Run jumpers from second digit memory outputs *high 2* (2H2) and *low 2* (2L2) to two more of the inputs of the eight-input gate. This programs second digit 5. Digit

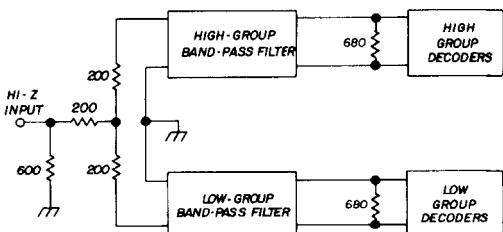


fig. 10. Wiring of the bandpass filters.

9 is high-group 3, and low-group 3. Run jumpers from third digit memory outputs *high 3* (3H3) and *low 3* (3L3) to the last two inputs of the eight-input gate. This programs third digit 9. Now, whenever the access digit is sent followed by 159, the output of this module will go high. Note that if *access digit* and then 519, 951, 195 or 915 or any other combination of these 3 digits except 159 is sent, nothing will happen.

### complete system

The complete unit consists of the sub-assemblies installed together in a box. It was decided to make the unit rack-mountable. In keeping with the easy-to-expand philosophy, it was decided to mount everything except the function modules in one chassis. The function modules were mounted in a separate chassis so that more and more chassis could be added as expansion is required. On the initial model the tone decoders, prefilters, memory, three-digit display and power supply are mounted behind one 1 3/4-inch rack panel.

The three-digit display consists of three of the circuits shown in fig. 4 and are connected to the NOT outputs of the

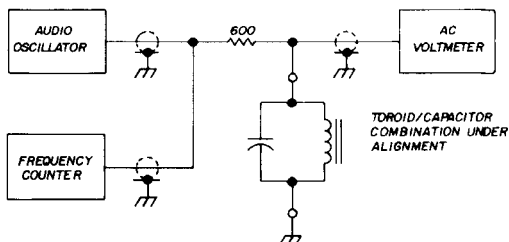


fig. 11. Test jig for tuning up the active band-reject filters.

quad latches on the memory board. Therefore, the display displays the three digits in memory, even if the three digits are not a command. This chassis has a BNC connector for audio input, a fuse, a 9-pin connector for power output and a 25-pin connector for logic output.

Two of the ten-function module boards are mounted behind another 1 3/4-inch panel. This gives 20 functions per 1 3/4-inch rack space. This chassis has two 25-pin connectors, for logic in from the memory unit and logic out to the next function-module unit and a 9-pin connector for power.

Expanding the decoder is simple. Up to ten groups of ten function modules can be added in parallel with each other

table 1. Digit information for programming the decoder.

low group	high group			
	1	2	3	4
1	1	2	3	Fo
2	4	5	6	F
3	7	8	9	I
4	*	∅	#	P

with no other consideration. Adding another set of ten groups can be accomplished by adding inverters between the NOT outputs of the memory and the NOT output of the *command enable* flip-flop and driving this set of ten groups from these inverters. More sets of ten groups can be added as above, until there are a total of ten sets being driven by the NOT outputs.

### summary

As of this writing, three of these decoders have been built. All are in use in different Northern California repeater systems. The unit appears to be very reliable and allows for great versatility in the system.

My profound thanks to Dave Bradley, K6AMA, who did much of the preliminary breadboarding, and to Lance Ginner, K6GSJ, who offered so much skepticism about the unit working, that he forced me to actually build it.

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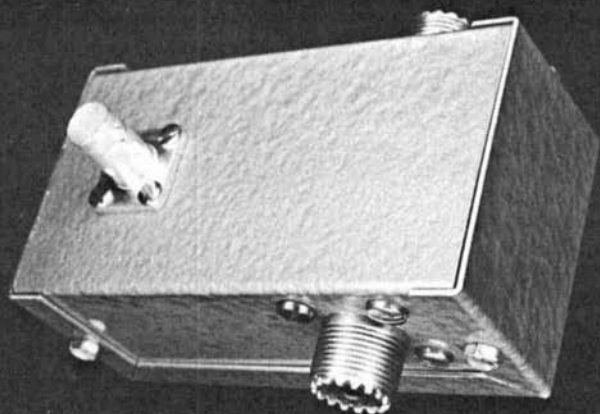


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## rf sampling network — the Milli-tap

This unit allows accurate measurements of rf voltage, vswr, frequency, spectrum and power without materially affecting the vswr on the line

Most amateurs use coax transmission line to deliver their transmitter output to the antenna. While there are many test units that will give an indication of what goes on inside the line — such as directional wattmeters, impedance and vswr bridges — high-quality instruments are priced beyond the operator's pocketbook. Those of lesser quality are not only inaccurate but can themselves upset the transmission

line circuit to compound errors.<sup>1, 2</sup> In an effort to solve this dilemma, the Milli-tap was developed and its specifications disclose the advantages to be gained.

First, its vswr is less than 1.08:1. Hence, it can be put into a line without materially degrading the system. The attenuation to signals in the coax line is virtually zero (the major loss is in the chassis connectors themselves), and the attachment of readout instruments such as vtvm's, oscilloscopes or whatever have no effect on the line operation. The test signal measurement point provides very close to 1/1000th of the coax line signal level across 50 ohms and hence duplicates in miniature the voltage in the line itself. With the recommended parts it can be used with transmitters running the full legal maximum power on CW, a-m or ssb.

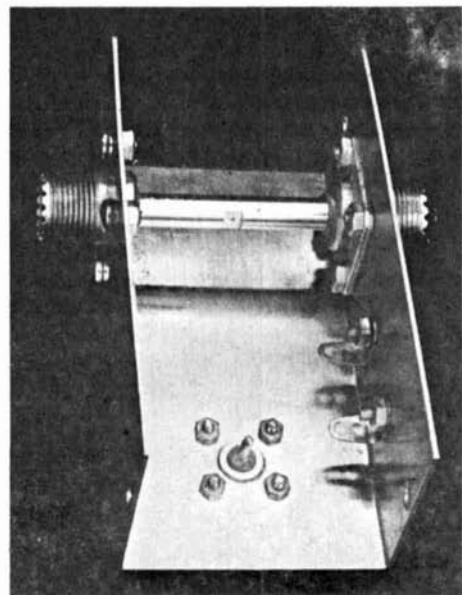
### construction

Construction is made easy by using an LMB "Tite-Fit" aluminum chassis, 4 x 2 1/8 x 1 5/8 inches in size. All of the circuit is constructed in one half of the chassis with the other forming the cover. The drilling layout appears in fig. 1. The heart of the unit is the air coax section, and this is where to begin. Each of the female uhf coax connectors (SO-239) is

Howard F. Sheperd, Jr., W6QJW, Del Mar, California 92014

altered by carefully sawing off the terminal and then filing it to a length of about 1/32 inch. The photograph shows how each will appear when finished. Apply a touch of solder to the stud end, wipe clean while hot and mount in the chassis holes with 6-32 machine screws and nuts. Tighten lightly as the screws will be removed later.

At this point, install the BNC female fitting which will provide the test signal point. In order to stay as close as possible to an impedance of 50 ohms, the brass center conductor rod should be machined from 5/16-inch stock to a diameter of 0.270 inch and a length of 1-16/32 inches. If you do not wish to be a purist, quarter-inch rod can be used, although the overall accuracy will suffer. The center of each rod end is drilled to a depth of 1/16 inch using a number 30 drill. A hole is also drilled in the center of its length with a number 60 drill to a depth of 3/16 inch. Use the edge of a thin file to create a flat notch centered on this small hole to a width of 1/8 inch and a depth of 1/16 inch.



Partially completed assembly with the air-coax center conductor in place.

Heat one end of the rod while holding it vertical and melt enough solder into the end hole to fill it almost to the top. After cooling, do the same to the other end. File away any excess, clean out each hole with the number 30 drill to a depth of 1/32 inch.

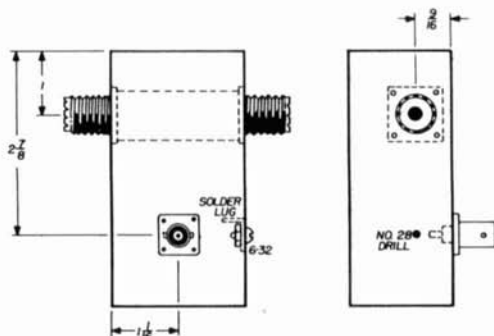


fig. 1. Drilling template for the Millitap.

Next prepare R1 by cutting one lead to 1/8 inch and the other to 3/16 inch. Tin both ends. Heat the center conductor rod with a heavy soldering tool on the opposite side of the center hole and place a very small amount of solder in the small hole. Keep the rod warm and insert the 1/8-inch end of the R1 into the hole until the body of the resistor fits all the way down in the slot. Cool it well without moving the resistor or rod. Clean off any excess solder from the area. Place the rod between the coax plug terminal stubs by first clipping one rod end over the terminal stub and then the other. You should be able to preliminarily position it so R1 is parallel to the back of the chassis and projects toward the test signal terminal. Again heat each end of the center conductor rod until it slips over a coax terminal. Some amount of solder will be forced out of the joint as the chassis box edges are clamped toward each other. Clean it away using a knife or file. The photograph shows the assembly complete to this point.

#### outer conductor

The outer conductor is next cut from

0.003-inch brass shim stock using light-weight tinsnips to form a rectangle 1-26/32 inches wide by 1 31/32 inches long. Carefully drill a hole 1/4 inch from a short edge, centered on the sheet, with

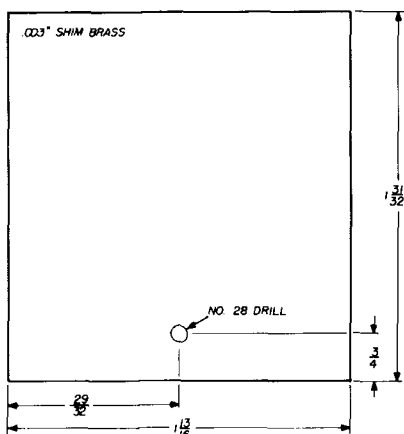


fig. 2. Drilling and cutting template for the outer conductor of the air coax section.

a number 26 drill. See fig. 2 for detail. Using a piece of half-inch dowel or a half-inch drill shank, form the conductor sheet into a cylindrical shape. Remove the nuts and bolts holding the female uhf coax connectors and, after slipping R1 through the hole in the conductor sheet, form it around the shoulders of the connectors. Cut four pieces of solid number 24 to 28 AWG tinned bare wire and pass them around the line assembly, twisting the ends with long nose pliers until the conductor sheet edges meet smoothly. The chassis should now appear as in the third photograph (the upper soldering lug was not used in the final version).

After rotating the uhf connectors so that their holes and the chassis holes align, the outer conductor is finished by applying solder to the point where each of the four retaining wires crosses the gap. Put a generous drop of solder on the top of a hot iron and apply it to the bottom of the outer conductor so that solder will not flow inside the line. After inspecting to see that each retaining wire

is secured to each edge of the outer conductor sheet, use small diagonal pliers to cut the wires on each side of the joints. Replace the nuts and bolts securing the uhf connectors, but this time bend two solder lugs into right angles so that when placed under the top nuts on each connector the flat side of the lugs will be right at the surface of the outer conductor. Solder each lug after the bolts and nuts have been tightened. The air coax section is now finished. Next install the attenuator network R2, R3 and R4 as shown in fig. 3 and the photograph.

The unit is now ready for final testing. This is accomplished by using a voltage source of from 100 to 300 Vdc or a 60 Hz ac voltage which is connected between the inner conductor of one of the uhf plugs and the chassis. Be certain to exercise every precaution to avoid personal contact with this high voltage. Measure this source voltage carefully using the most accurate voltmeter you have available. Next measure the voltage across the BNC test signal point. It should be 1/1000th of the applied voltage (0.1 volt for 100 volts, 0.3 volt for 300 volts, etc.). As resistor tolerances are rather wide and the effects of heating during soldering are unpredictable, an exact

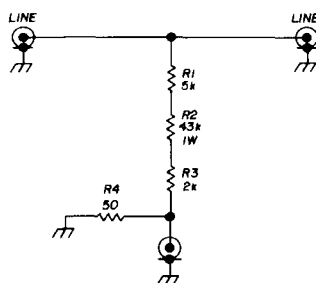


fig. 3. The voltage divider network. All resistors are 1/2 watt except R2 which is rated at 1 watt.

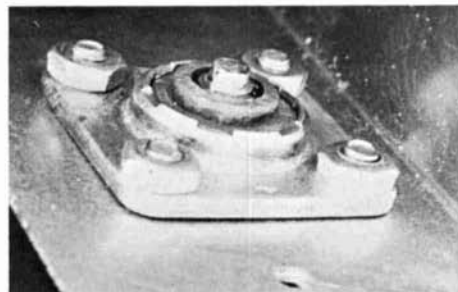
1000 to 1 division may not occur; however, tests with several of these units have shown very close results.

If you are satisfied as to the accuracy of your voltmeter but an exact 1000 to 1

ratio does not exist, change the value of R3 up or down as needed to get the exact division. It should be noted that while this test is carried out with dc or 60-Hz ac, it can be made at any rf frequency and the values of the attenuator changed to obtain even greater accuracy at your frequency of interest. Tests have shown however, that for ranges up to 56 MHz, the dc or ac check is generally sufficient. After testing fit and bolt on the cover portion of the chassis.

## operation

To use the Milli-tap, simply insert it in your coax line at any convenient point near your transmitter. If you wish to check power, load into a 50-ohm non-reactive dummy load and read the voltage at the test signal point on a vtvm with an rf Probe or on an oscilloscope. Most vtvm's are calibrated with rms values. Remember your scope will show peak values. Apply the formula  $P=(1000E)^2/50$ , where E is the voltage measured at the output tap, to determine the power being transmitted in the line. Please note that this power test is accurate only if your antenna feed point is truly 50 ohm non-reactive in nature and you are using true 50-ohm coax or if you are feeding a 50-ohm dummy load through 50-ohm coax. If the foregoing is

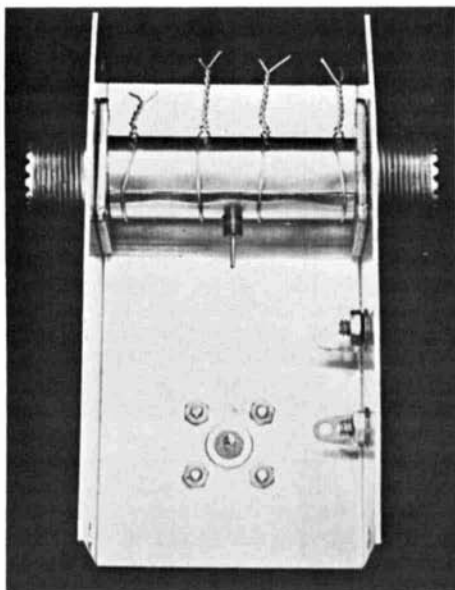


The modified 50-239.

not true, then the actual power cannot be determined without first determining the impedance existing at the point where the Milli-tap is inserted into the transmission line. However, it can be used for relative

power measurements and for other purposes as noted below.

