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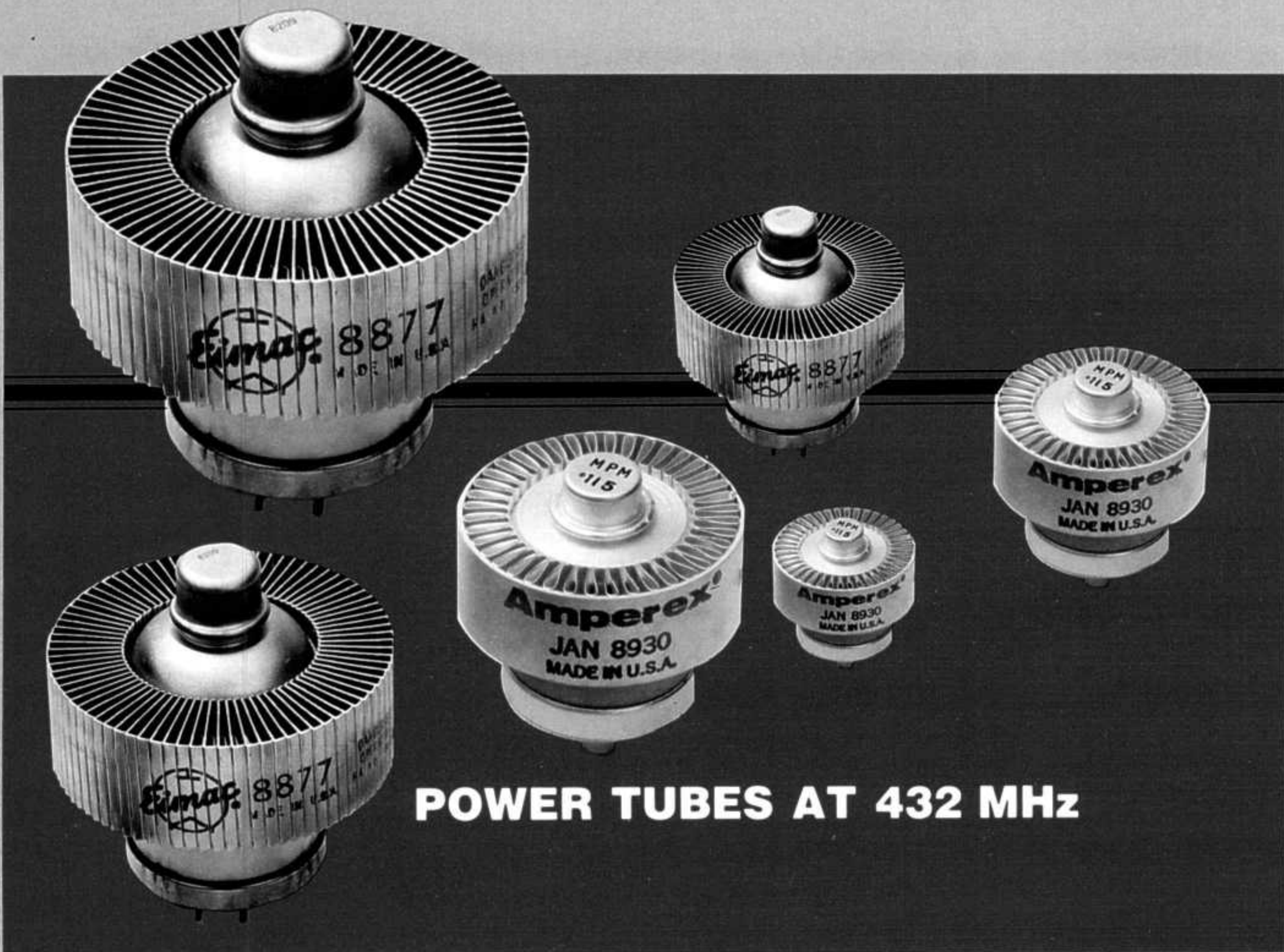

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THE AMERICAN RADIO RELAY LEAGUE, INC

The American Radio Relay League, Inc, is a noncommercial association of radio amateurs, organized for the promotion of interest in Amateur Radio communication and experimentation, for the establishment of networks to provide communications in the event of disasters or other emergencies, for the advancement of the radio art and of the public welfare, for the representation of the radio amateur in legislative matters, and for the maintenance of fraternalism and a high standard of conduct.

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Purposes of *QEX:*

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters
2) document advanced technical work in the Amateur Radio field
3) support efforts to advance the state of the Amateur Radio art.

All correspondence concerning *QEX* should be addressed to the American Radio Relay League, 225 Main Street, Newington, CT 06111 USA. Envelopes containing manuscripts and correspondence for publication in *QEX* should be marked: Editor, *QEX*.

Both theoretical and practical technical articles are welcomed. Manuscripts should be typed and double spaced. Please use the standard ARRL abbreviations found in recent editions of *The ARRL Handbook*. Photos should be glossy, black-and-white positive prints of good definition and contrast, and should be the same size or larger than the size that is to appear in *QEX*.

Empirically Speaking. . .

Amateur Radio Technical Conferences

About 150 people attended the League's 7th Amateur Radio Computer Networking Conference held in Columbia, Maryland on October 1. Tom Clark, W3IWI, was the prime mover behind the conference program, and Don Bennett, K4NGC, was responsible for registration. Andre Kesteloot, N4ICK, Dave Tillman, WA4GUD, and Jack Colson, W3TMZ, participated as coordinators. Host organizations were: Johns Hopkins Applied Physics Laboratory Amateur Radio Club, Tucson Amateur Packet Radio (TAPR), Amateur Radio Research and Development (AMRAD), Radio Amateur Satellite Corporation (AMSAT) and the League.

Every now and then, we need to remind ourselves of the precious high-tech resource we have in Amateur Radio experimenters. This conference specialized in packet radio, but there are others concentrating on amateur satellites and VHF/microwave technology. In addition, practically every Amateur Radio convention has several technical forums on a variety of subjects. The neat thing is that Amateur Radio experimenters are current with the state-of-the-art in industry. In fact, many Amateur Radio experimenters are the same people advancing technology in industry.

Amateur Radio conferences provide an opportunity to have papers printed in the conference record, to give an oral presentation, to answer questions, to hear other ideas, to discuss topics with people with similar interests, and to maintain some regular social contact with colleagues. However, the exchange does not end there. The dialog continues via ham radio, electronic mail, regular mail, telephone, and personal meetings.

A highlight of the 7th Computer Networking Conference was the unveiling of the ARRL Digital Committee's work on AX.25 version 2.0 link-level protocol. A paper by Terry Fox, WB4JFI, outlined changes proposed to fix problems with the existing protocol and to extend the address fields. At present, there is a 6-character limitation on the length of call signs--reciprocal call-sign prefixes presently won't fit into the space. At first, it didn't look like there was a workable way to extend the address fields, but the Digital Committee came up with what appears to be a practical method. As a parallel effort, Eric Scace, K3NA, generated System Description Language (SDL) flow charts of the protocol with proposed changes. SDL diagrams are much superior to the older state tables and provide implementers with an unambiguous protocol specification. Both US and foreign implementers have been advised of these proposed AX.25 changes. The Digital Committee is scheduled to meet on December 10-11 to consider comments from implementers and others. The Committee will meet again sometime early in 1989 to consider further input. If you have comments, please send them to Chairman, Digital Committee, c/o ARRL HQ.