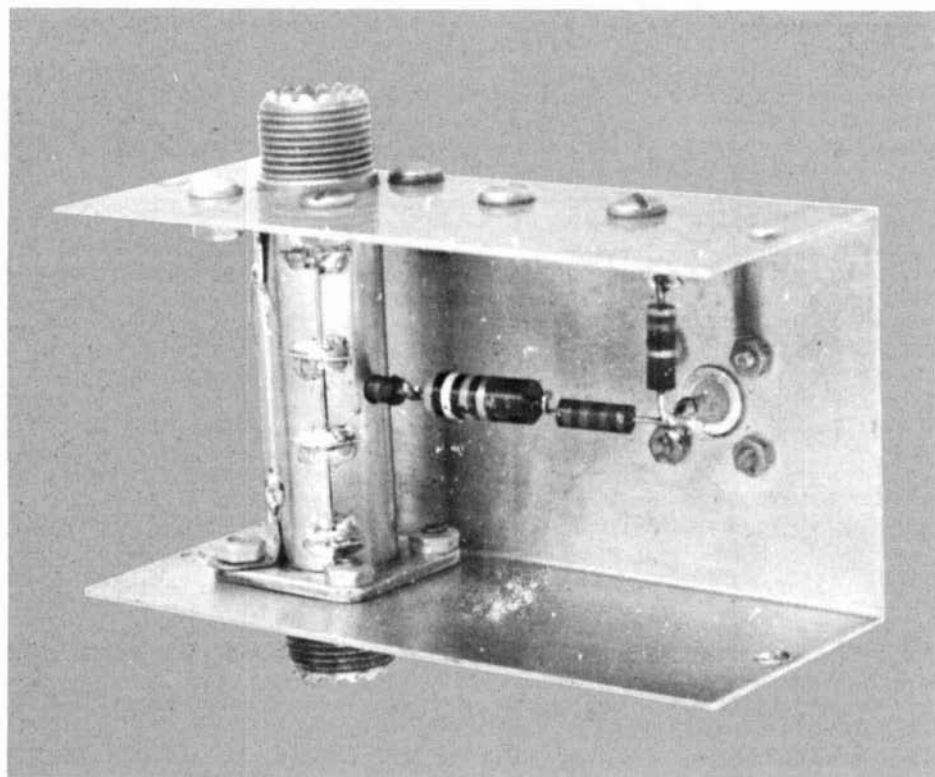
The Milli-tap also furnishes a means of determining vswr by use of two one-eighth wavelength sections of coax line



Construction stage in which the air-coax outer conductor is being formed and held in place by twisted wires. Note resistor R1 which is led through the hole drilled in the sheet brass.

for the frequency to be used which are inserted in the antenna transmission line as shown in fig. 4A. The Milli-tap is then inserted in turn into the three junctions that result, and voltage readings are recorded with a constant power applied to the line in the manner described by Fisk.<sup>3</sup>

Another less sophisticated approach is to utilize a single quarter-wave line section at the frequency of interest, per fig. 4B. Apply some convenient level of transmitter carrier power and read the voltage at signal test point A. Next remove power and move the Milli-tap to the opposite end of the quarter-wavelength section. Restore the same amount of power and again read the voltage. Obviously, if the voltage readings are essentially the same the system being measured is close to a true 1-to-1 vswr. If not, adjustments can be made to the antenna with further



The completed Milli-tap.

measurements to minimize the voltage difference.

An hf oscilloscope can also be connected to the test signal point in order to observe the wave shapes produced by the transmitter or a spectrum analyzer can be tapped in to examine carrier suppression, sidebands, harmonic or spurious signals. Likewise, a sensitive frequency counter can be so connected to monitor carrier frequency. Less sensitive counters may be

used by utilizing an amplifier to raise the level of the test signal to that required by the instrument. Many other test applications are possible and provided the maximum voltage in the coax line itself does not exceed 325 volts rms (which represents over 2000 watts PEP in a non-reactive 50-ohm line). Other test procedures will suggest themselves to the reader, and due to its simplicity, the Milli-tap should give a lifetime of performance.

#### references

1. Louis D. Breetz, W3KDZ, "Possible Errors in VSWR Measurement," *QST*, November, 1959, page 22.
2. Jerry Hall, K1PLP, "Accuracy of SWR Measurements," *QST*, November, 1964, page 50.
3. Jim Fisk, WA6BSO, "Simplified RF Impedance and Power Measurements," *73*, January, 1966, page 20.

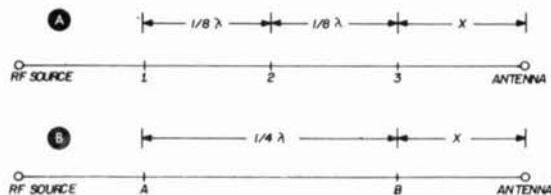


fig. 4. Vswr measurement setup. Junctions 1, 2, 3, A and B are fitted with plug connectors to match the Milli-tap and are bridged with barrel coax connectors.

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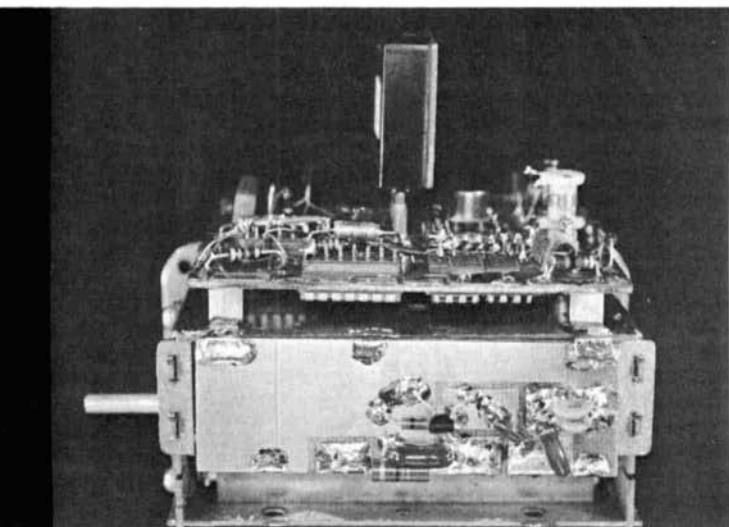
The portability of the "405" is unequalled. Weight is just 2½ pounds and the size 4½" x 7" x 8". The power supply for 115/230 VAC is about the same size and weighs 8 pounds. It is a separate unit so it need not be included in a mobile installation or where 12 VDC is available.

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## tunable six- and ten-meter phase-locked loop

This novel circuit  
is based  
on the use  
of a  
D-type flip-flop

■ Kenneth W. Robbins, W1KNI, Sudbury, Massachusetts 01776

Dual or triple conversion in vhf receivers is a common method of obtaining the adequate frequency stability required in modern communications systems. The crystal-controlled first oscillator heterodynes incoming signals to a lower band where tunable oscillator stability is acceptable. Single conversion using a high i-f such as 9 MHz and a tunable heterodyned first oscillator is another approach. A frequency-synthesized first oscillator is yet a third technique, but currently too costly for ham use. Described here is an inexpensive version of a circuit developed by Motorola.<sup>1</sup>

This circuit uses the unusual properties of a type-D flip-flop operating as a mixer, phase locking a vhf oscillator to a stable broadcast-band vfo. In this unit a vfo, tunable from 0.5 to 1.5 MHz, has a locked oscillator tracking it from 48.4 to 49.4 MHz. This latter signal mixes with 50- to 51-MHz signals and heterodynes them into a fixed i-f at 1.6 MHz (a solid state car radio).

Vhf stability is the *same* as the vfo which can be made very stable and easily checked against broadcast stations. There is nothing special about the various frequencies; these can even be chosen to obtain conversion to 20 meters.

## D-type flip-flop

Since the most intriguing item in this circuit is a D-type flip-flop, some parameter tests were run on a common SN7474N. It performed very well for clock frequencies up to 9 MHz, and with the D input signal, ran up to about 80 MHz. Normal operation causes an odd sort of square wave to be developed at the Q and  $\bar{Q}$  outputs; if the inputs have crystal stability, the beat-frequency output, as measured on a counter, will also have the same stability, even though the scope trace may indicate timing jitter.

Initial checks were carried out using an FT243 crystal on 6.747 MHz and an old General Radio 1001A signal generator. Although it was capable of driving the D input with a necessary minimum 2-volt sine wave, it was found that identical results could be obtained by setting up a 1.3-volt dc bias, and ac-coupling a 0.1 V rms or larger rf signal in. This also simplified the buffer circuitry installed later. Setting the generator on 48.229 MHz produced a 1.0-MHz beat with the seventh harmonic of the crystal at 47.229 MHz. This beat was stable to a few Hz for minutes at a time.

## circuit adjustment

Satisfied with flip-flop mixing performance, my attention next focused on the MC4044P edge-triggered phase detector which requires TTL logic swings for operation. One input is fine as it comes from the flip-flop. The other input, vfo derived, starts out as a low amplitude sine wave and this must be squared up to

\*Complete printed-circuit layouts for the PLL are available from *ham radio* magazine for 25 cents.

table 1. Tuning and crystal chart for receiver local oscillator use.

### direct tracking

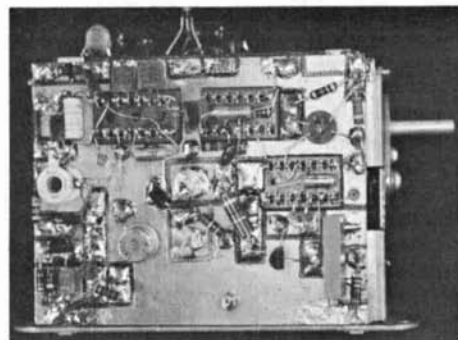
receiver frequency (MHz)	vco (MHz)	crystal (use one) (MHz)
50.0/51.0	48.4/49.4	5.32, 5.98, 6.84, 7.98
51.0/52.0	49.4/50.4	5.43, 6.11, 6.98, 8.15
28.0/29.0	26.4/27.4	5.18, 6.47, 8.63
29.0/30.0	27.4/28.4	5.38, 6.72, 8.96

### inverted tracking

50.0/51.0	51.6/52.6	5.90, 6.63, 7.58, 8.85
51.0/52.0	52.6/53.6	5.41, 6.01, 6.76, 7.73
28.0/29.0	29.6/30.6	5.18, 6.22, 7.77
29.0/30.0	30.6/31.6	5.35, 6.42, 8.02

develop a proper driving signal. One half of a 7413 dual Schmitt trigger was used initially and worked alright, but in the interest of reducing cost and improving isolation, RTL squaring amplifier was used in the final design.

The jfet source-follower dc output level must be optimized. I found that for this circuit correct adjustment for maximum lock range requires the following procedure: Set vfo to 1.0 MHz. Close push-to-test switch, which applies 1.65 V to the gate, then vary source resistor to obtain either 2.6 V on pin 8 of the 4044 or a mid-scale reading on a 5-mA meter



Top view of the vfo printed-circuit board with the FT243 crystal in place. Printed circuit layouts are available from ham radio.\*

(see fig. 1). Next, tune vco to wanted frequency, then release switch.

Phase locking will take hold and may be verified by meter tracking of any further tuning-slug change. Set slug for a mid-scale reading. That's it. Vfo tuning limits will cause a current variation of about plus or minus 1 mA. If a voltmeter is used, pin 8 will be 2.0 V at 1.5 MHz and 3.2 V at 0.5 MHz. Maximum possible swing is 1.0 to 4.5 V.

A pilot lamp and transistor wired as shown in fig. 2 is entirely adequate in lieu

of a milliammeter. A steady full *on* or *off* lamp condition when vco tuning is changed means out-of-lock, while half normal brilliance indicates lock-up. Correct circuit adjustment follows the same procedure as before, first setting up 2.6 V on pin B of the 4044. With the vfo on 1.0 MHz, alternately depress and release push-to-test switch while varying vco tuning until there is no change in lamp brightness. This corresponds to a midscale current meter reading. Lamp glow will change slightly for full vfo coverage.

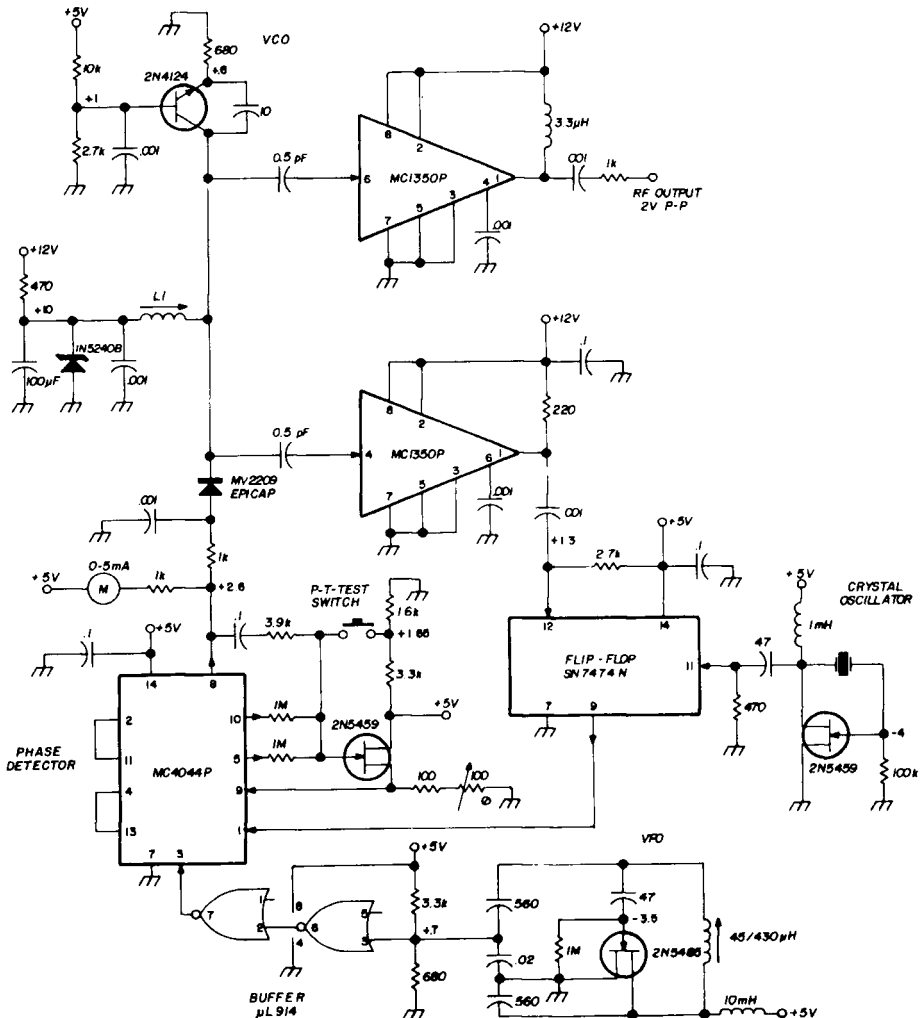


fig. 1. Circuit of the tunable 6- and 10-meter phase-locked loop. L1 is 6 turns no. 28 enameled (48-54 MHz) on a CTC 3/16" slug-tuned form; use 12 turns no. 28 for 26-32 MHz.

A scope connected to pin 9 of the 7474 is very useful in observing the in-lock and out-of-lock square wave present there. Depending upon vco tuning, its frequency will be anywhere from zero to several MHz unlocked, but exactly the same as the vfo when phase locked. RTL buffer output has unsymmetrical fast rise and fall pulses, with edges being in the order of 30 nano-seconds. A pair of inexpensive MC1350P wideband amplifiers provide excellent isolation and amplification of the vco. This oscillator uses only stray capacitance across the tank coil to maximize pull range of the Epicap diode.

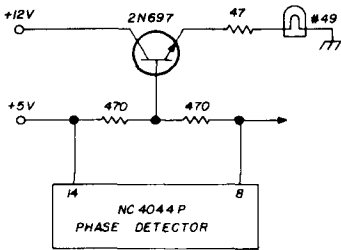


fig. 2. Alternate phase-lock indicator using a number 49 pilot lamp.

The slug-tuned vfo is built from a car radio tuner. Its normal 0.55- to 1.6-MHz spread may be used unaltered, but the high-end signal tends to come through directly on a 1.6-MHz i-f, so this one was fudged to cover .5 to 1.5 MHz. Lacking such an assembly, a Colpitts vfo may be built using a dual-section 420 pF broadcast variable and fixed inductor. RTL buffer drive would be via a link.