Another highlight of the conference was AMSAT's new microsats. Many had a first look at a Microsat mock-up. (See October *QEX*, p 13, for a photo and brief description of the project.) Microsats will undoubtedly be the focus of considerable attention at the AMSAT Annual Meeting and Space Symposium being held in Atlanta November 11-13. This project is a perfect example of how something made its debut at a conference (last year's AMSAT symposium), continued hot and heavy on electronic mail and was supplemented by face-to-face meetings between some of the participants. Try running an engineering project when all the players are volunteers, in different parts of the country, and see each other only occasionally. It's not easy, but that's the stuff of which Amateur Radio satellites are made.

We had heard from various sources on the eastern side of the Atlantic Ocean that European microwave experimenters were light-years ahead of their American counterparts. Perhaps it was true to some extent. Since the League began publishing the proceedings of VHF/microwave conferences over a year ago, indications are that the European perception has changed. Indeed, American microwave experimenters have been doing serious work and are now getting more visibility for their accomplishments. Also, publishing experimental work produces a flywheel effect on both sides of the Atlantic.

Proceedings of these technical conferences are available from ARRL HQ and are regularly advertised in *QST*, the latest mention being on p 192 of the October issue.—*W4RI*

Characteristics of Some Common Power Tubes at 432 MHz

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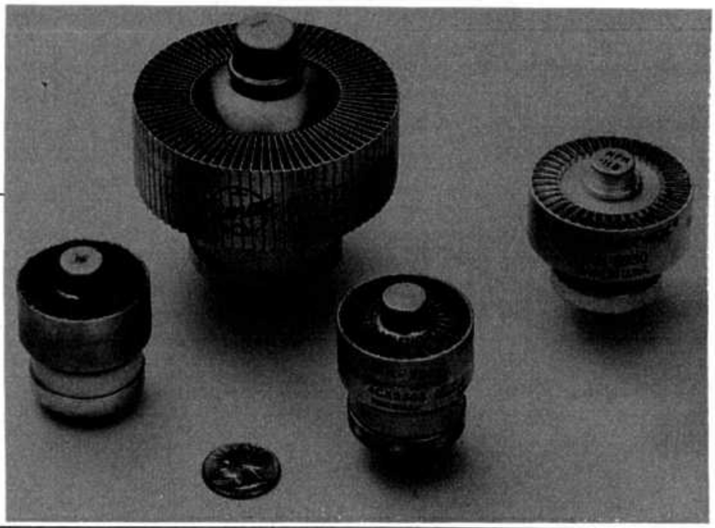


For years the "standard" power amplifier for 432 MHz DX work has been the K2RIW parallel 4CX250B kilowatt.[1] This amplifier is designed for class-C operation (nonlinear CW or FM) at an output of 1 kW. The current amateur output power level of 1.5 kW, plus the dominance of SSB for non-EME communication at 432 MHz, has created a search for more powerful amplifiers. Solid-state devices capable of producing output power greater than 200 W are not currently available to most radio amateurs. Transmission at the 1.5 kW output level still requires the use of vacuum tubes. Some amateurs, like Tim Pettis, KL7WE,[2] are using power splitters and combiners to use a pair of amplifiers as one. Those who have been fortunate enough to obtain large triodes or surplus tetrode cavities are able to run the legal limit using a single tube.

The purpose of this article is to describe the capabilities of commonly available power tubes that can operate at 432 MHz, not to compare or critique power amplifier designs. I have written this article for two reasons. First, amateurs new to 432 MHz are not likely to be familiar with the power tubes that can—or cannot—work effectively. Finding suitable tube types on your own can involve expensive trial and error. This article covers subjects important to tube choice—IMD, neutralization, linearity and surplus availability, among others. Second, the power-tube data sheets supplied by tube manufacturers do not tell a complete story. Important specifications—such as power-drift stability, power gain (in real 432-MHz circuits), allowable intermittent voice or CW power levels—are often not included. I'll try to shed some light on all these subjects.

The two tables included in this article are intended to help you identify and sort out some of this power-tube data. Table 1 lists the operating characteristics of a variety of tubes at 432 MHz and is separated into two parts. Part 1, Table 1, concerns power tubes that should be run in pairs to achieve high power levels. Part 2, Table 1, details the "big" tubes—those tubes that can hold their own at high power levels.

The power outputs shown in Table 1 are *linear* power output. Yes, I've heard the stories about getting 1.2 kW from a pair of 4CX250Bs, but such an amplifier is certainly not linear at that power level. The

[1]Notes appear on page 7.

Table 1
432-MHz Power Tube Comparison

Specifications and prices listed in Part 1 are for pairs of tubes. Specifications and prices listed in Part 2 are for single tubes. The 4628, 7650, 7213 and 8792 are specified for cathode-driven operation. Drive power and IMD levels for the other tetrodes are for grid-driven service. Note: Driving the cathodes of tetrodes produces stable output with lower IMD products at the expense of lower gain.

Part 1

Tube	*Cost, New ($)*	*Linear Pwr Out (W)*	*Linear Effic. (%)*	*3rd-Order IMD (dBc)*	*Drive (W)*	*Cost, Surplus ($)*	*Notes*
4X150A/7034	110	350	40	−23	25	50	glass problem
4CX250B (BC, FG)	180	600	55	−23	15	100	sockets-$250
4CX250K (M)	600	600	55	−23	12	150	coaxial base
4CX300A/8167	300	650	50	−23	20	150	drift problem
8122/8122W	400	700	55	−23	20	200	drift problem
4CX350A (F, FJ)	300	750	50	−25	20	150	sockets-$250
4CX250R, 8930	250	850	55	−25	20	150	sockets-$250
3CX400U7	800	1000	60	−35	50	250	coaxial 8874
8874	690	1100	52	−35	70	200	IVS operation
3CX800A7	696	1500	54	−36	60	400	IVS operation
3CX600U7	1300	1500	60	−38	50	250	rare, coaxial
4CX600J, (JA)	2000	1500+	60	−35	45	500	very rare

Part 2

Tube	*Cost, New ($)*	*Linear Pwr Out (W)*	*Linear Effic. (%)*	*3rd-Order IMD (dBc)*	*Drive (W)*	*Cost, Surplus ($)*	*Notes*
7650	1100	850	60	−30	22	100	IVS operation
4CX600B, 4CX800B	1200	900	63	−35	28	200	stability
4CX1000A	800	1000	35	−25	25	150	socket-$800
4CX1500A	800	1000	35	−40	25	150	socket-$800
8283, 3CX1000A7	(obsolete)	1200	45	−31	200	450	IVS operation
8877/ 3CX1500A7	835	1300	40	−40	130	350	IVS operation
7213, 7214	1400	1500	55	−25	70	125	IVS operation
8792/V1	1800	1500	52	−44	85	600	rare,coaxial
4628	2500	1500	50	−35	20	500	big, coaxial

power output ratings for these tubes are based on the voltage and current ratings listed in Table 2.

Table 2 identifies the common operating conditions (anode and screen voltage, anode current and so on), normally found on the manufacturers' data sheets. Such data shows you the technical operating parameters for a given tube, but not how well it can perform at 432 MHz.

The anode current (anode mA) listing in Table 2 lists values in two rating systems, CCS (continuous commercial service) and IVS (Intermittent Voice and CW Service).[3] CCS is the standard power-tube rating system and describes continuous-carrier conditions, or key-down, operation. The IVS rating describes *intermittent, safe* operation. Both the IVS and CCS ratings are conservative; under normal Amateur Radio operating conditions, these tubes can be operated beyond the listed ratings for brief periods of time. A guide to high-output operation is a tube's pulse-operation rating, normally listed on the manufacturer's data sheets. This rating indicates how hard a tube can be pushed when the transmit time is a small percentage of total operating time. Now that I have told you about pulse-operation ratings, I must caution you that not all power tubes are suitable for pulse work and that there are critical limits to how far a tube can be pushed. High IMD products, peak cathode current limits and key-down-overload limits should be considered if you're thinking of pushing your power tubes.

The following power-tube data is based on my personal experience, plus the experience of other radio amateurs who have used some of these tubes at 432 MHz. The data for the less-common power tubes was obtained from the tube manufacturers' test amplifiers or commercial cavities operating in the 432-MHz region.

Table 2

Power-tube ratings. This table is derived from the manufacturers' data sheets. See text for specific information on suitability and applications.

Tube	*Anode (kV)*	*Screen (V)*	*Anode mA CCS IVS*	*Freq ratings (MHz)*	*Filament/heater V/A‡*	*Anode Dissipation (W)*
4X150A, 7034	2	400	250 275	150	6.0/2.6	250
4CX250B, 7203	2	400	250 275	500	6.0/2.6	250
4CX350A, 8321	2.5	400	300 325	110	6.0/2.9	350
4CX250R, 7580W	2	500	250 325	500	6.0/2.6	250
4CX300A	2.5	400	250 300	500	6.0/2.9	300
8122, 8122W	2.2	400	250 335	450	6.0/1.3	300
8930	2.4	400	250 325	500	6.0/2.6	350
7650	2.5	1200	500 600	1215†	6.3/7.0	600
4CX600J, 8809	3	400	600 700	110	6.0/5.4	600
4CW800B	3	400	600 700	500	6.0/4.4	800
4CX1000A, 8168	3	400	1000 1100	110	6.0/9.0	1000
4CX1500B, 8660	3	400	900 1100	110	6.0/10.0	1500
7213, 7214	3.5	1000	700 1250	400	5.5/17.5	1500
8792/V1	3.5	1000	700 1250	400	5.5/17.5	1800
3CX400U7	1.5	—	400 500	1000	6.3/3.0	400
8874	2.2	—	350 500	500	6.3/3.0	400
3CX800A7	2.25	—	600 650	350	13.5/1.5	800
3CX600U7	2	—	600 700	1000	6.0/5.4	600
3CX1000A7, 8283	3.5	—	1000 1500	220	5.0/30.5	1000
3CX1500A7, 8877	4	—	1000 1350	250	5.0/10.5	1500
8938	4	—	1000 1350	500	5.0/10.5	1500

* Specified maximum input power of 2.5 kW.
† Specified maximum input power of 1.25 kW.
‡ Filament/heater voltages may typically have to be reduced by 5 to 10%.

4X150A/7034

Although the 4X150A/7034 is similar to the common 4CX250B in linear power output (250 W), it is not recommended for use at 432 MHz (the 4X150A/7034 is primarily designed for 150-MHz service). The major difference between the 4X150A/7034 and the 4CX250B is the glass anode-to-screen insulator. This insulator heats and develops holes, or breaks its seals, when used at 432 MHz. Note: Do not confuse the 4X150A/7034 with the original 4X150. The 4X150 can be easily identified by its glass base insulator; the 4X150A/7034 has a ceramic-metal base insulator.

4CX250B

The 4CX250B, Fig 1, is the standard VHF/UHF power tube for amateur use. These tubes are attractive to hams for two reasons: They are relatively inexpensive ($180 new v $100 surplus) and are commonly available on the surplus market. There have been many stories about incredible 4CX250B "beyond-spec" power output, but in reality, the 4CX250B is a mediocre tube for linear service. A pair of 4CX250Bs produce about 600 W PEP at 432 MHz before you start making enemies with IMD-related splatter. Some enhancements have been made to the 4CX250B. Two examples are the 4CX250B/8957—a stable, long-life tube—and the 4CX250FG/8621, which has a 26.5-V heater.

4CX250K

This family of 4CX250s consists of coaxial-base versions of the 4CX250B that are designed for wideband, grid-pulsed RF amplifier service. These tubes generate the same amount of power, but with a properly designed input circuit, they produce that power with lower drive levels. The 4CX250K, along with the 4CX250M (26.5-V heater, coaxial-base version) is usable at 432 MHz.

4CX300A

This tube has a lower frequency limit of 110 MHz. Reports from users indicate that these tubes have a lot of thermal power drift when used at 432 MHz. (The alleged thermal drift could be caused by several factors, including the basic tube design, amplifier problems and faulty neutralization. I cannot personally verify these reports because I have not used 4CX300A tubes at 432 MHz.) The new and surplus tube prices ($300 and $150 a pair, respectively) make these tubes an iffy proposition (based on potential problems), but they are usable if the price is right and if you want to spend some time troubleshooting amplifier problems. The 4CX300A has a twist-lock base similar to the 4CX1000A, and is not

Fig 1—The venerable 4CX250B. This tube is designed for class-C RF service and class-AB RF or audio service. Typical RF service conditions for a 4CX250B in class-C operation are: anode voltage—2 k, screen voltage—300, anode current —250 mA, drive power—2.9 W, output power—390 W. Its physical dimensions are relatively small: 2½ inches high by 1⅝ inches in diameter. It weighs approximately 4 ounces and can be operated in any position. See text.

directly interchangeable with the 4CX250-family power tubes. There is also a high-cathode-current version, the 4CX300Y. These tubes are not commonly found in surplus channels.

8122 and 8122W

The 8122 has the same reputation for thermal power drift as the 4CX300A (I have not used this type of tube either, so I don't know if the problem can be eliminated). The 8122 has an 11-pin base similar to the 8874. Sockets for the 8122 are made from 11-pin base units in combination with screen-bypass capacitors. Because of the price of these tubes, new or surplus, you may be wasting your money. If you have a couple of 8122s, find an HF operator who has a National NCL-2000 amplifier or a NC-1000 transceiver, make him an offer he can't refuse, then purchase something else!

4CX350A

The 4CX350A is a ruggedized, high-linearity 4CX250B designed for class-AB operation. Its specification sheet looks great: Full ratings to 110 MHz, anode supply characteristic of 2.5 kV at 300 mA, and better linearity than the 4CX250B. I have heard that this tube is very inefficient, but such operation could have occurred as a result of substituting a 4CX350A for a 4CX250B without properly adjusting the amplifier.