An earlier version of this phase-locked loop used a MC4024P dual voltage-controlled multivibrator. One half functioned as a crystal-controlled oscillator while the other half amplified and squared up the vfo signal. Crystal oscillator warmup drift was unacceptable mainly because a high harmonic is used for mixing. Also, chip isolation was insufficient in preventing integral harmonics of the vfo from zero beating with the crystal and developing

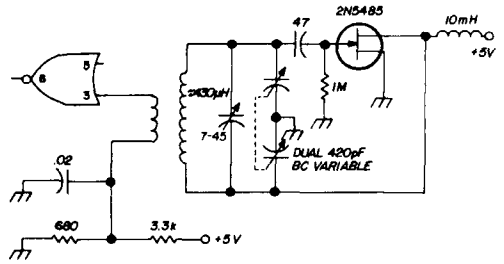


fig. 3. Alternate vfo circuit using a dual-section 420-pF broadcast variable.

enough spurious variation in Epicap control voltage to randomly push the vco frequency around a few hundred Hz. This is because pull range is something like 1 kHz/mV. Therefore, control signal purity is extremely important.

### circuit operation

This circuit, in a room temperature environment, has frequency drifts from start-up amounting to about 3 Hz for the crystal oscillator and not more than ten times that for the vfo. Total drift of the locked vco is less than 50 Hz at 48 MHz; a few half-hour runs made during testing checked out at about 38 Hz. For minimum waveform distortion, the untuned buffer should work into a moderate impedance of a few kilohms such as the resistive-loaded input of a dual-gate mixer. The buffer may have a tuned tank and link coupled output if you desire.

Wired as shown, signals at pins 1 and 3 of the phase detector produce direct tracking. That is, as the vfo moves up in frequency, so does the vco. If these leads are interchanged, tracking inverts and this mode may be useful, depending upon

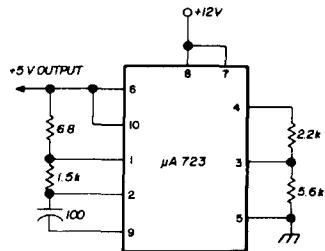


fig. 4. 5.0-volt regulator for the PLL.

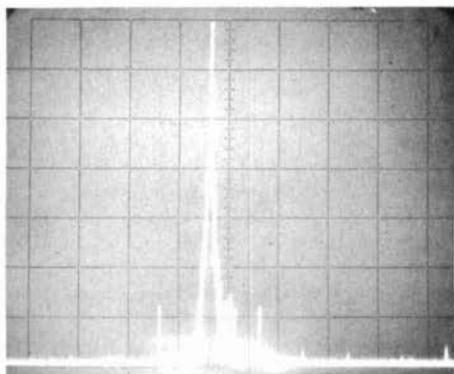


fig. 5. Rf output of the PLL at 50.5 MHz.

what crystals and frequencies are involved. To see how this works, refer to the tuning and crystal chart in table 1 which shows 6- and 10-meter local oscillators in conjunction with a 1.6-MHz i-f and a vfo tuning from 0.5 to 1.5 MHz. There are many possible crystal combinations; only those within the 5- to 9-MHz spectrum have been listed.

Other intermediate frequencies and vfo ranges can be worked out as well as frequencies for transmitter vfo use. It is advisable not to go too low in crystal frequency because of possible mode jumping. Harmonics are less widely spaced and, with the lowpass filter having a time constant of about 1/4 second, any fast transient in the tuning diode network can cause it to shift the vco out of one lock and into an adjacent lock before servo action can pull it back.

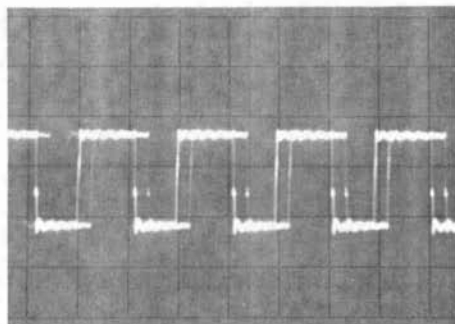


fig. 6. 1 MHz phase-lock signal at pin 8 of the MC4044P phase detector. Signal is 2 volts peak-to-peak.

If test equipment is available to monitor the phase-locked loop, an informative experiment can be run to induce this malfunction by using a low-end 80-meter crystal, vfo set near its high end, vco locked, and rapidly changing the vco slug tuning. These worst-case factors are absent in normal operation, of course, but confidence in the circuit is gained by being aware of its limitations and operating within such bounds.

An additional tradeoff for simplicity is that each 1-MHz tuning range will require another crystal as shown on the chart. Frequencies listed do not have to be matched exactly; vfo dial calibration will take care of it. One exception appears in the transmitter control list (table 2) where a single 5.500-MHz crystal serves for the first 1 MHz on 6 and 10 meters.

table 2. Crystal chart for using the phase-lock signal for transmitter control. The 48-MHz output may be multiplied three times for use on 144 MHz.

vco output MHz	crystal frequency MHz
50.0/51.0	5.50, 6.18, 7.07, 8.25
51.0/52.0	5.61, 6.31, 7.21, 8.41
48.0/49.0	5.27, 5.93, 6.78, 7.91
48.33/49.33	5.31, 5.97, 6.83, 7.97
28.0/29.0	5.50, 6.87, 9.16
29.0/30.0	5.70, 7.12, 9.50

## summary

The engineers at Motorola have certainly come up with a very clever circuit that should find its way into many hf and vhf amateur-band receivers because of low cost and high performance. It should also make a dandy low-drift and stable transmitter frequency control. In addition, the PLL technique neatly sidesteps problems of spurious emissions due to unwanted mixer products getting into the output signal..

## reference

1. Treadway and Reed, "Generate Stable High-Frequency Signals," *Electronic Design*, 6 January, 1972.

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Gene C. Berrier K5RTA  
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The carrying case was pretty torn up and the antenna was snapped off right at the case. I returned home and hooked it up in the car and it works like it always did.

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Gene C. Berrier



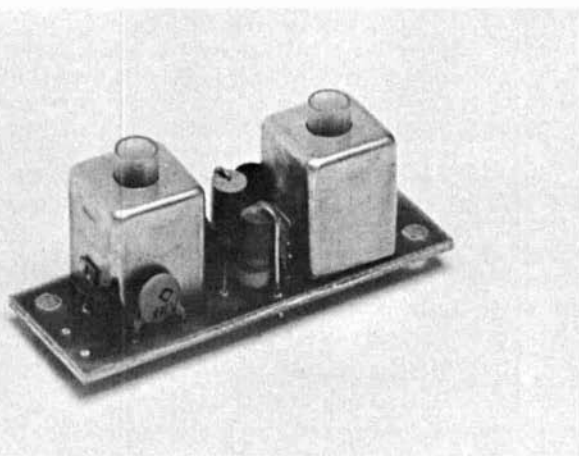
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## improved six-meter preamplifier

A six-meter version  
of a popular  
two-meter unit  
along with hints  
and improvements  
for both units

Jerry Vogt, WA2GCF, Rochester, New York 14612

In an article entitled, "Improved Two-meter Preamplifier," which appeared in the March 1972 issue of *ham radio*, I described an easy-to-duplicate, non-neutralized two-meter preamplifier and offered to make kits available to other amateurs. The response to the article was overwhelming. Apparently, there is quite a need for such units; something which comes as no great surprise. Among the replies received were many interesting notes describing experiences of others in trying to build preamps for a variety of uses.

Of course, I did my best to answer the many questions received including the numerous requests for information on adapting the two-meter unit to 50,220 and 432 MHz. The mail prompted not only the design for the new six-meter preamp described here, but also some additional work in refining the existing two-meter preamp. Among other things, the overall size was reduced by half, and



the input circuit was made considerably sharper to provide additional out-of-band rejection. The six-meter preamp in this article reflects the refinements developed for the new two meter unit.

The schematic of the six-meter preamplifier is shown in fig. 1. The design parameters are essentially the same as previously detailed in the March issue. Suffice it to mention that the circuit is an ac-coupled cascode configuration, without the need for neutralization. Therefore, anyone can tweak it to his heart's content, without throwing it into oscillation.

In construction, the six-meter preamplifier is very similar to the one described and illustrated in the previous article. The unit is built on a printed-circuit board, with one shielded coil at each end and the junction field-effect-transistors with their related parts in the center. Coils are a special adaptation of a commercial plastic coil form which is not generally available to amateurs and use 10-32 slugs made of iron 9 material. The preamp may also be made with other coil forms and shields; however, the tricks are to establish a good layout for shielding and to discover how many turns of wire are required. The diligent experimenter with a vhf signal generator and an rf millivoltmeter of some sort should have no great difficulty if he observes normal vhf construction techniques.

For the amateur not so well equipped or the experimenter who doesn't wish to re-invent the wheel, kits and wired units are available, complete with detailed con-

table 1. Component values for six- and two-meter preamplifiers. All capacitances are in picofarads.

	50 MHz	145 MHz
C1	20	5
C2	50	20
C3	270	270
C4	680	270
C5	15	5
C6	82	20
L1 (10-32 form)	8.5 t.	3.5 t.
L2,L3	5.6 $\mu$ H	1.0 $\mu$ H
L4 (10-32 form)	10.5	4.5 t.

struction information.\* Clubs may wish to obtain kits for construction as a group. This type of project has been tried in this area with projects much more involved than this, and they have been very successful. Table 1 lists coil and capacitor data for the preamp. Although you may not duplicate the parts exactly, the table should serve as a guide for selecting alternate components.

### test setup

Several readers have asked how to make a test setup for tuning the preamps after construction. As you might imagine, I use quite an elaborate setup, including an HP-608 signal generator, a specially-developed solderless test fixture with spring-loaded pin contacts and an rf millivoltmeter. The fixture includes a built-in 100-ohm load resistor and a built-in detector circuit although a resistor at the end of your coax cable or soldered to the board will also work. An

\*The following are being made available in conjunction with this article. Both 6- and 2-meter models are available; so *specify which you want*. A complete parts kit, including drilled printed circuit board, all components, and complete instructions for construction are available at \$6.00, postpaid. Completely built and tested preamps are available at \$10.00, postpaid. Special frequencies between 25 and 170 MHz are available at \$12.00, postpaid. Special Factory built preamps (only) may be returned for repair for a fixed repair charge of \$3 (prepaid) if trouble develops within 90 days (usually damage incurred during installation). Quantity prices are available to clubs and individuals. Contact Hamtronics, 182 Belmont Road, Rochester, New York 14612.

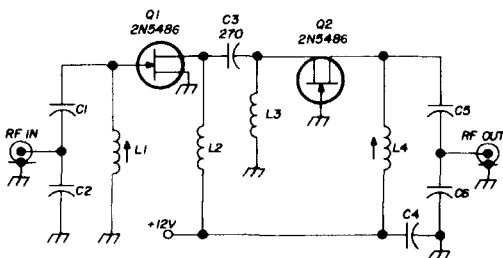
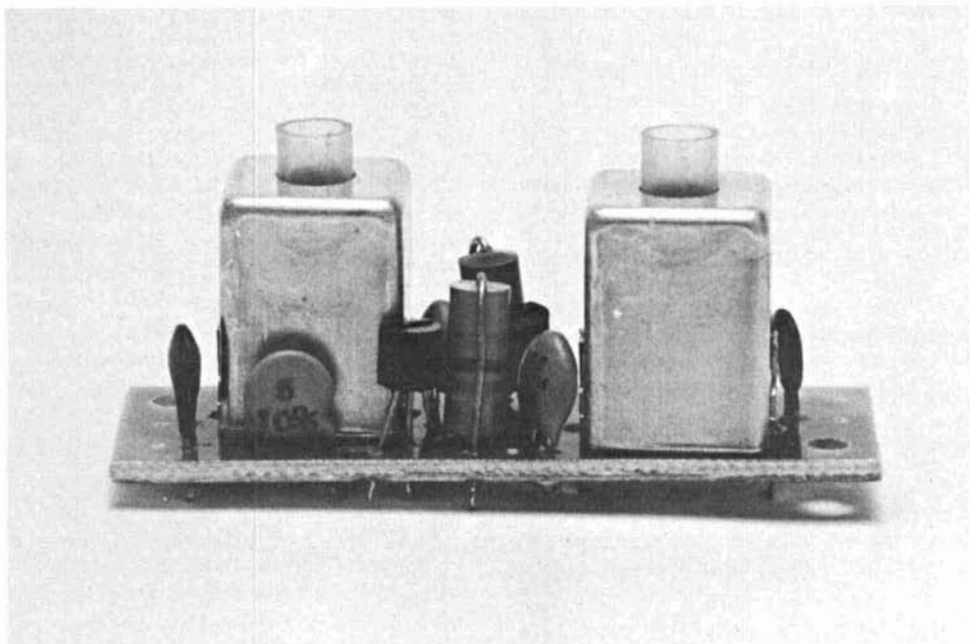


fig. 1. Schematic diagram of the six- or two-meter preamplifier. Parts values are listed in table 1.

rf probe of the type shown in the *ARRL Handbook* will work well for initial coil peaking if you have a very sensitive vtvm (on the order of 100 mV full scale). The important thing is to keep all leads extremely short.

careless in completing the installation in your set. I have had people tell me that they had shorted coax cables, high voltage across the 12 volt input line, coil windings wired to the wrong points in the circuit and other assorted accidents. Tran-



The preamp is built on a small printed-circuit board just over 2-inches long. This photograph is nearly twice actual size.

I use a 100-ohm load instead of a 50-ohm load, since I've found that most receivers present a greater than 50-ohm load to the preamp. Since any high-gain amplifier will take off if you don't load it properly, I do all testing with the high load resistance. There is plenty of reserve gain in the preamp due to the cascode design; so that even if loaded down to 50 ohms or less by the few receivers which do present that low a load, there is ample gain to mask out the noise in the front end of your receiver and improve the sensitivity.

### hints

After you have built your preamp, I suggest that you take a good look at some of the hints and kinks in my previous article. You would be surprised at the problems you can generate if you are

sisters are very unforgiving; so check everything before firing it up for the first time, especially in the set. Don't wire it into your transmit rf line (easy to do with a transceiver), don't wire with hook-up wire in lieu of coax (its been done) and don't use a dropping resistor from your 200-volt line without a zener diode (that's been done, too). Look into the power supply section of any good handbook for zener diode regulators if you want to derive your 12 volts from a high voltage line. Handbooks give you all the details on doing it. Make sure that you anchor the preamp down to your set's chassis or case — don't let it rattle around.

I hope that some of these suggestions will help to keep you out of trouble and in good spirits. Have fun with your souped-up receiver.

ham radio

# SBE

## SCAN-VISION

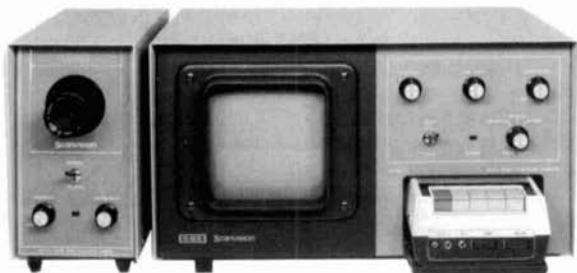
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# zap that transient

How to use  
transient suppressors  
to protect sensitive  
solid-state components  
from high  
voltage pulses

Carl C. Drumeller, W5JJ, 5824 N.W. 58 Street, Warr Acres, Oklahoma 73122

No, this is not a dissertation on killing bums or hitchhikers! Rather, it is some advice on preventing transient voltage surges from killing your solid-state components. These surges, which have a duration normally measured in microseconds or, at most, in milliseconds, still can be deadly to devices that have a limited puncture voltage rating. And that takes in most solid-state components!

Transient high-voltage surges come from so many sources and are so easily (universally?) generated that they are inescapable facts of life which one must expect to live with — and to cope with. They can be originated in either dc or ac circuits, and most often get their start in a brief but destructive life by either the closing or the breaking of a circuit having a flow of current. If, for instance, that circuit contains some inductance, breaking the current flow causes a collapse of the lines of force about that inductor, generating a voltage pulse that can range to surprisingly-high values.