You may be wondering what special magic gives the 4CX350A 100 W more plate dissipation than a '250. The answer is specification sleight-of-hand: The 4CX350A specs call for higher air flow than that recommended for the 4CX250! (In my opinion, radio amateurs are very hung up on plate dissipation. When using external-anode tubes, hams should consider the stated plate dissipation as a nominal value. In addition, a tube's plate dissipation rating depends on ambient temperature, altitude and air flow across the surface of the tube. *Cathode emission* is the more critical element in rating tube power capability!)

4CX250R

This is the best of the 4CX250 family and the only one of the family (along with the 8930) that I would spend money on. Although the 4CX250R has the same nominal ratings as the B model, better internal construction allows 325 mA IVS peak anode current per tube. (The tube is designed for conditions where shock and/or vibration are a problem.) The 8930, Fig 2, has identical internal construction with a larger anode radiator than the 4CX250R. The new v surplus cost factor is good ($300 new, $150 surplus) making the tube initially attractive. The one drawback, however, is the cost of the tube sockets—$250 a pair. Basically, you are probably better off spending the money on 3CX800A7s (discussed later), unless you have a line on sockets at a good price.

3CX400U7

The 3CX400U7 is a coaxial-base 8874 (discussed later) designed for use at 900 MHz. Eimac® built a large number of these tubes for use in 900-MHz cellular telephone repeater cavities. As the cavity manufacturer replaced the tubes and cavities with solid-state transmitters, they sold the old units to hams for only $50 (a great deal for 200 to 300 W at 902 MHz). This came to an end when the cavity manufacturer found that some hams were reselling the surplus equipment—at a tremendous profit—to competing commercial interests. (The manufacturer now crushes the cavities when they are taken out of service.) I wouldn't spend a lot of money on 3CX400U7s, but should you find a pair, they can produce a cool, efficient and linear 1 kW output at 432 MHz—as long as you don't mind making coaxial sockets.

8874

This rugged, reliable triode, Fig 3, has been around for 17 years. It is easily adaptable to the K2RIW parallel-tube kilowatt design and can produce a stable and linear 1 kW output. (I designed a single-tube, 432-MHz amplifier using the 8874.[4,5]) The 8874 is now in the same price class as the newer and more powerful 3CX800A7 (see below). 8874s are

Fig 2—Similar to the 4CX250R, the 8930 is a premier tube for use at 432 MHz. Operating conditions for an 8930 in class-AB amplifier service are: anode voltage—2.5 k, screen voltage—400, plate current—250 mA, output power—300 W. See text.

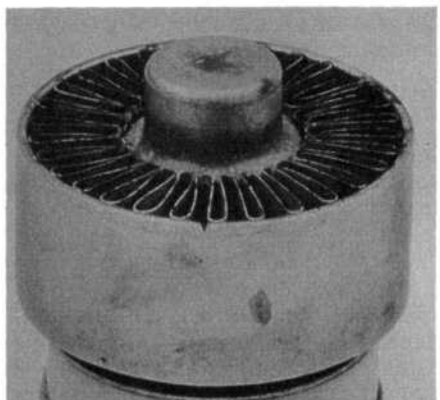


Fig 3—The 8874 triode transmitting tube. RF service conditions for this tube in class-AB operation are: anode voltage—2.2 k, plate current—350 mA, dc grid current—45 mA, driving power—27 W, output power—500 W. See text for a discussion of this tube and its capabilities.

readily available in the surplus market and make a simple, but solid, final.

3CX800A7

An improved 8874, the 3CX800A7 is a power triode used in zero-bias, class-B amplifiers. This tube offers very high power gain, has a large anode radiator and is capable of producing reliable, long-term power at 600 W. 750 W per tube is easily obtainable in IVS service. Due to the close interelectrode spacings and high gain, running the 3CX800A7s at high power requires grid-overload-protection circuitry. Russ Miller, N7ART, documented a two-3CX800A7 432-MHz amplifier in *VHF/UHF and Above Information Exchange* and the *1986 Central States VHF Conference Proceedings.*[6] I have designed and built a single 3CX800A7 amplifier that will appear in the upcoming *ARRL Microwave Book.*

Although this tube is expensive, the necessary sockets are cheap and operation is stable, efficient, highly linear and reliable. Its expense can be justified: The 3CX800A7 is probably the most cost-effective, long-term means of running high power on 432 MHz.

3CX600U7

This little-known and hard-to-find tube is perfect for 432-MHz operation. Designed for CW and pulse service up to 1 GHz, it is basically a more powerful 3CX400U7. A pair of these tubes provide 1.5 kW with very high efficiency and low drive levels. The problem is that you may have to take a second mortgage on your QTH to purchase a pair! If you find 3CX600U7s available at a reasonable price, don't pass them up.

4CX600J/8809

This very expensive gold-plated tube was designed for airborne military applications. The 4CX600J/8809, and its large-anode brother, the 4CX600JA/8921, feature low IMD products and low grid interception. Both of these tubes have good linearity and can produce a reliable 750 W per tube. The base is the same as that of a 4CX250, and the anode has the same diameter as an 8930. A pair of these tubes would make an excellent 432-MHz amplifier; don't pass them up if you have an opportunity to purchase them at a low price. Note: Assuming that you can find a pair, driving the cathodes is the way to go. Eimac has built and described a single tube, 432-MHz cavity using this tube.[7]

7650

The 7650 has been around for years. This tube is not very well known because RCA stopped selling it to the amateur market about 20 years ago. This tube is a medium-power tetrode; you can get 1 kW out of a 7650 in intermittent service, but you sacrifice linearity. Al Katz, K2UYH, has been using single-tube 7650 amplifiers for years (one of these designs was documented in *The Lunar Letter Magazine*[8]). A pair of these tubes will easily produce 1.5 kW. DL7APV recently built an amplifier using a pair of 7650s and reports 1.5 kW output is very easy to obtain. The 7650 is available surplus, but is usually passed by because few amateurs know what 7650s are or what to do with them. If you can find 7650s for a reasonable price, use them.

4CX600B/4CW800B

These are wideband, linear versions of the 4CX600J. They use an unusual screw stud base with a screen ring. Joe Reisert, W1JR, has been using a water-cooled 4CW800B in a rectangular cavity for many years. He reports that 900 W out is obtainable (he also seems to go through a tube every few years). The cavity that W1JR uses was described in an Eimac application note.[9] Note: Using water cooling is quite common in amateur circles on 1296 MHz, but it is rarely used on the lower bands. Don't invest lots of money in these tubes, but if you find them cheap, grab them.

4CX1000A/4CX1000K

These tubes are not recommended for use at 432 MHz. (I have heard reports that they can be made to work at 432 MHz, but I'll bet that they are not very efficient.) The difference between the A and K models is that the K model has a ring for the screen contact instead of the A's three tabs. Either tube, used in a proper socket, can give high input-to-output isolation (stability). If you are going to give one of these tubes a try, the best way is to run its screen at ground and float the cathode. (This technique was thoroughly described by H. Barber, W6GQK,[10,11] but for a much lower frequency—144 MHz—and is used in all large commercial and military UHF tetrode amplifiers.) Neutralization can be a problem because 432 MHz is above the self-neutralized frequency of the tube and socket, requiring screen tuning. You're better off using a 4CX1000 on 144 or 220 MHz and using a different tube on 432 MHz.