How high? Ten times, if there are no limiting conditions present. That means the innocent-appearing 117-volt power line feeding your power supply transformer can be the source of a pulse peaking at 1170 volts! Usually, though, and we can be thankful for this, there are factors present that limit such wild excursions to a little over twice the normal voltage. But don't bet your transistors

and diodes on Lady Luck always riding your shoulder; she's notoriously fickle! Those fortuitous circumstances that save our necks (and diodes) usually take the form of intentional or accidental capacitances, resistances and inductances that serve to soften the abrupt thrust of the escalating voltage. A transformer is an excellent example. Fortunately, it's less expensive to produce a power transformer with a poor frequency response; therefore, our 60-Hz transformers simply balk at passing those high-frequency components of the steep wavefront of a transient pulse. Then, too, the effects of turn-to-turn and layer-to-layer capacitance add soothing and smoothing.

If, however, you're using a rectifier connected directly to the power line (a dangerous practice itself), there's no transformer to protect your diode; so you'll have to rely on other factors such as the cold resistance of a 117-volt pilot lamp across the line. There are many circuits, usually involving capacitors and resistors, that help to swamp out the undesired surges.

### transient suppressors

To do the job right, though, you should consider some of the devices marketed especially for transient suppression. The trademarks vary with the manufacturers, of course, but these suppressors can be classified into three categories: spark gaps, capacitors and non-linear resistors (including semiconductors). Let's ignore the first two and concentrate on the last one. In this category, you're looking for a resistor that, for the voltage normal to the device you want to protect, offers a very high resistance. For voltages somewhat higher than this normal value, though, you'd like for the resistor to present a very low resistance and to be able to handle (for a few milliseconds) a very high current.

Sounds like cloud nine dreaming, doesn't it? Yet, there are quite a number of such varistors available. They may be made of silicon carbide, they may be

silicon zener diodes, they may be selenium diodes or they may even be gas discharge tubes. Other types exist, but manufacturers do not like to reveal their exact compositions.

An ordinary resistor obeys Ohm's law:  $E = IR$ . A varistor, however, follows a variation which looks like this:  $I = KEa$ ,

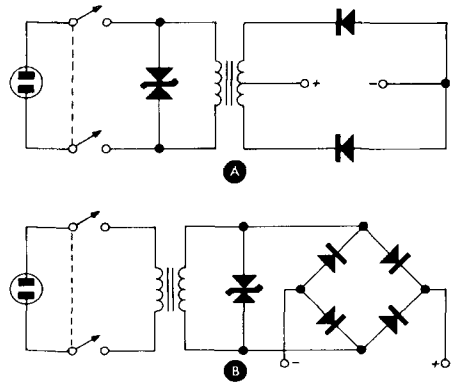


fig. 1. Using transient suppressors for effective protection of solid-state components. In (A) varistor is installed in the primary of the power-supply transformer. In (B) the varistor is connected across the secondary winding.

where  $K$  is a constant dependent upon the composition and size, and  $a$  is what you might call the figure of merit for its performance as a varistor. This is unity for a normal resistor, of course, and may be as high as 70 for some of the better designs. Even the run-of-the-mill varistors have an alpha of five or better. So, as you can see, the current that varistor will drain off really shoots up as you raise the voltage.

Most, but not all, varistors have a knee in their I-E relationship. Below this knee, the varistor may behave more or less like a normal resistor. Above the knee the alpha factor becomes evident. You'd like, of course, to have a varistor with a sharp knee just above the highest voltage you expect to encounter in normal operation of the circuit to be protected. By consulting the curves provided by the several manufacturers of varistors, you can select

one with suitable characteristics. These curves need to be read with care, though, as they can give illusionary information when either the ordinate or the abscissa scale is depicted in other than the units directly applicable to the intended use. Curves plotted on log-log graphs are the least likely to be misleading.

### commercial transient suppressors

Several manufacturers produce varistors, each identified by a registered tradename. General Semiconductor Industries Inc., calls their devices Trans-Zorbs. These are silicon semiconductors, and, although their mode of operation is not given in the literature, I suspect that they're zener diodes. Packaged in either metal or plastic, they look like small diodes. For up to 1/120th of a second, which is much longer than the duration of a transient, they'll handle 200 amperes. You can buy them for protecting circuits carrying dc voltages from 5 to 190 volts. For a 5-volt logic power supply, you'd want the ICTE-5, which sells for \$4.50 in single quantity. For 15-volt ICs, the 1.5KE16A, at \$2.30, would do the job. The 24-volt 1.5KE27 is the same price. For protecting the input side of a power transformer, the 1.5KE150, costing \$2.50, would serve. These can be purchased from General Semiconductor at 230 West Fifth Street, Tempe, Arizona 85281.

International Rectifier uses the trade mark *Klip-Sel* for their transient killers. As you might suspect from the name, they're selenium cells of special design, and are available in either polarized (for dc circuits) or nonpolarized (for ac circuits). Allied Electronics, 100 North Western Avenue, Chicago, Illinois 60680, is one of the firms that will sell *Klip-Sels* in single quantity. Because of the rather high minimum voltage at which a selenium cell starts conduction, *Klip-Sels* are best adapted for use in the primary, 117-volt side of power supplies. A polarized *Klip-Sel*, KSA6DPF, suitable for such an application, costs \$6.25. For moderate power, the KYP6DPF at 83

cents will do the job. This is pretty cheap diode insurance.

The varistor most recently marketed is the *GE-MOV*, which is of the metal oxide type, combining both high alpha and small physical dimensions. Because of the range of voltages in which it is available, 150 to 1000, it is suitable for use in the primary circuit of stepdown transformers or either the primary or secondary circuits, within voltage limitations, of step-up transformers. The *GE-MOV* will handle extremely high short-duration current peaks, well above 1000 amperes. This capability is coupled with quite low costs. The VP130A10, which is adapted for use in 117-volt circuits, is priced at \$1.80 in single-lot quantities. It may be purchased from any of the General Electric distributors, which are located in most large cities. Newark Electronic, 500 North Pulaski Road, Chicago, Illinois 60626, is a centrally located source.

All of these varistors have one application characteristic in common: they are selected not to start conduction immediately upon a voltage excursion just above normal, but to exert their full clamping effect at approximately 2.5 times the applied rms voltage. Thus, there is no appreciable power dissipation in the varistor under normal operating conditions or for very mild transients. Of course, you recognize the presence of these mild transients; that's why you normally specify and use solid-state rectifiers that are rated at several times the expected voltage.

Now that you know just about all you need to know about a varistor, there might remain one question: Where do you use them? The accompanying schematic diagrams show the answer. There's one problem in drawing these diagrams; each manufacturer uses a different symbol to identify his product. I've selected one, but this selection by no means is to be taken as a recommendation for that manufacturer's product over the others. They're all good, all effective, all worthy of being in every power supply.

ham radio

# solving overload problems

## with vhf converters

Straightforward ideas  
for locating  
and fixing  
pesky overload  
problems  
in high-performance  
vhf converters

For many hams, especially those out in the wide open spaces, the main problem in vhf receiving equipment is to hear *something*. The average ham's thinking on the subject of sensitivity and noise figure is a lot clearer than it was twenty years ago, and sensitive receiving equipment is standard these days. However, when the vhf bands open and the ham across town comes out from under his rock and fires up his two-meter kilowatt, another problem shows up: overload. It's serious in

New England when those guys are slugging it out from the mountaintops at contest time, and a major problem in North Jersey about any time the band is good. If we had a clear idea of what's causing the trouble maybe we could fix it. Let's try to sort out the causes of the problem.

One is the other guy's lousy transmitter. To prove that the trouble is from this cause, you need to show that the strength of his signal is *not* the important factor. An attenuator, or simply turning the beam so that he's knocked down to a reasonable level, will check this factor. If, at a mild S9 level, he still has splatter and buckshot all over the next two hundred kHz, maybe you should call him on the telephone and complain. Usually, attenuating his signal fixes things pretty well, and that implies that you have work to do on your receiving apparatus, even if he *is* overmodulating.

Which brings us to overload in the converter rf stage. My own experience is that less rf gain is better, but that the particular kind of device you're using in the front end (tube, fet or bipolar transistor) has only a minor effect on the problems most vhf amateurs have — which kind only matters when other effects are reduced by ten or a hundred times. I *do* know that the problem can be licked, i.e., we can make low-noise preamps which will show no trouble from

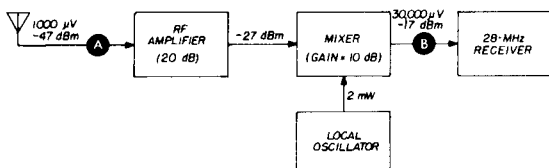
Hank Cross, W100P, 111 Birds Hill Avenue, Needham, Massachusetts 02192

strong signals until the stages following have completely overloaded.

## the mixer

As any sideband type can tell you, an

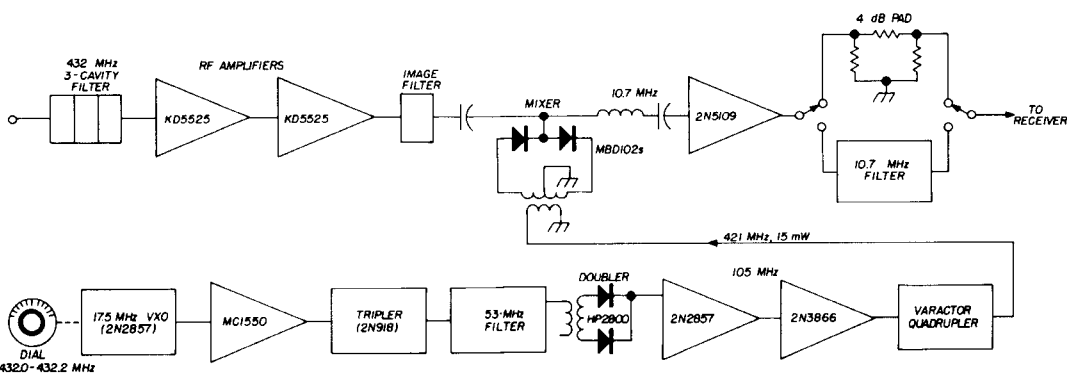
**fig. 1. High-performance vhf receiving setup.** The attenuating pad at A checks the other guy's transmitter. The pad at B determines whether the overload problem is in the converter or the receiver (see text).



amplifier which puts out about ten watts as a linear amplifier will flat-top at around a watt when used as a mixer. Transistors do this, too, and that means that the mixer overloads before the rf stage. Diode mixers or fet mixers will handle more input signal; they also take more local-oscillator drive. Anzac lists a double-balanced mixer (MHSM-3) which is linear within one dB up to 30 milliwatts, provided you have 200 milliwatts of local-oscillator power. (Conversion loss is 9 dB.) The first i-f amplifier, of course, must be linear with four milliwatts of

on the lower bands. The R390, BC348 (with the original amount of rf gain), BC342 and RBC are particularly good. (The only amateur communications receiver I can say that about is the original Collins 75A.)

Intermediate frequency (the converter's output frequency) also has a bearing on the results: most receivers have better rf selectivity at, say, forty meters than on the ten-meter band, so the usual receiver following a c-c converter will have overload trouble plus or minus 50 kHz at 7 MHz, say, and  $\pm 100$  kHz at 14 MHz and



**fig. 2. The 432-MHz vxo converter used by W100P.** The MC1550 IC is used as an amplifier-limiter to level the 17.5-MHz output from the vxo.

input signal! The stage after *that* is beyond the scope of this discussion.

If you use a crystal-controlled converter which passes a relatively wideband (if all the QRM is within a 200-kHz wide band, *that's* relatively wide) the receiver following is possibly a source of trouble.

200 kHz or more on 28 MHz. Some receivers used in combination with a high-gain converter should have a pad (6-dB for instance) between the converter output and the receiver input. A switchable pad (Kay or Waters) installed between converter and receiver is a good



thing to try. If attenuation helps, there must be an optimum value.

For the special case of a band where all the activity is within less than 200 kHz, there is an excellent solution: Vary the frequency of the first oscillator, and put a crystal filter in as early as practical at the first i-f. At 432 MHz I used a vxo which had up to 400 kHz of range. With about 20 dB of rf gain, it seemed reasonable to use a crystal mixer followed by a

obviously a maximum value of signal that can be amplified linearly. The *output* compression point, for a vhf amplifier, depends mostly on current and load resistance. For low-level amplifiers, the bias point is usually optimized for noise figure.

If a survey is made, you will find that optimum NF for most vhf transistors occurs at currents between 1 and 5 mA. Among these, those which exhibit a given

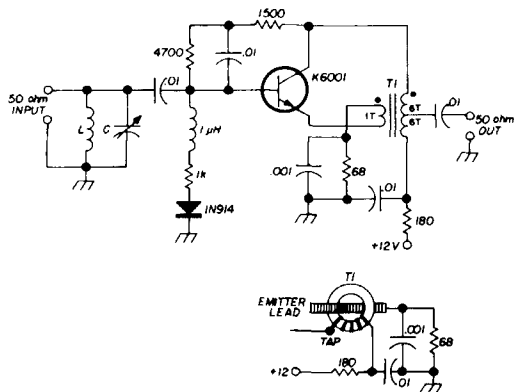


fig. 3. Vhf feedback amplifier for 144 MHz. Without the tuned circuit at the input performance is only 3 dB down on 50 and 220 MHz. Gain is about 15 dB on two meters, noise figure is 1.5 dB at 15 mA. Transformer T1 is 6 bifilar turns on Ferroxcube 1041CT 3E2A core. Keep the emitter lead as short as possible.

low-noise high dynamic range first i-f amplifier which in turn fed a 10.7 MHz filter (four crystals) before the second conversion. The crystal filter was arranged so it could be switched in and out of the signal path, (with a 4-dB pad replacing it to keep levels the same). It was easy to tell if it was of any benefit. It was. See fig. 2.

### amplifiers and overload

Let's think about an amplifier. It has some value of gain. It has a noise figure. And it has, for one way to specify it, a "one-dB-compression point." If we assume that the amplifier is exactly linear up to, say, ten milliwatts output, and that it limits sharply at that point (flat-tops) then as we run the input signal up to the limiting level and 1 dB beyond, the gain will be 1 dB less than for a signal low enough to stay within the linear range, i.e., it is compressing by 1 dB.

For a particular value of gain, there is

NF at higher current are preferable. Some types, which have optimum NF at 1 to 2 mA, may still be very quiet at 5 to 15 mA. One commercial transistor (2N5109) has good NF from 1 to 15 mA, best usually at 3 mA, but specified as 3 dB max at 200 MHz at 10 mA. In terms of signal-handling capability and noise figure it compares favorably with a fet.

Somewhat higher priced types (MS-175, K6001) will give 1.5 dB NF at 15 mA at 150 MHz. In a feedback amplifier gain is 15 dB and the output compression point is over 20 milliwatts (see fig. 3). At 2 mW out, that is, two two-milliwatt signals, the in-band intermodulation product (third-order product) is more than 40 dB down. Such an amplifier is still operating with good linearity when succeeding stages are overloading, and therefore, there is little point in worrying about how to further improve the *first* stage.

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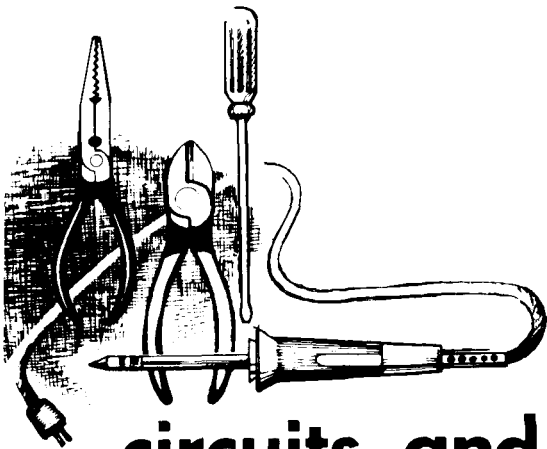
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# circuits and techniques

ed noll, W3FQJ

## antenna tuning units

Antenna tuners come in a variety of different sizes, circuits and tuning arrangements. Most are homemade, but some commercial units are available, including the low-power Ten-Tec AC5, and the higher power Johnson Matchboxes and Drake Matching Networks.

Antenna tuning units are used primarily for transmission-line impedance conversion (high to low or low to high), but they may also be designed for converting from one type of feedline to another (balanced to unbalanced or vice versa).

Three very common applications for antenna tuning units (or ATUs) are shown in fig. 1. The impedance at the input end of the coaxial transmission line is matched to the output impedance or the transmitter. This may be an unbalance-to-unbalance match such as shown in figs. 1A or 1B, or an unbalance-to-balance match as illustrated in fig. 1C.

The antenna system impedance can be several times higher (or several times lower) than the transmitter impedance, and a good match can still be obtained with a relatively simple circuit such as the L-network, pi-network or T-network shown in fig. 2. I personally prefer the T-network.

The L-network in fig. 1B is the most common antenna tuner configuration for matching random-length, single-wire antennas. The multiple tapped coil accommodates the random wire length over a wide span of operating frequencies. The variable capacitor sets resonance and influences the impedance ratio needed for satisfactory matching.

The arrangement of fig. 1C links a balanced antenna and transmission-line system to the low-impedance and unbalanced output of a transmitter. Resonant tuning is provided by the split-stator variable capacitor, while impedance matching is mainly a function of turns ratio and coupling between the separate coils.

## atu circuits

A simplified circuit for the Johnson kilowatt matchbox is shown in fig. 3. An untuned link, L1, transfers transmitter

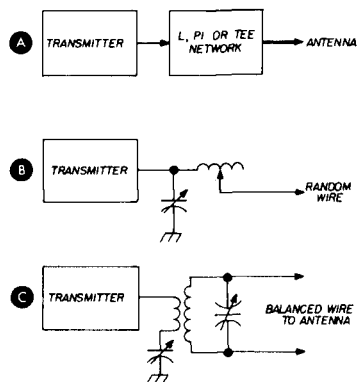


fig. 1. Common applications for antenna tuning units.

output power to a multiturn and band-tapped secondary coil, L2. Resonant tuning is the responsibility of variable capacitor C1. Loading and matching are handled by the dual-differential capacitor C2.

The Johnson Kilowatt Matchbox matches balanced antenna system inputs between 50 and 1200 ohms, and unbalanced, between 50 and 200 ohms. This is not to say that the tuner can be used to match low impedance antennas (impedances lower than 50 ohms). If you want to match a very low impedance antenna, such as a beam, without an antenna matching section, you can still obtain proper matching to the transmitter by using a transmission line of a proper overall length. A very low impedance

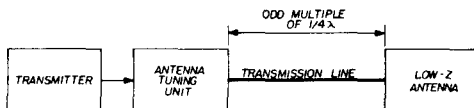


Fig. 4. Tuning a transmission line attached to a low-impedance antenna.

various components of an antenna tuner, it can be made to have added versatility as shown in fig. 5. This arrangement also includes a tuned primary for further optimizing performance and obtaining an exact impedance match. In this circuit the impedance of the parallel resonant circuit can be made high, medium or low, depending upon how the terminals are interconnected.

A low-C parallel circuit is obtained by

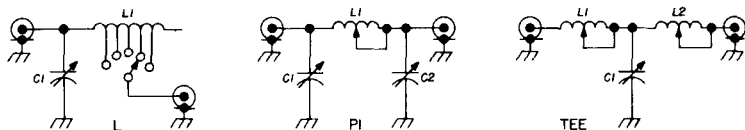


fig. 2. Three basic antenna tuner networks, the L, the PI and the T.

antenna can be made to reflect an impedance higher than the characteristic impedance of the transmission line by using an overall transmission-line length that is some odd multiple of a quarter wavelength, fig. 4.

Keep in mind that a mismatch at the antenna can be reflected to the receiving end of the transmission line as an impedance higher or lower than the surge impedance of the line by regulating the overall length of that line.

### balance-to-unbalance versatility

If leads are brought out from the

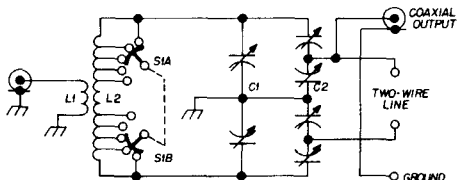


fig. 3. Partial schematic diagram of the Johnson Kilowatt Matchbox.

connecting series-connected capacitors in parallel with the coil. This can be done by joining 1C and 2A. The transmission line is attached by joining 1A to 1B and 2C to 2B. A high-C matching resonant circuit is obtained when 1C is linked to 2C and 2A to 1A. Output is again provided by connecting 1A to 1B and 2C to 2B.

In low-impedance series tuning, the capacitors must be connected in series with the coil. To do this you need only connect 1B to 1C and 2B to 2A.

### unbalanced-to-unbalanced T-tuner

The T-network is an excellent tuner for an unbalanced system. It has great range and versatility and can be used to match almost anything connected to the antenna end of a coaxial feed line. It will also function in the same manner when matching a random length of antenna wire as well as a Windom antenna, fig. 6.

The T-section antenna tuner is basically a low-pass filter consisting of two

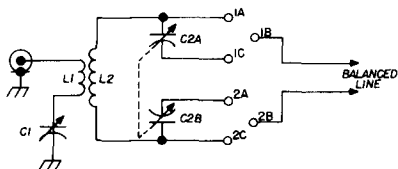


fig. 5. Versatile antenna tuning circuit for balanced transmission lines.

series-connected inductors along with a capacitor connected between their junction and ground as shown in fig. 2. Although there is some interaction between the two coil sections, L1 and L2, the value of L1 has a significant influence on the matching between the antenna system and the tuner, while inductor L2 has a greater influence on matching between the tuner and the transmitter. Interaction between the two coil sections can be minimized by mounting them at right angles to one another. Capacitor C1 establishes the proper resonant condition and, if adjustable, acts as a fine tuning adjustment.

For a specific case of matching on a particular frequency, the basic equation of the T-network is:

$$X_{C1} = \sqrt{Z_{IN} R_T}$$

where

$Z_{IN}$  = the input impedance to the line, and

$R_T$  = the output impedance of the transmitter.

Multifrequency and multi-band operation requires the inductors be tapped and the capacitor made variable. Two seven-position switches permit operation on bands 1.8 to 54 MHz. Each coil consists of 30 turns of number 14 wire, 2-5/8-inch

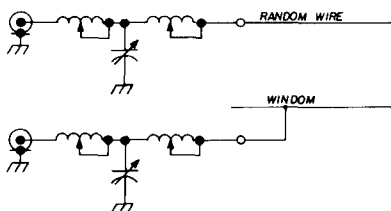


fig. 6. Using T-networks for single-wire fed antennas.

length with a diameter of 1-3/4 inches (this is similar to Air Dux 1411 coil stock).

Some experimental work with tap positions will permit optimum performance on each band. In my case ten-position switches were used and taps were placed on the coil so as to decrease distances between taps toward the low inductance end, fig. 7. This arrangement permits greater versatility, and I have yet to connect an antenna that could not be made to load the transmitter.

A 50-pF variable is used for 6 through 20 meters. When operating on 40, 80 and 160 meters an additional two-gang 365-pF variable (sections connected in parallel) is switched into the circuit.

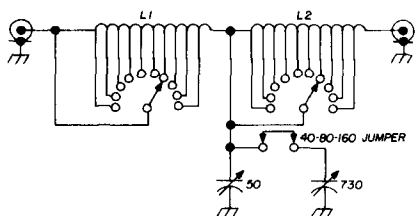


fig. 7. Versatile T-network antenna tuner. L1 and L2 are each 30 turns, tapped at 2, 4, 6, 8, 10, 13, 17, 21, 25 and 30 turns.

When adjusting the tuner you will soon learn the switch positions that favor each band, and, as expected, less and less inductance is needed, the higher the frequency band. However, ideal matching requires some experimentation with each antenna type to find the two most favorable switch positions. Switch positions are found that result in a very low, minimum swr. As the switch positions are selected the variable capacitor is tuned for minimum swr.

You should keep a log for any given antenna so the tuner settings can be quickly changed when you make a band change. If another antenna is used, optimum settings are not likely to be the same. This is a tuner that can be used to load anything, but it does require some initial pre-adjustment to locate the ideal settings for any given antenna. Remember that the tuner can be made to load

anything but this does not guarantee that the anything you use will function as a good antenna.

### T-matching at antenna

In commercial radio services the T-match is popular when the matching is done at the antenna. Three common configurations are shown in fig. 8. If the antenna is inductive, the inductance is tuned out by using an input capacitor, C1, which has the same reactance. The T-network must then only match a resistive component to the transmission

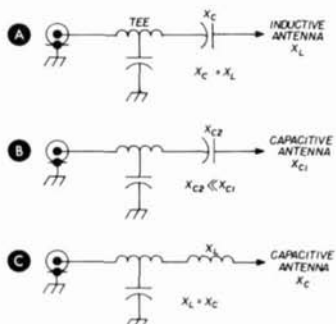


fig. 8. T-networks for impedance matching at the antenna.

line. If the antenna is capacitive, the capacitive reactive component must be tuned out by the input coil of the T-network. An alternative plan, shown in C, uses an input coil, L1, which has the same reactance as the capacitive component of the antenna.

In multifrequency and multi-band operation, as in amateur practice, the components must be variable. The T-network tuner of fig. 7 is ideal for this type of operation. It performs particularly well when vertical antennas are to be matched at the antenna, and the swr on the transmission line between the tuner and transmitter must be reduced to an insignificant value.

Antenna tuners are a great addition to the amateur station and should be considered essential devices for every ham antenna experimenter.

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# noise bridge for impedance measurements

Novel modifications  
to an  
existing circuit  
allow measurement  
of reactive  
as well as  
resistive components  
of unknown impedances

A useful instrument in the station of the active amateur is one that will measure resistive and reactive components of an unknown impedance throughout the hf range. Such an instrument is described here. The idea for its construction was brought about by a previous article in *ham radio*.<sup>1</sup>

## features

Using a communications receiver as a detector, this instrument will measure:

1. Antenna impedance.
2. Electrical length, velocity factor, and characteristic impedance of coaxial transmission lines.
3. Input impedance of rf amplifier circuits, small inductors, capacitors, baluns, and other rf transformers.

The instrument is effective over a range of approximately 2-30 MHz. Construction is not difficult and readily available parts are used. Power is supplied by a single 9-volt transistor battery. The dials for the reference components are direct reading.

## circuit

A diode noise generator, 3-stage amplifier, and rf bridge comprise the circuit (fig. 1). The amplified noise-generator output is coupled to a small toroidal rf transformer. A receiver connected to the DET terminal will indicate a noise null (S-meter or receiver audio output) when the impedances at each end of the transformer secondary are equal, indicating bridge balance. Calibrated scales are used for the controls of components  $C_x$ ,  $R_x$  to measure an unknown impedance,  $Z_x$ . The unknown impedance can be measured in terms of equivalent parallel  $C_x$ ,  $R_x$  within the following limits:

- $R_x$ : 0 to 250 ohms (resistive)
- $C_x$ : 0 to +70 pF (capacitive)
- $C_x$ : 0 to -70 pF (inductive)

If, when measuring  $Z_x$ , a negative

G. Pappot, YA1GJM, Kabul, Afghanistan



value is shown on the dial for  $C_x$ , the unknown will have an inductive reactance component, where the inductance can be found from

$$L_x = \frac{-1}{\omega^2 C_x}$$

where

$L_x$  = unknown inductance (H)

$\omega = 2\pi F$  (Hz)

$C_x$  = reference capacitance (F)

of 8 turns.\* In the schematic (fig. 1), the large dots indicate the beginning of each winding.

Control  $R_x$  has a scale that reads between zero and 250 ohms, and control  $C_x$  has a linear scale reading between -70 and +70 pF. The scales can be calibrated using resistors and capacitors of known accuracy connected in parallel with the  $Z_x$  terminal. Two-watt composition resistors in the 10 to 150-ohm range have

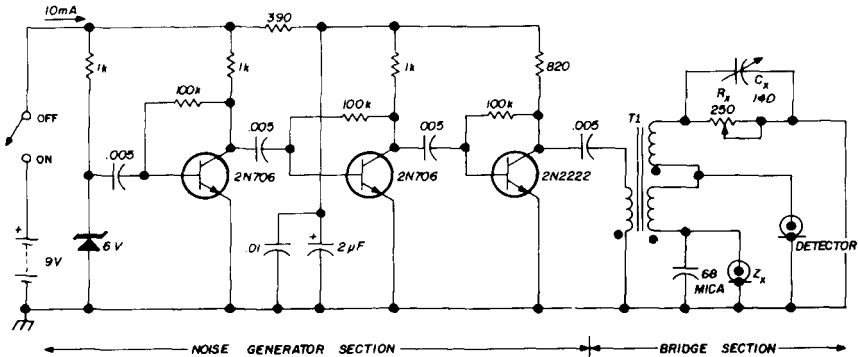


fig. 1. Impedance-bridge schematic. T1 is trifilar wound on a toroid core (see text). Reference elements  $C_x$ ,  $R_x$  are adjusted to produce a null when the impedance to be measured is connected to the  $Z_x$  terminal. A sensitive receiver is connected to the DET terminal.

More practically,

$$L_x = \frac{-25,300}{F^2 C_x}$$

where

$L_x$  = unknown inductance ( $\mu\text{H}$ )

$F$  = frequency (MHz)

$C_x$  = reference capacitance (pF)

## construction

The entire circuit including battery is mounted inside an aluminum box measuring 4 x 7 x 10 cm (1.5 x 2.75 x 4 inches). The noise generator section is mounted on a PC board. Capacitor  $C_x$  is an air dielectric variable with linear response. Resistor  $R_x$  is a 250-ohm carbon composition pot, CRL No. ACS9-251-U. Terminals for  $Z_x$  and DET are general-purpose vhf connectors, type SO-239.

The bridge section should have leads as short as possible. The toroid core for the bridge transformer has an O. D. of 9 mm (0.35 in.). Windings are trifilar, consisting

approximately -14 pF (inductive) reactance in parallel with their indicated resistance value. Thus a capacitor of 14 pF must be connected in parallel with such resistors to cancel the inductive reactance and produce a pure resistance for use within the frequency range of the bridge.

## operation

The unknown impedance is connected to the  $Z_x$  terminal. If antenna impedance is being measured, care must be taken to use a transmission line whose length is a multiple of one-half wavelength.

Connect a receiver to the DET terminal and switch on the noise bridge. The receiver S-meter will indicate the noise input. Adjust the receiver to the fre-

\*A suggested toroid core is the Micro-Metals T-37-10 available from Amidon Associates, 12033 Otsego St., North Hollywood, California 91607. See Hank Olson's article in *ham radio*, April, 1971, page 21. editor.

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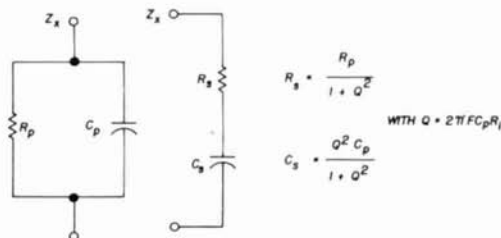
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quency at which  $Z_x$  is to be measured. The dials of  $R_x$  and  $C_x$  are now adjusted for a noise null. When the bridge is balanced at maximum detector sensitivity, the  $R_x$  and  $C_x$  dials will indicate the parameters of the unknown in terms of equivalent parallel components of resistance and positive or negative capacitance. The dials are direct reading and independent of frequency.