4CX1500B

This is simply a new, more linear version of the 4CX1000A. The same caveats apply: Use it on 144 MHz! Eimac also produces a coaxial-base version, the 4CX1500BC.

3CX1000A7/8283

This is a ceramic-metal 3-1000Z with a 4CX1000-type twist-lock base. The tube is primarily designed for class-AB linear-amplifier service in grid- or cathode-driven configuration. A 432-MHz amplifier using this tube was designed and built by Bill Orr, W6SAI, and John Chambers, W6NLZ.[12] This amplifier develops lots of output power, but it also uses lots of drive—it only has about 7 dB gain. In general, the 3CX1000A7 performs much better at lower frequencies. Eimac now makes a ceramic-metal version of the 3-1000Z, the 3CX1200A7. This tube is designed to use the same socket as the 3-1000Z and is not suitable for use above 100 MHz.

8877/3CX1500A7

The 8877, Fig 4, is an amateur standard up through the 220-MHz band. It is readily available on the surplus market because of its acceptance by the commercial market. The 8877 is a great tube

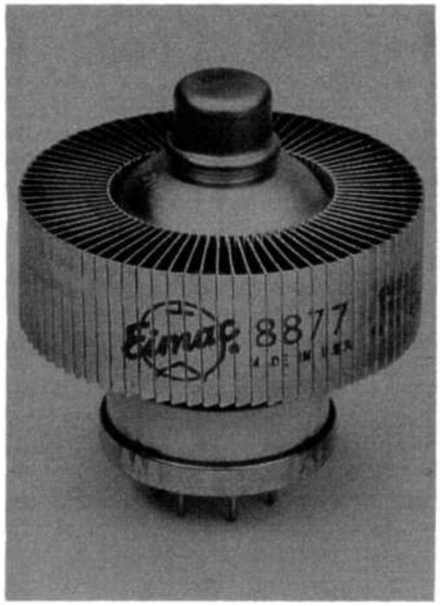


Fig 4—The 8877 is one of the more popular tubes in amateur service. Its frequency limitations are discussed in the text. Operating conditions for an 8877 in class-AB service at 220 MHz are: anode voltage—2.5 k, anode current—1 A, driving power—57 W, output power—1.52 kW.

below 250 MHz, but marginal on 432 MHz. Because of wide interelement spacings and relatively high grid inductance, it is inefficient (40%) and exhibits low power gain (10 dB or less). (Anyone who tells you of getting more than 40% efficiency at 432 MHz with an 8877 needs a new wattmeter.) If you do decide to use an 8877, use high anode voltage (over 3 kV under load) and lots of cooling air. You can get 1.5 kW out, but only under IVS conditions. Phillip May, K5AZU, designed and described a 432-MHz input circuit for the 8877.[13]

7213 and 7214

These are old workhorse RCA tubes.

Both are tetrodes with 1.5 kW of anode dissipation (the 7214 is a pulse-rated version of the 7213), are CCS rated and can comfortably handle 3.5 kV at 700 mA. In a single-tube configuration, either of these tubes will comfortably generate 1.5 kW of power at 432 MHz. Several surplus 7213/7214 cavities that can operate in the 432-MHz band are currently available. Jay Liebmann, K5JL, has used one of these tubes for years. I know of several amateurs who have tried to make the 7213 work in stripline circuits without much success. The chief problem with these designs seem to be their use of a bypassed screen (instead of at ground). Screen inductance, capacitance and coupling between the input and output circuits are all critical parameters which must be managed before the tube will successfully operate at 432 MHz. Some of the military cavities I have seen use a tuned screen for neutralization. In cathode-driven operation—the recommended method—power gain should be over 13 dB. 7213s are commonly available on the surplus market at reasonable prices.

8792/V1

This is the modern, more-linear version of the 7213. (There is also a wideband, high-gain version, the 8792/V2.) What I said about the 7213 applies to the 8792 with the single exception being that 8792s are much harder to find surplus. They are designed for cathode-driven service (as are the 7213, 7214 and most other UHF tetrodes).

8938

The 8938 is essentially the UHF version of the 8877. Depending upon plate voltage and drive levels, it can run at 50 to 55 percent efficiency, is very linear and can easily deliver a stable and continuous 1.5 kW output. The 8938's only technical drawback is its relatively low power gain (about 12 dB when stabilized). The chief problem with the 8938 is economic. The list price for a new 8938 is over $1500, and these tubes are not readily available on the surplus market. In addition, only two commercial transmitters currently use these tubes. A good surplus channel once existed, but it disappeared when amateurs were caught buying low and selling high, as in the 3CX400U7 cavity situation mentioned earlier.

A simple and effective stripline design for the 8938 tube was built and described by Tony Souza, W3HMU.[14] I have also designed a stripline amplifier using this tube that will appear in the upcoming *ARRL Microwave Book*. The 8938 is also suitable for operation in a cavity. Eimac builds a commercial cavity, the CV-2410, which is designed for use in the 430- to 470-MHz range. Unfortunately, at $5000, it is prohibitively expensive for most amateurs.

Summary

I have described a variety of tubes that work at 432 MHz. All of these tubes have external anodes and ceramic insulation. Of all the tubes listed, I recommend the 3CX800A7—a modern, high-gain, high-linearity, low-bias triode. Several high-power tetrodes are available from surplus channels that should also work well if you are willing to work with complex drive and tuning circuits.

One brief note on surplus availability. I am not against basic, capitalistic profit motives. There is, however, a difference between profit and cost recovery. If you come across any of the more desirable tubes, please use them or pass them on at your cost to someone who can use them. The surplus channels are drying up because some individuals are cornering the market. Manufacturers do not have to use the surplus channels to dispose of excess or used equipment—in some cases it's cheaper to crush or throw gear away. Please don't try to take advantage of their generosity—help them help us.

Notes

[1]R. Knadle Jr, "High Efficiency Parallel Kilowatt for 432 MHz," *QST*, Apr 1972, pp 49-55, and May 1972, pp 59-63.

[2]T. Pettis, "Hy-brid Hi-power," *VHF/UHF and Above Information Exchange*, Jun 1988.

[3]IVS ratings refer to amateur intermittent SSB voice and keyed CW operation. Typical key-down tune-up time should be limited to less than 60 seconds when a tube is operated under IVS ratings. Tubes must not be run continuously at their listed IVS power-output levels. Note that with the 8874 and 3CX800A7, the primary power limitation is the cathode's ability to *safely* deliver the necessary emission. The power-handling capability of the 4CX1000, 3CX1000A7 and 8877 is limited by the rate at which heat can be removed from the tube. See also W. Orr, "Intermittent Voice Operation of Power Tubes," *ham radio*, Jan 1971, pp 24-30.

[4]S. Powlishen, "A Grounded-Grid Kilowatt Amplifier for 432 MHz," *QST*, Oct 1979, pp 11-14.

[5]S. Powlishen, "Improving the K1FO 8874 432-MHz Amplifier," *QST*, Jul 1987, pp 20-33.

[6]R. Miller, "The Audry II UHF Amplifier," *VHF/UHF and Above Information Exchange*, Mar 1988.

[7]R. Miller, "Using the EIMAC 3CX800A7 at 432 MHz," *1986 Central States VHF Conference Proceedings*.

[8]A. Katz, "432 MHz 7650 P.A.," *The Lunar Letter Magazine*, Mar 1983.

[9]*An Eimac Family of 4CX600 Tetrodes, Application Bulletin No. 14*, published by Varian EIMAC, 1678 S Pioneer Rd, Salt Lake City, UT 84104.

[10]H. Barber, W. Orr, R. Rinaude and R. Sutherland, "Modern Circuit Design for VHF Transmitters," *CQ*, Nov 1965, pp 30-34 and *CQ*, Dec 1965, pp 40-45, p 92.

[11]H. Barber, W. Orr, R. Rinaude and R. Sutherland, "Modern Circuit Design for VHF Transmitters," *Varian EIMAC Amateur Service Newsletter AS-27*, Varian EIMAC, 1678 S Pioneer Rd, Salt Lake City, UT 84104.

[12]W. Orr and J. Chambers, "2-kW PEP Amplifier for 432 MHz," *ham radio*, Sep 1968, pp 6-9.

[13]P. May, "8877 432 MHz Amplifier Cathode Circuit," *VHF/UHF and Above Information Exchange*, Jun 1986.

[14]T. Souza, "A 432-MHz Power Amplifier Using Stripline Techniques," *ham radio*, Jun 1977, pp 10-14.

Bits

Sixth Space Symposium and Annual Meeting

AMSAT, the Radio Amateur Satellite Corporation, will hold its Sixth Space Symposium and annual general meeting, November 11-13, 1988, at the Airport Marriott Hotel, 4711 Best Rd, College Park, Georgia. Leonid Labutin, UA3CR, Chief of Communications for the recent Project SKI-TREK, and President of AMSAT-UA, will be the honored guest.

Cosponsored by the Atlanta Radio Club, the symposium and general meeting will feature lectures, seminars, and demonstrations on all facets of space communications. Family oriented programs will also be held in conjunction with the scheduled AMSAT programs. For additional information and registration forms, write: AMSAT Space Symposium, PO Box 29221, Atlanta, GA 30359.—*Tom Francis, NM1Q*

Build-It-Yourself Handheld Transceiver

The August, 1988 issue of *CQ-DL*, the monthly publication of the DARC (German Amateur Radio Club) features an interesting project: a 144-MHz handheld transceiver called The Gnome. The Gnome features 32 (expandable) channels with 5-kHz repeater splits or simplex operation. The unit is battery powered (7.2 V dc) consuming 215 mA on transmit (0.8 W output), and 30 mA on receive.

Because the article was written in German, I was not able to determine the quality of writing, or how complete the technical information is. The schematics, logic diagrams and pictorials, however, seem complete and informative. If you like to build challenging projects, and can find someone willing to translate the Gnome article for you, it would be worthwhile to check out this project. Contact the Deutscher Amateur-Radio-Club e. V., Postfach 1155, 3507 Baunatal 1, tel (05 61) 49 20 04.—*Tom Francis, NM1Q*

Flexible and Rigid Resin System

The General Electric Silicone Products Division has developed the TRIPLUS™ resin family consisting of TPR 178 (for flexible coatings) and TPR 179 (for rigid coatings). Both of these silicone resins are solventless, resist high temperature (1200°F in the cured state) and offer excellent weatherability. TPR 178 and 179 can be blended to provide a range of different coatings from flexible to rigid. In addition, both formulas have negligible volatile organic compound (VOC) emisions at room temperature, complying with EPA and OSHA regulations. For more information on these high-performance silicone resins, contact GE Silicones, Inquiry Handling Service, PR#COAT-1-V-88, 260 Hudson River Rd, Waterford, NY 12188, tel 800-255-8886.—*Tom Francis, NM1Q*