The following expressions can be used to find  $Z_x$  in terms of equivalent series-connected components:



### detector notes

I have used a Collins R390/URR and a KWM-2A as detectors in this circuit. With both receivers connected in parallel with the DET terminal, the R390 produced a very sharp null while that from the KWM-2A was relatively broad. This effect was noticed only when measuring frequency-dependent elements (antennas, tuned circuits, etc.). The effect did not occur when measuring pure resistances. Apparently the bridge produces a noise-spectrum gap exactly at the measurement frequency. This wideband gap, as presented to the receivers, provides an opportunity to measure receiver performance with respect to spurious signals much in the same manner that telephone wideband amplifiers are tested using whitenoise generators.

### references

1. Don Nelson, WB2EGZ, "The RF Bridge," *ham radio*, December, 1970, pp. 18-21.
2. Hank Olson, "How to Use Ferrite and Powdered-Iron for Inductors," *ham radio*, April, 1971, pp. 15-27.

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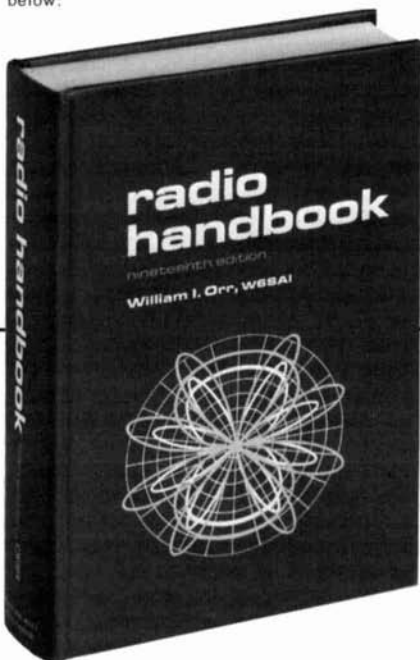
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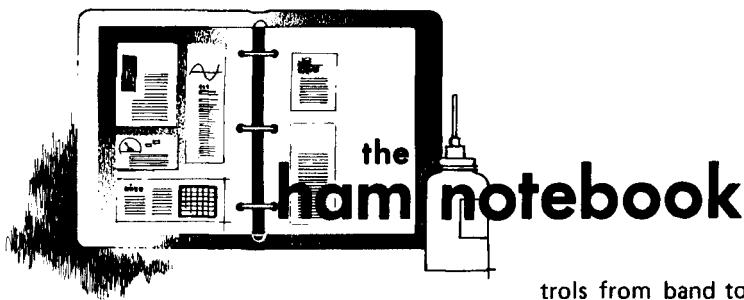
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## eliminating tuner overload

I have been building and using crystal-controlled converters with various 80-meter receivers for a number of years. To keep panel controls as simple as possible, all of these converters were built without rf gain controls. Consequently, the rf gain on each tuner used had to be juggled to prevent the converter from overloading the front-end of the tuner. Using my latest solid-state tuner, the problem became particularly annoying. While the obvious solution was to add an rf gain control to each converter, this would mean adding a negative bias supply as well, and the whole thing would become cramped and messy.

I considered the idea of inserting an attenuation pad between converter and receiver and came up with a simple method which works well and takes five minutes to install.

Each of the converters is link-coupled to the output connector. The easiest method of installing a pad is to merely insert one resistor of the correct value in series with this output link. Depending on the tuner being used, this resistor may be as much as five kilohms. With a 50-ohm input impedance receiver, this would represent a 20-dB attenuation between converter and receiver. In my case, I first tried a 2700 ohm resistor which worked so well I did not experiment further.

While inserting this resistor means the converter no longer has 50-ohm output impedance, it is doubtful that this will create any problems unless the tuner used is particularly unstable. The benefits gained in not having to juggle gain con-

trols from band to band will be immediately obvious.

Mike Goldstein, VE3GFN

## hot etching

I have found a successful method to keep etching solution warm during a printed circuit project. The only equipment necessary is the plastic container in which the solution is stored, a wash basin and a modified bleach bottle (see fig. 1).

Heat the solution in its plastic container "baby bottle" fashion. When the water is too hot to put your finger in, turn off the heat. The solution is now ready. Pour the solution into the bleach bottle along with the board to be etched. Place the bleach bottle in the wash basin filled with hot water so that it floats. The hot water in the basin will keep the solution warm throughout the process. If agitation is needed, position the basin under the hot water spigot so water can flow into it creating a rocking motion. To prevent the bottle from rotating, scotch tape two pieces of string from the sides of the basin to the opening in the bleach bottle. In a few minutes, the board is etched.

Of course, the bleach bottle can be replaced by any suitable tray. However,

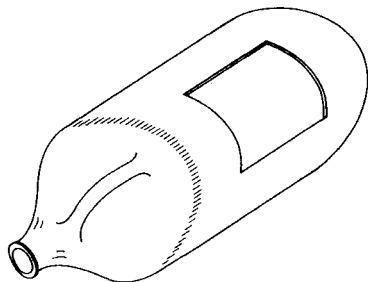


fig. 1. Using old bleach bottle for etching printed-circuit boards.

the big advantage comes when the etching job is done. Merely unscrew the cap and pour the solution back into its container without spillage as with flat trays.

Joseph Turkal, K8EKG

## regulated 5-volt supply

The power supply shown in fig. 2 is useful for powering your latest TTL IC project. The unit features easy construction, low noise and good regulation.

The MOV on the schematic is a General Electric metal-oxide varistor — which performs similar to back-to-back zener diodes. It provides line transient protection. I used a VP130A10, which sells for \$1.80. Voltage regulation is by a Fairchild  $\mu$ A7805, three-terminal voltage regulator. Be certain to mount this device with a good heat sink if you want to draw the full rated current. The regulator chip sells for \$2.20. Do not eliminate the bypass capacitors C1 and C2 — they serve a very useful function.

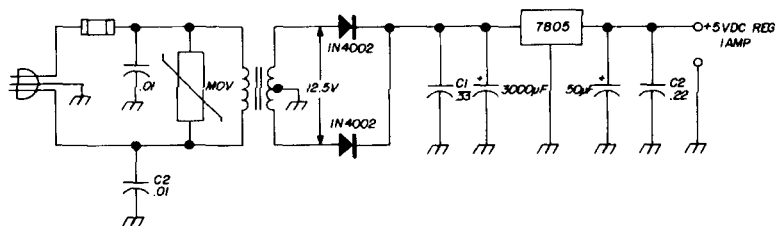


fig. 2. Simple 5-volt regulated power supply.

The regulator and MOV are available from Hamilton Electro Sales, 10912 Washington Boulevard, Los Angeles, California.

Hilary McDonald, W5UNF

## RTTY test generator

The RTTY RY generator described in the March, 1971, issue of *ham radio* can be made into a compact test unit, including a 120-volt loop supply and 3.3 volt Vcc for the generator board, and housed in a 2-1/8 x 3 x 5/4-inch Minibox. The supply for the generator board is ob-

tained by using a 6.3-volt transformer (Radio Shack 273-050) and bridge to supply approximately 9 volts dc. This is connected to an NPN emitter-follower voltage-regulator circuit. A 4-volt zener in the base of this transistor provides a regulated 3.3 volts at the emitter.

The 120-volt loop supply is added by connecting another 6.3-volt transformer back-to-back with the one used in the 3.3-Vdc supply. This provides 110 Vac, isolated from the power line, which is rectified to provide the 120-Vdc loop voltage. A 2500-ohm adjustable resistor permits setting loop current to 60 mA. Two closed-circuit phone jacks are connected in series with the loop supply. With the printer plug in one jack, loop current can be monitored with a milliammeter plugged into the other jack. Local copy can be generated by plugging the keyboard into the second jack and, of course, when the RY generator is active the loop is keyed to give local RY copy.

The clutch circuit is wired in this unit to a normally-closed momentary-contact

switch. This provides a steady 60 mA of magnet current which may be keyed by the keyboard for local copy. Depressing the momentary contact switch will cause the loop to be keyed with a stream of RYs until the switch is released.

Tom Gibson, W3EAG

## added uses for the vom/vtvm

Most of us are familiar with the normal uses of the vom or vtvm, and the scales on the instrument may occasionally give us other ideas. Perhaps you have

already used yours to check which end of an unknown diode was the cathode, or for the polarity of a transistor. Did you think of your vom as a current and voltage source?

Volt-ohmmeters (and vtvm's, too) measure resistance as a matter of current flow through the meter with, usually, an internal battery as the source. A combination of meter shunts and series resistors give a number of ranges. Many of these, where related by x10, x100, etc., vary the current inversely by the same factors. A

age, but indicated on the ohms range, multiplied by whatever range is in use. For example, on my Simpson 260, the center scale reading is 125 volts on a 250-volt scale. Immediately opposite this is a 12-ohm reading, which is the internal impedance on the Rx1 range. On the Rx100 range this will increase to 1200 ohms. Some variation will be found due to battery drain and condition.

I suggest that for ready use of the vom for a current or voltage source, that a table of values be applied with a piece of

**table 1. Current flow of various volt-ohmmeters when used as a current source.**

	Micronta 22-022	Simpson 260 series 5	Weston 980	Weston 564	Eico 104	Triplett 625-N	RCA Voltohmyst WV-87A 20
Rx1	50 mA	100 mA	60 mA	140 mA	60 mA	*70 mA	125 mA
Rx10	5 mA		6mA	14 mA	6 mA		14 mA
Rx100	.5 mA	1 mA	0.6 mA	1.4 mA		*15 mA	1.6 mA
Rx1K	50 $\mu$ A		60 $\mu$ A	.14 mA	60 $\mu$ A		.16 mA
Rx10K		60 $\mu$ A				*73 $\mu$ A	15 $\mu$ A
Rx100K							1.5 $\mu$ A
Rx1000K							

\*On 400, 50k and 10M ranges.

Micronta 22-022, 20k/v, 3-V battery  
 Simpson 260, 20k/v, 1½/6-V battery  
 Weston 980, 20k/v, 1½/15-V battery  
 Weston 564, 1K/V, 4½-V battery  
 Eico 104, 20k/V, 4½-V battery  
 Triplett 625-N, 10/20k/V, 4½-V battery  
 RCA Voltohmyst, 1½-V battery

typical Rx1 range may have an external current flow of 50 mA, reducing to 5 and 0.5 mA on the Rx10 and Rx100 ranges. Since most 20,000-ohm-per-volt voms have a basic 50- $\mu$ A movement, this is used for the Rx1000 range, sometimes shunted to a slightly higher value.

Some voms and vtvm's use a single 1.5-V cell, others use two, three, four or more. This voltage is available between the test leads. Occasionally this voltage will be varied between the lower and higher ohm ranges. The internal impedance of the voltage/current source is indicated by the ohms reading at the center scale of the meter movement; i. e., the point where the meter movement is reading half of full-scale current or volt-

tape to some convenient spot on the instrument. This should include the polarity of the test leads for voltage between them, the voltage normally found on various ohm-meter ranges, and the current flow at full-scale reading (prods shorted). The internal impedance can be read directly off the ohmmeter scale.

The values found on seven more or less typical instruments in my shop are listed in **table 1**. They will give you an idea of what to expect. Here's hoping your vom or vtvm can be even more useful to you.

Eugene Hubbell, W7DI

## counter reset generator

Rather than fuss around with discrete components while building the reset generator for a new counter, I decided to go modern and use the 74121. This 14-pin DIP IC really makes life easy as shown in **fig. 3**. My counter uses a 74196 in the units position and its clear demands a low to reset. The other four counters are 7490 decades which demand a high to reset, but must be kept low to count. The two outputs of the 74121 monostable fill

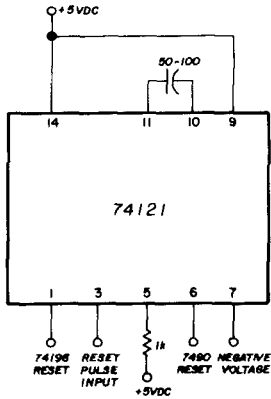


fig. 3. Counter reset generator circuit.

the bill quite nicely. The timing capacitor has to be large enough to produce an output pulse that will reset the 74196 reliably. If this is done, the 7490 decades will reset reliably also. The 74196 seems to be the fussier of the two counters, hence, this comment.

Allan S. Joffe, W3KBM

## rigid mobile mount

I mounted a newly-purchased Japanese two-meter transceiver under the dash of the car with the one bracket supplied. The unit was not rigid enough and re-

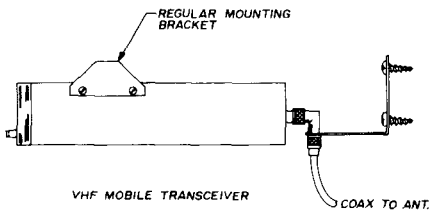


fig. 4. Bracket at rear of mobile transceiver greatly increases rigidity.

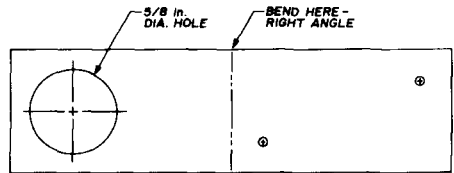
quired another bracket from the rear of the unit to the heater duct. The extra bracket had to be designed so that the rig could be taken out easily. I solved the problem by means of the antenna connector on the rear of the transceiver.

First, I screwed a right-angle connector (Amphenol UG-646) onto the chassis connector. I bent a right angle bracket,

drilled a 5/8-inch hole in it and mounted the bracket so the right-angle connector fitted through the hole. The connector from the antenna was then screwed down, thus making a rigid mount.

I have found that the single bracket with which most of the small transceivers are supplied is not adequate for a rigid installation.

Vern Epp, VE7ABK



NOTE: HOLE PATTERN, LENGTH AND WIDTH OF BRACKET, AND BEND POINT TO BE DETERMINED BY INDIVIDUAL REQUIREMENTS FOR MOUNTING.  
MATERIAL - 16 GAUGE ALUMINUM

fig. 5. Layout for the rear mounting bracket.

## restoring panel lettering

A white tire lettering stick (used by sports car owners to restore lettering on their racing tires) is ideal for restoring faded lettering and dial graduations on old equipment. The stick is a paint product and will be more durable when dry than other marking methods. Also, the sticks are easy to obtain at almost any tire or automotive store.

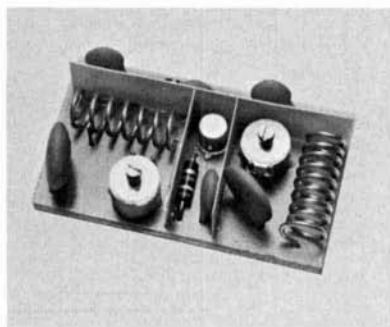
To restore an engraved plate, first be sure the panel and engraving are perfectly clean or the white will not adhere to the indentations. Cut a fresh surface on the end of the lettering stick and rub the stick over the engraving until the letters and lines are filled flush with the panel surface. Wrap a paper towel around something flat and immediately rub off the excess white paint. Do not wait to do this as the white will dry on the panel where it is not wanted.

On particularly bad surfaces, it will take two or more tries at cleaning and filling with the lettering stick. Be sure to start with a fresh surface on the end of the stick each time.

Ross N. Hayes, W8CL

# new products

## two-meter preamp



Boasting 20-dB gain and a 2.5-dB noise figure, Data Engineering's new two-meter preamplifier is designed to boost the sensitivity of most two-meter a-m, ssb and fm receivers to  $0.1 \mu\text{V}$ . The tiny unit can be mounted inside of most existing receivers and transceivers or added externally in a minibox enclosure.

The unit uses a mosfet circuit with input, output, mosfet and power components separated and rf bypassed by gold-plated copper shields. With a 90-day guarantee, the unit sells for \$9.50 in kit form and \$12.50 fully assembled. Stock units are powered by 12 Vdc. An option for 150 to 250 Vdc operation is available for \$2.95.

More information is available from Data Engineering, Inc., Box 1245, Springfield, Virginia 22151 or by using *check-off* on page 110.

## slow scan tv system



Linear Systems, Inc., has announced the introduction of the SBE Scanvision system designed for use in the exciting and rapidly growing slow-scan television amateur radio market. Slow-scan television is undoubtedly the most exciting thing to happen in amateur radio in many years, and Linear Systems is very pleased to become involved in it at this relatively early stage. It brings the amateur hobby into an area of new technology which permits the transmission of pictures in signal bandwidth no greater than that required for voice signals, and represents a chance for amateurs around the world to get to know one another even better.

The two-component SBE slow-scan system consists of a specially designed high resolution tv camera designated model SB1-CTV. The other component in the system is the model SB1-MYV monitor. Controls on the monitor provide selection of camera, receiver or tape source of video signal, contrast, brightness and horizontal hold.

A completely unique feature of the Scanvision monitor not available on other equipment of this sort is a built-in cassette tape player which permits simultaneous recording of off-air signals for storage. It also permits the preparation of programming at more convenient times. The tape recorder can be removed from the set.

The list price for the camera, slow-scan monitor and integral tape recorder is \$999.90. For more information, contact Mr. David C. Thompson, President, Linear Systems, Inc., 220 Airport Boulevard, Watsonville, California 95076, or use *check-off* on page 110.



## super-keyer



Perhaps the most sophisticated keyer on the market, Data Engineering's new Memory-Matic 8000 keyer features not just a very flexible iambic keyer, but the capabilities of eight 1000-bit, plug-in message memories. Messages in memory can be interrupted during transmission to insert impromptu additions — all without a discernible change between the transmitted code speed of the recorded message and the added comment.

Memories are plug-in with both 500- and 1000-bit memories available. Additionally, the unit can send any message in memory automatically at fixed intervals — as needed, for example, in meteor scatter communications. These intervals are clocked by the 60-Hz line current and can be synchronized to WWV.

A switch on the keyer can eliminate the dot, dash, or both memories with or without automatic character and work spacing — proving as fully automatic or as partially automatic operation as desired. The unit also has variable dot to dash weighting, two tune positions including "dot tune" for ssb transmitters, self-test and off-the-air testing capability, provision for use with many types of keys, a powerful built-in monitor and speaker and a built-in 117/220 Vac power supply.

The details on the flexibility and possibilities of this new keyer would take up too much space in this column. Full information is available by writing to Data Engineering, Inc., Box 1245, Springfield, Virginia 22151 or by using *check-off* on page 110.

The Memory-Matic 8000 sells for \$398.50 with three 500-bit memories and one 1000-bit memory. Additional plug-in 500-bit memories are \$21.50 and 1000-bit memories are \$37.50.

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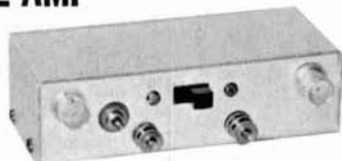
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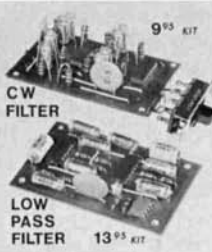
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## allied electronics catalog

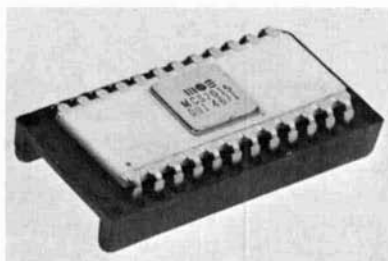


The new 1973 Allied Electronics catalog is a comprehensive buying guide for everything in industrial electronic parts and supplies. Compiled to meet the needs of industry, schools, institutions and government agencies, it's also the catalog for everyone looking for one dependable source for hard-to-get items — one or a thousand. Considered by many as the "Bible of the Industry," the catalog lists over 50,000 separate stock items from more than 400 manufacturers. Merchandise is grouped by sections; numerical cover margin tabs guide you quickly to the products you need.

Detailed specifications, descriptions and illustrations cover a vast array of components including semiconductors, integrated circuits, LEDs, tubes, relays, timers, transformers, resistors, capacitors, connectors, coils, chokes, sockets, plugs, jacks, switches, fuses, batteries, clips, lamps, wire and cable and much more.

Other major sections include test equipment, intercoms, power supplies, electronic counters, sound equipment, chemicals, hardware, technical books, tools and solder equipment. Allied Electronics Catalog no. 730 sells for \$5.00 (or free with \$10.00 minimum order), and is available from Allied Electronics, 2400 W. Washington Boulevard, Chicago, Illinois 60612.

## time zone converter



Southwest Technical Products Corporation has developed a read-only-memory time zone converter using a TTL compatible MOS circuit in a standard 24-pin ceramic package. This ROM converts the input time zone information used in digital electronic clocks into any other selected twelve-hour time zone. The addition of the time zone converter makes possible instant switch selection of any world time zone on any digital clock using standard BCD logic for the readout system. The 4671 automatically takes care of borrows, carries and other necessary logic to make the desired conversion. Normal TTL logic levels, +5 V and -12 V are required for operation. Single unit price is \$19.50. More information is available from Southwest Technical Products Corporation, 219 West Rhapsody, San Antonio, Texas 78216 or from *check-off* on page 110.

## ham radio film

Media Five, a West-coast film distributor, has just released a new 15-minute, 16-mm color motion picture entitled, "This is Ham Radio". As well as demonstrating practical science in action, "This is Ham Radio" details the fun, challenge—and real importance—of a fascinating hobby shared by more than a half million radio amateurs around the world.

The film stresses licensing requirements, low-cost rigs, the relative ease of earning a Novice ticket from the FCC and getting on the air. Fast-paced scenes show dozens of different activities, and featured at every turn are young people: operating mobile rigs, testing emergency

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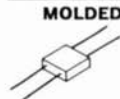
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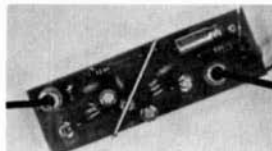
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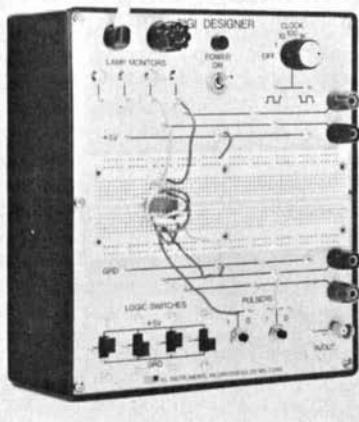
GREENVILLE, NH 03048

gear (in the rain, of course), relaying messages across the ocean or just rapping with friends across town.

Narrator is college-bound teenager Matt Futterman, WB6KPN, Extra-class ham who got his first license at age 13. He describes some of the lure of ham radio: building your own equipment, assisting Civil Defense officials in emergency communications, meeting new friends, learning the Morse code well enough to think in it, sharing the excitement of world-wide person-to-person communication and getting involved in something really worthwhile.

"This is Ham Radio," educational counterpart of the awarding winning "The Ham's Wide World," was produced in cooperation with the American Radio Relay League. "This is Ham Radio" is available for rental, purchase, or preview toward purchase from Media Five Film Distributors, 1011 North Cole Avenue, Hollywood, California, 90038. Sale \$175. Rental information on request. Produced 1970.

### digi-designer



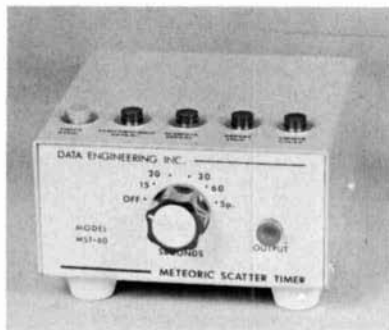
EL Instruments announces a new aid in breadboarding for the experimenter interested in digital circuits. The Digi Designer incorporates the EL SK-10 component socket, a variable, six position 1 to 100 kHz clock, four logic lamps, four switches, two bounce-free pushbuttons

for use as pulsers and an internal 5 Vdc power supply. There are numerous terminal points on the front panel for external inputs or patch cords.

The Digi Designer enables the user to completely design and test a circuit by merely plugging his components into the SK-10 socket, and interconnecting with standard number 24 AWG hook-up wire. No soldering is necessary.

The Digi Designer is available from stock in kit form for \$49.95 or wired for \$95.00. Complete information is available from EL Instruments Inc., 61 First Street, Derby, Connecticut 06418 or by using *check-off* on page 110.

## communications timer



Data Engineering has introduced a precise timer for use with meteor scatter, moon bounce or tropospheric scatter communications. Transmissions can be synchronized with WWV and transmitted at precise intervals of 15, 20, 30 and 60 seconds. The output of the timer is used to automatically start coded CW transmissions, while the output indicator signals the start of manually sent CW.

The unit designated the MST-60, sells for \$49.50 and carries Data Engineering's protection against rf and line spikes affecting the timer's accuracy.

The unit designated the MST-60, sells for \$49.50 and carries Digital Engineering's standard five year guarantee against defects in parts and manufacture. More details are available by writing to Data Engineering, Inc., Box 1245, Springfield, Virginia 22151 or by using *check-off* on page 110.

# Reception

the moment  
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## TRI-EX W-51 TOWER

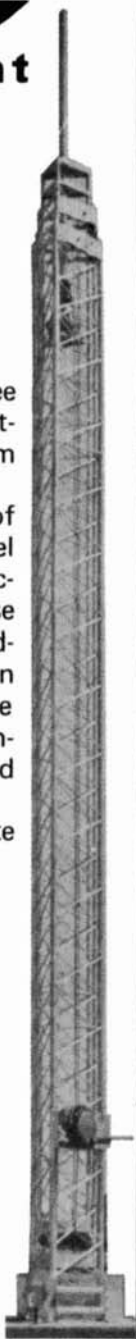
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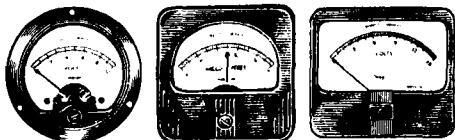
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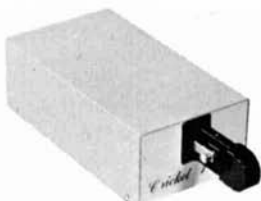
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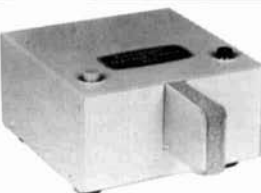
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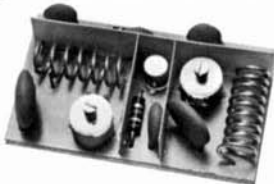
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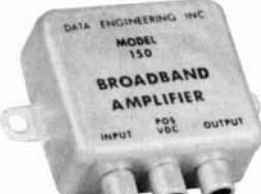
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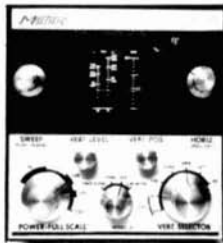


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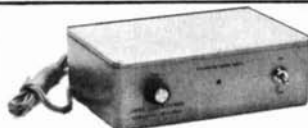
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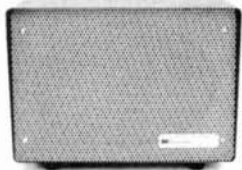


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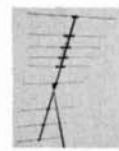


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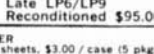
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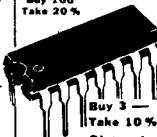
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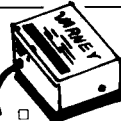
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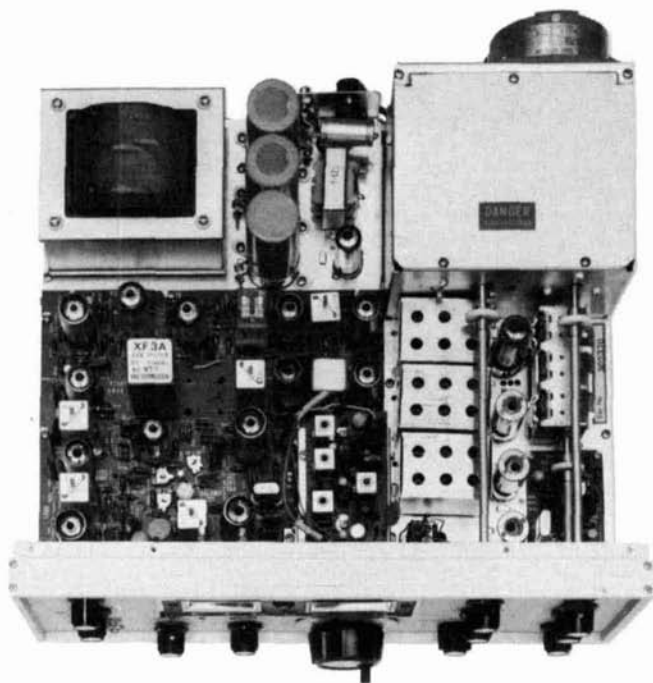
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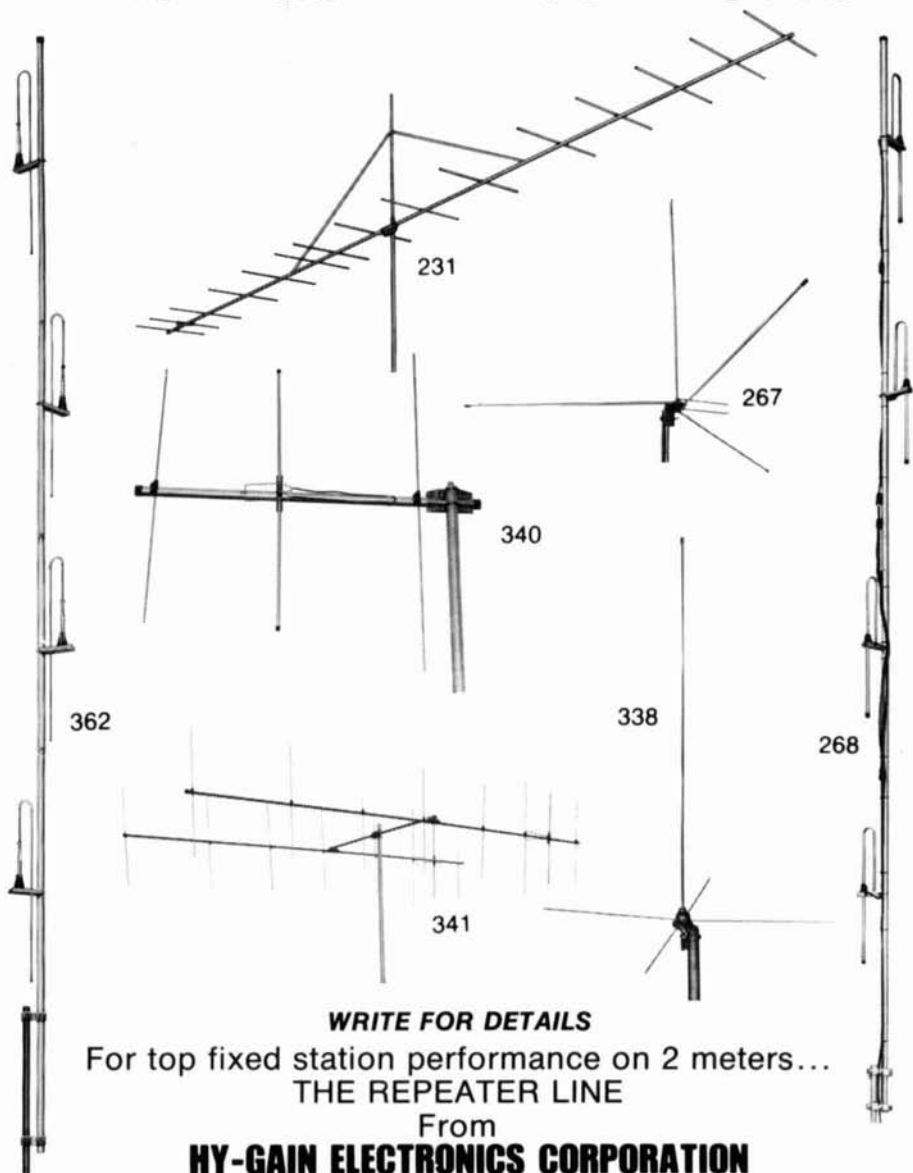
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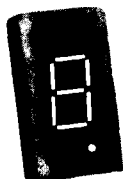
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Coming soon the LP2000 Micro-transmitter in a 10-pin IC package.