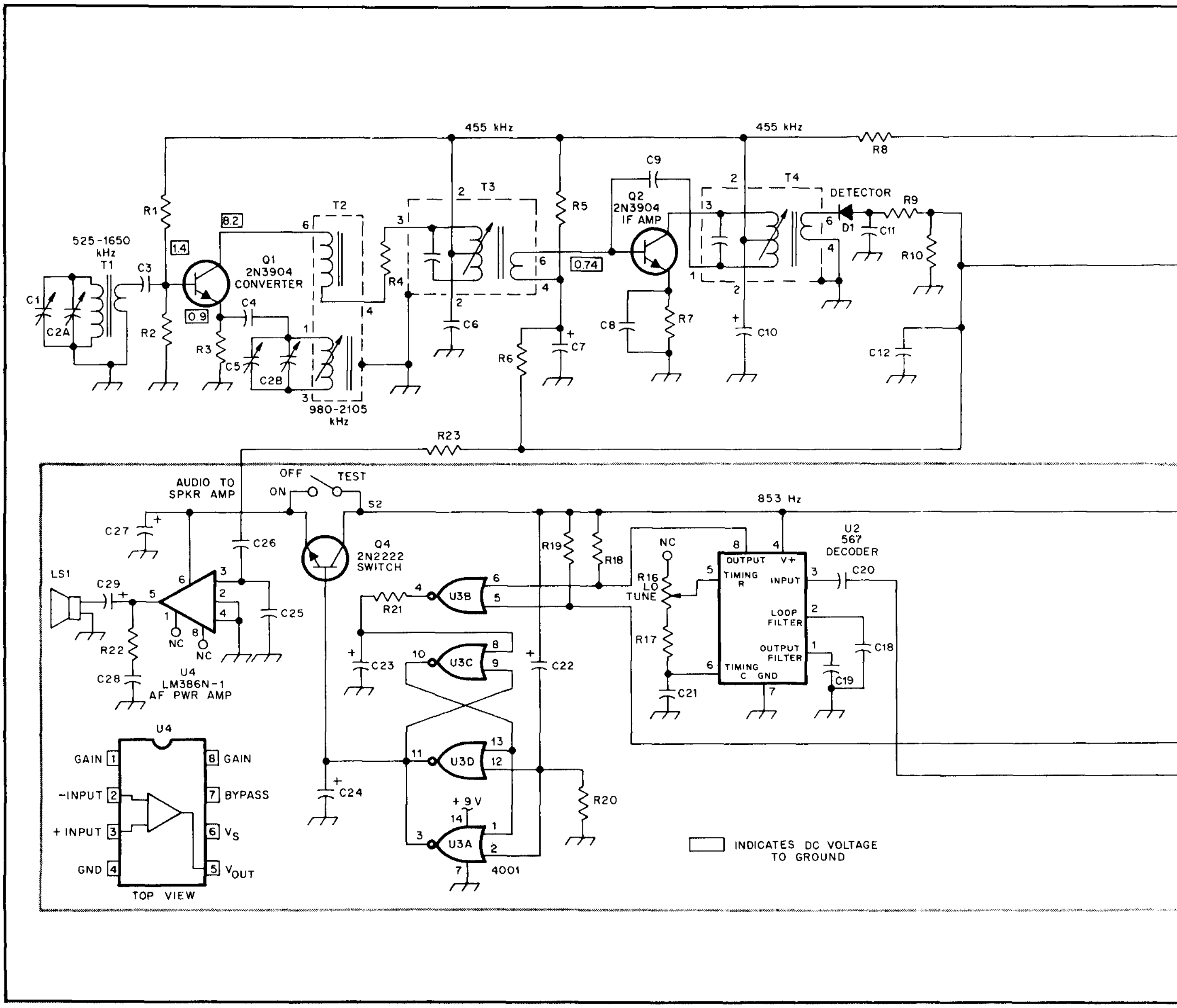
An Emergency Broadcast System Receiver

By Karl Williamson, KAØBUA
9712 Cote Brilliante
Overland, MO 63114

The theory behind the Emergency Broadcast System (EBS) is that early warning of an emergency can save your life or property. The EBS receiver described in this article can be built into an enclosure no bigger than a pocket pager. It silently listens for EBS attention signals and turns on its speaker when a test or emergency message is broadcast. With parts in hand, this project can be completed in a few evenings.

The Emergency Broadcast System

Have you have been listening to your favorite AM, FM or TV station when they broadcast a long piercing sound? Chances are good that you caught them testing their EBS equipment. Some people call the signal a "doomsday" sound because they equate the EBS signal with warning of a nuclear attack. This is misleading, though, because the EBS is intended to provide more than attack warnings. According to FCC regulations, even your local station may activate the EBS network for "any emergency that warrants an emergency response." As examples of such emergencies, FCC cites "tornadoes, hurricanes, floods, tidal waves, earthquakes, icing conditions,



heavy snows, widespread fires, discharge of toxic gases, widespread power failures, industrial explosions and civil disorders." Participation in the EBS is voluntary, but most broadcasters are enrolled. The easiest way to learn if a given station participates in the EBS is to phone and ask!

EBS tones must conform to strict specifications. FCC regulations require that the EBS attention signal be composed of tones at 853 and 960 Hz, each of which must contain no more than 5% distortion and drift no more than ½ Hz. The attention signal must last from 20 to 25 seconds and modulate the transmitter at least 40%.

The EBS network uses the attention signal "to activate muted receivers for inter-station receipt of emergency cuing announcements." The EBS receiver described in this article activates its loudspeaker on receipt of the EBS attention signal.

The EBS Receiver Circuit

The EBS receiver (Fig 1) covers the standard broadcast band between 525 and 1650 kHz. If you select a station transmitting on one of the channels listed in Table 1, you'll be monitoring what the FCC calls a Class II-A station. These stations are required to operate around the clock at output levels from 10 to 50 kW.

The resonant circuit composed of the ferrite bar antenna and tuning capacitor (C2A and its trimmer, C1) select the desired signal and feed it to Q1, the converter. T2 contains the local oscillator (LO) inductor and collector feedback coil. The nominal LO tuning range is 980 to 2105 kHz.

T3 feeds the 455-kHz IF signal to Q2, and T4 further improves the receiver selectivity and couples the IF output to detector D1. An audio filtering network and AGC components round out the receiver circuit.

Table 1

Class II-A AM Broadcast Stations

kHz	*Location*
670	Chicago, IL
720	Chicago, IL
770	New York, NY
780	Chicago, IL
880	New York, NY
890	Chicago, IL
1020	Pittsburgh, PA
1030	Boston, MA
1100	Cleveland, OH
1120	St Louis, MO
1180	Rochester, NY
1210	Philadelphia, PA

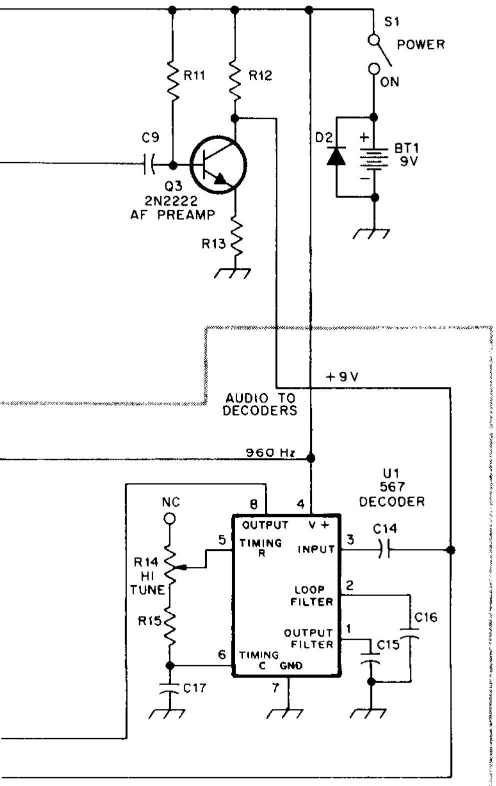


Fig 1—Schematic of the EBS receiver. Resistors are ¼-W, 5%-tolerance, carbon-film units. See Table 2 for the names and addresses of component sources.

BT1—9-V alkaline battery.
C1, C5—10-pF trimmers on C2A and C2B.
C2—Two-section "poly-vari-con" tuning capacitor. Oscillator section, 5-59.2 pF; antenna section, 5-141.6 pF (Mouser 2TR222).
C3, C6, C12—0.022-µF disc ceramic.
C4—0.0068-µF disc ceramic.
C8—0.047-µF disc ceramic.
C9—1-pF disc ceramic.
C11—0.01-µF disc ceramic.
C13-C16, C18-C20, C26, C28—0.1-µF stacked metallized film.
C14, C23, C24—10-µF 10-WVDC electrolytic.
C17, C21—0.047-µF stacked metallized film.
C22—1-µF 10-WVDC electrolytic.
C25—0.0047-µF disc ceramic.
C27, C29—220-µF, 10-WVDC electrolytic.
D1—Germanium diode (1N59 suitable).
D2—Silicon power diode (1N4001 suitable).
LS1—8-Ω, 2½-inch speaker.
Q1, Q2—2N3904 or equivalent.
Q3, Q4—2N2222 or equivalent.

R1—27 kΩ.	**R6, R19—10 kΩ.**
R2—5.6 kΩ.	**R8—330 Ω.**
R3—2.2 kΩ.	**R9, R13—1 kΩ.**
R4, R7—560 Ω.	**R10—6.8 kΩ.**
R5—68 kΩ.	**R11, R20—1 MΩ.**

R12, R15—20 kΩ.
R14, R16—2-kΩ trimmer potentiometer (Digi-Key no. D4AA23 suitable).
R17—22 kΩ.
R18, R19—100 kΩ.
R21—220 kΩ.
R22—4.7 Ω.
S1, S2—SPST toggle or slide switch.
T1—Surplus or home-built ferrite bar antenna. The home-built version consists of no. 32 (or thinner) enameled wire wound on a 0.37-inch diam, 3-inch long ferrite bar (Amidon R61-037-300). See the text and Fig 2 for winding instructions.
T2—Oscillator transformer, red core (Toko RWR-T1106A; a Mouser 421F300 may serve as a substitute).
T3—455-kHz IF transformer, yellow core (Toko RLC-T1105A; a Mouser 421F301 may serve as a substitute).
T4—455-kHz IF transformer, black core (Toko RZCO-T1104; a Mouser 421F103 may serve as a substitute).
U1, U2—CMOS or micropower 567 PLL decoder (Chelsea no. L567CP suitable).
U3—4001 quad two-input NOR gate.
U4—LM386N-1 audio power amplifier.