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LM370 AGC/Squelch amp	\$4.85
LM373 AM/FM/SSB IF strip/Det	\$4.85
LM309K 5V 1A regulator. If you are using TTL you need this one.	\$3.00

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CA3020 RCA 1/2 W audio	\$3.07
CA3020A RCA 1 audio	\$3.92
CA3028A RCA RF amp	\$1.77
CA3001 RCA	\$6.66
MC1306P Motorola 1/2 W audio	\$1.10
MC1350P High gain RF amp/IF amp	\$1.15
MC1357P FM IF amp Quadrature det	\$2.25
MC1496 Hard to find Bal. Mod.	\$3.25
MFC9020 Motorola 2-Watt audio	\$2.50
MFC4010 Multi-purpose wide-band amp	\$1.25
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MPF102 JFET	\$60
MPF105/2N5459 JFET	.96
MPF107/2N5486 JFET VHF/UHF	\$1.26
MPF121 Low-cost dual gate VHF RF	.85
MFE3007 Dual-gate	\$1.98
40673	\$1.75
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MC789P Hex Inverter RTL	\$1.00
MC790P Dual J-K Flip-flop	\$2.00
MC799P Dual Buffer RTL	\$1.00
MC780/880 RTL decade counter	\$3.00
MC1013P 85 MHz Flip-flop MECL	\$3.25

## MOTOROLA TUNING DIODES

Silicon voltage variable capacitance diodes in TO-92 plastic case like plastic transistors. Both standard Motorola and HEP numbers are listed; devices are same. Capacitance value is typical at -4Vdc. Tuning ratio is approx. 3:1.

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MV2105/R2502 15 pF	\$1.10
MV2109/R2503 33 pF	\$1.10
MV2112/R2504 56 pF	\$1.10
MV2115/R2505 100 pF	\$1.10

## MORE RCA IC's

CA3088E AM rcvr subsystem	\$2.50
CA3089E FM IF system with circuits for IF amp., Det., AF preamp., AFC, Squelch, & tuning meter	\$3.90
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9528 Dual "D" FF toggles beyond 160MHz	\$4.65
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A 95H90 & 9582 makes an excellent prescaler to extend low frequency counters to VHF — or use two 9528s for a 160 MHz prescaler.

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**WORLD QSL** — See ad page 108.

**11TH ANNUAL MID-WINTER SWAP AND SHOP** on Sunday, February 11, 1973 at the DuPage County Fairgrounds, Wheaton, Illinois. Hours: 8:00 AM to 5:00 PM. \$1.50 advance/\$2.00 at the door. We are expanding to two buildings this year. Refreshments and unlimited parking. Bring your own tables. Free coffee and donuts 9:00 - 9:30 AM. Hams, CB'ers, electronic hobbyists, friends and commercial exhibitors are cordially invited. Write W.C.R.A., Bill Rambow, W9BAVD, P. O. Box QSL, Wheaton, Illinois 60187 for information.

**WANTED:** HP340B; Models 343A & 349A. Noise sources. WA0JDH, Mel Overdeck, 130 Harrison Ave., So. Hopkins, Minnesota 55343.

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**WANTED:** Ham Radio, 1968, April, July, Sept., Oct.; CQ, 1961, June, Nov. 1962, April, 73. 1961, Jan., June; 1969, Jan., July QST, 1921, Feb., Oct., Dec., 1924, Feb., Mar., April, July, 1962, Oct. Donald Strock, W7LAN, 1419 35th St., Anacortes, Wash. 98221.

**SAROC EIGHTH ANNIVERSARY** January 4-6, 1973. Advance Registration \$10.00 per person entitles registrant to SAROC Special room rate \$15.00 per night plus room tax, single or double occupancy, tickets for admission to technical seminars, Swan Electronics and SAROC Social Hour Friday; Hy-Gain/Galaxy Electronics and SAROC Cocktail Party Saturday, Buffet Hunt Breakfast Sunday; Ladies who register will be offered a special program on Saturday. Advance Registration with Flamingo Hotel mid-night show, two drinks, \$17.00. Advance Registration with Flamingo Hotel Dinner Show (entrees Brisket of Beef or Turkey) no drinks, \$21.00. Tax and Gratuity included except for room. SAROC Roundtrip Jet Vacation Flight Departure Cities: Baltimore/Washington, Boston, Chicago, Cleveland, Columbus, Detroit, Hartford, Milwaukee, New York/Newark, Philadelphia, Pittsburgh, St. Louis, Kansas City, Denver, Omaha and Lincoln. Send for details. Sixth National FM Conference, ARRL, WCARS 7255, WPSS-3952, MARS, meetings and technical sessions scheduled. Accommodations request to Flamingo Hotel, Las Vegas, Nevada before December 15th. Advance Registration to SAROC Southern Nevada ARC, Inc., Box 73, Boulder City, Nevada 89005, Before December 31st.

**SAVE MONEY** on parts and transmitting-receiving tubes. Foreign-Domestic. Send 25¢ for giant catalog. Refunded first order. United Radio Company, 56-HR Ferry Street, Newark, N.J. 07105.

**BEL 6M BEAMS.** A/S HM171 regular list \$109.95. Close out price \$29.95. FOB Cleveland, OH. Communications World, Inc., 4788 State Rd., Cleveland, OH. 44109.

**DRAKE-2C** with calibrator, noise blander, and O-multiplier speaker. \$175.00; Drake-2NT, \$85.00; and EICO 722 VFO, \$20.00; all for \$260.00. All in super mint condition with manuals and cables. John Fagan, 721 W. Border, Arlington, Tex. 76010.

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**SELL:** Surplus Collins TCS transmitter receiver, and power supply. Great for 160, 80, 40. \$75 complete. Dick Bromfield, 256 William St., West Haven, Conn. 06516.

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Direct Counting: 10Hz to 80MHz guaranteed (1Hz to over 100MHz typical)

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Readout: 5 digit LED plus over-range

Input Sensitivity: 100 millivolts max. on any freq.

Input Impedance: 1M $\Omega$  paralleled with 15pf.

Power Requirement: 120VAC or 12VDC

SMALL SIZE 2 1/8" H, 5 1/4" W, 6 3/4" D.

Guarantee 1 year all parts, 90 days labor

PRICE \$250.00

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Many thousands of you have become very familiar with the various Radio Society of Great Britain books and handbooks, but very few of you are familiar with their excellent magazine, **Radio Communication**.

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**WANTED:** Collins 30S-1. Call 609-695-6430 or 609-392-2111 ext. 600, Jim Zimskind, K2OJL.

**RTTY PICTURE TAPES.** Stamp for list. John Sheetz, 5 Hansell, New Providence, NJ 07974.

**FIGHT TV!** with the RSO Low Pass Filter — p115 March 73 — write for brochure — Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada.

**SURPLUS MILITARY RADIOS,** Electronics, Radar Parts, tons of material for the ham, free catalogue available. Sabre Industries, 1370 Sargent Avenue, Winnipeg 21, Manitoba, Canada.

**SCALERS** — Complete units. 260MHz unit \$70; high sensitivity 280MHz unit \$90. Add Calif. tax and \$1.50 shipping. Guaranteed. W6PBC, Belmont Spectrum Research, 1709 Notre Dame, Belmont, Calif. 94002.

**B.A.R.T.G. SPRING RTTY CONTEST,** 0200 GMT, March 24th to 0200 GMT, March 26th 1973. The Total contest period is 48 hours but not more than 36 hours of operation is permitted. Listening counts as operating time. The 12 hour non operating period can be taken at any time, but off periods may not be less than 2 hours. Times on and off must be on the log and score sheets. The contest is also open to SWL's. 3.5, 7.0, 14, 21 and 28 MHz bands. Stations may not be contacted more than once on any one band, but additional contacts may be made with the same station if a different band is used. ARRL countries list, except that KL7, KH6 and VO to be considered as separate countries. Exchange will consist of, Time GMT, Message Number and RST. All contacts within one's own country will earn Two points. All contacts outside one's own country will earn Ten points. All stations will receive a bonus of 200 points per country worked including their own. A country may be counted again if worked on another band but continents are counted once only. Two way exchange points times total countries worked, plus total country points times number of continents worked. Use one log for each band. Logs to contain: Date, time GMT, message and RST numbers sent and received and exchange points claimed. All Logs must be received by May 31st 1973 to qualify. Send logs to Ted Double, G8CDW, 89 Linden Gardens Enfield, Middlesex, EN1 4DX, England.

**WANTED: QST** magazines, 1916-1922. Paul Kluew, Edmore, Mich. 48829.

**WE BUY ELECTRON TUBES,** diodes, transistors, integrated circuits, semiconductors. ASTRAL ELECTRONICS, 150 Miller Street, Elizabeth, N. J. 07207. (201) 354-2420.

**QSL'S — BROWNIE W3CJ1** — 3111B Lehigh, Allentown, Pa. 18103. Samples 10¢. Cut catalogue 25¢.

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Makes wonderful mobile or fixed rig for 420 to 500 Mc. Easily converted for phone or CW operation

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BC-645 Transceiver, Dynamotor and all BRAND NEW, accessories below, including conversion in- while stocks last. **\$26.95**

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Complete set of 11 connectors  
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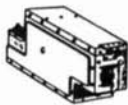
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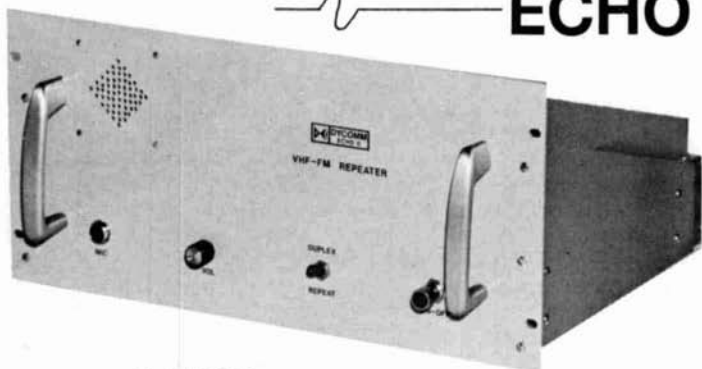
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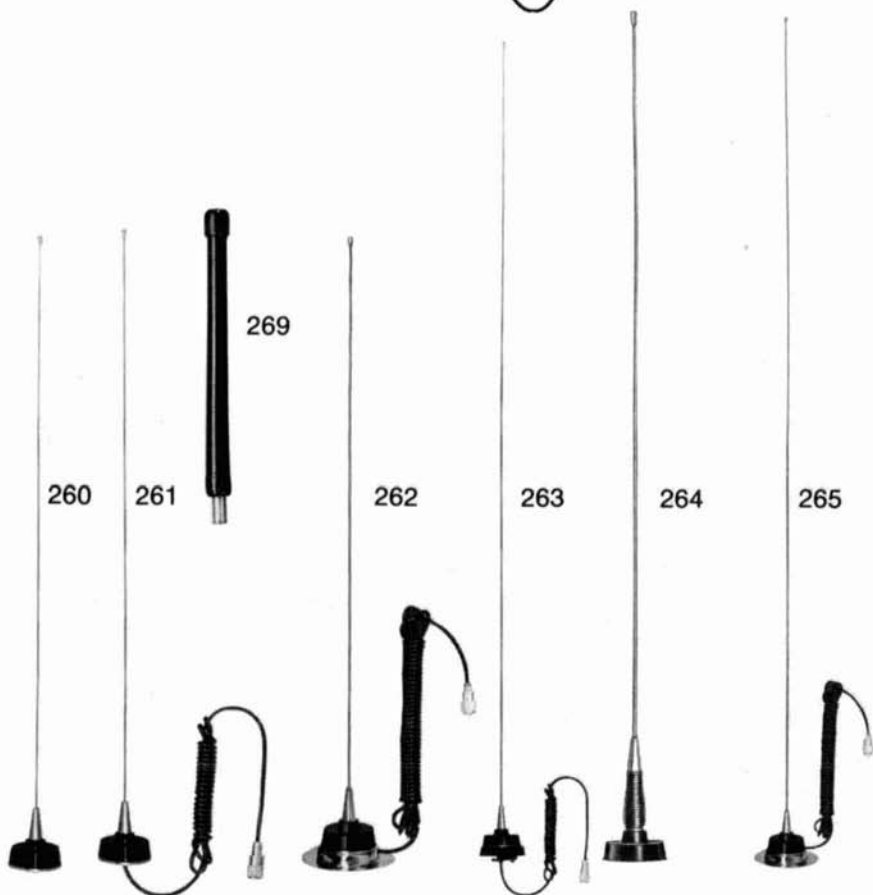
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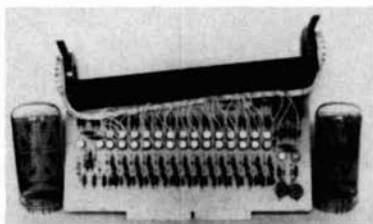
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W51 SHOWN

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Substitute 50 ft. free standing, add \$100

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HY-GAIN TH3JR	\$275
HY-GAIN DB10-15A	\$285
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\*TR-44 rotor w/cable add: \$ 35

HAM-M rotor w/cable add: \$ 65

**LAE W51 "DELUXE" Package (51 Ft.)**  
(Free Standing, 9 Sq. Ft. - 50 MPH)

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HY-GAIN HY QUAD	\$599
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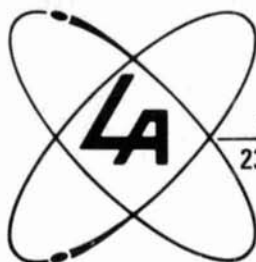
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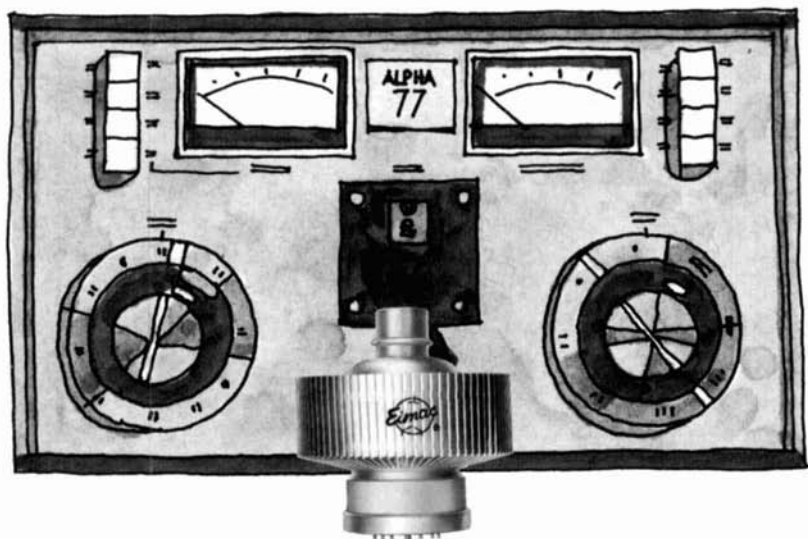
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