The recovered audio is fed to U4, the audio power amplifier, and to Q3, the audio preamp. In turn, Q3 feeds PLL decoders U1 and U2. Each decoder is tuned to one of the two EBS-attention-signal frequencies: U1 to 960 Hz, and U2 to 853 Hz. The decoders' outputs go low when the correct input tones are detected.

Because random bursts of 853- and 960-Hz energy occur many times per day in broadcast speech and music, the decoder outputs constantly go low for short periods. When both decoder outputs go low, the output of U3B goes high. To prevent falsing on non-EBS-signal energy, the long time constant of RC circuit R21-C23 ensures that 853- and 960-Hz tones must be present for several seconds to activate the EBS receiver. When an actual EBS attention signal is detected, the flip-flop composed of U3C and U3D latches high. (In conjunction with U3A, another RC circuit, R20-C22, prevents the flip-flop from powering up in the wrong state.) The high output of the flip-flop is filtered and used to turn on switch Q4, which connects U4 to the battery. With detected audio present at the input of U4, powering up U4 allows you to hear the EBS test message or—as the insurance people say, "God forbid"—the emergency announcement.

Options in Constructing the EBS Receiver

Originally, I designed the EBS receiver—complete with PC board—to make maximum use of the parts available in a Radio Shack® AM radio kit (former part no. 28-4029). This kit is no longer in the Radio Shack catalog, so some parts substitutions may be required if you want to build the circuit exactly as shown in Fig 1.[1] Circuit boards and complete parts kits are available from me; see Table 2.[2]

As another option, you can add the EBS-tone-decoder, flip-flop and output-amplifier circuitry—that portion of Fig 1 shown within a shaded box—to an existing broadcast-band receiver. Assuming that +9 V dc (relative to a negative ground), and audio at the different levels necessary for driving U1, U2 and U4 can be obtained from the receiver used, only four lines—AUDIO TO SPKR AMP, AUDIO TO DECODERS, +9 V and common—need be connected between the decoder circuit and the receiver circuitry.

Fig 2 shows how to configure the windings of ferrite bar antenna T1. To build T1, cut a 1⅜-inch-square piece of heavy paper and wrap it around the ferrite bar. Seal the paper to itself—not to the bar—with cellophane tape. The paper tube should be free enough to slide along the bar without being overly loose. Place a drop of instant glue at each end of the tube to secure the tube to the ferrite bar during winding.

As shown in Fig 2, wind a close-wound, 99-turn coil (tuned primary of T1) on the paper tube. Secure the ends of the winding with instant glue or household cement. Wind a close-wound 10-turn coil (link to Q1's base) beside this winding and secure it to the tube with glue or cement.

Tune-Up

Tune-up is easiest if these tools are available: nonmetallic alignment tool; frequency counter; oscilloscope; stable amplitude-modulated signal generator covering 500 to 1700 kHz; digital voltmeter. Con-

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Table 2

Sources for EBS Receiver Parts
Parts Kits and Circuit Boards

EBS receiver parts are available from the author as follows: (1) Etched, drilled and flux-coated glass-epoxy PC board—$8.95, plus $1 shipping and handling; (2) kit of parts that includes PC board; tuning capacitor and T2-T4; speaker; belt clip; ferrite bar antenna with prewound coil; LM386N-1; 4001B; and two L567 ICs—$32, plus $1 shipping and handling. Contact Karl Williamson, 9712 Cote Brilliante, Overland, MO 63114. (ARRL and *QEX* in no way warrant this offer.)

Component Dealers

Amidon Associates
12033 Otsego St
N Hollywood, CA 91607
tel 818-760-4429

Chelsea Industries
2555 Metro Blvd
Maryland Hts, MO 63043
tel 314-997-7709

Digi-Key Corp
701 Brooks Ave S
PO Box 677
Thief River Falls, MN 56701
tel 800-344-4539

Jameco Electronics
1355 Shoreway Rd
Belmont, CA 94002
tel 415-592-8097

Mouser Electronics
2401 Highway 287 N
Mansfield, TX 76063
tel 817-483-4422

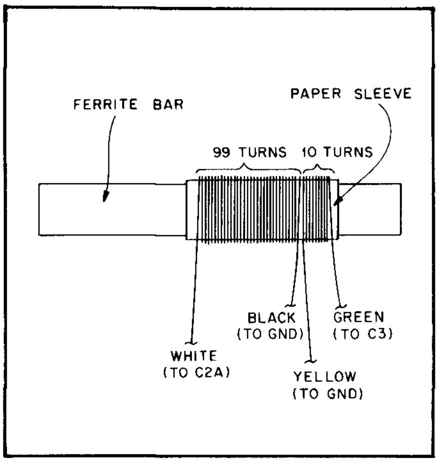

Fig 2—If a ready-made ferrite-bar antenna is not available, T1 can be wound using no. 32 (or thinner) wire as shown here and described in the text. The lead colors correspond to labels on the EBS receiver PC board (available from the author; see Table 2).

nect a fresh 9-V alkaline battery to the EBS receiver, and turn S1 (POWER) and S2 (TEST) to ON. You should hear noise from the receiver speaker. If you smell hot components or don't hear noise, *stop immediately* and correct the trouble.

Move T1's ferrite bar within the paper coil sleeve to peak the received noise. Adjust C2 for maximum noise. Next, readjust the position of the ferrite bar and adjust C1 as needed to peak the noise. When you've maximized the noise in this way, secure the ferrite bar to the coil sleeve with a drop of wax to prevent further movement of these parts relative to each other.

Turn C2 counterclockwise as far as it can go. Couple the signal generator to T1, and adjust the generator to 525 kHz. If you cannot hear the signal, adjust T2's core until you can. (Don't adjust the core of T2—and those of the IF transformers—more than 30° from their original positions, however.)

Next, turn C2 clockwise as far as it can go, and set the signal generator to 1650 kHz. Adjust C5 until you hear the signal. Finally, tune the EBS receiver to a station near 1000 kHz and adjust C1 for maximum volume. Now is also a good time to touch up T3 (yellow core) and T4 (black core) for best reception. Place drops of wax on C1, C5, T2, T3 and T4 to keep their settings from shifting.

Short the cathode end of D1 to common with a clip lead. Connect the frequency counter probe to pin 5 of U1 and adjust R14 (HI TUNE), to obtain a reading of 960 Hz. Move the frequency counter to pin 5 of U2 and adjust R16 (LO TUNE), to obtain a reading of 853 Hz. Seal R14 and R16 with wax, and remove the clip lead between D1's cathode and common.

The oscilloscope can be used to verify proper operation of the EBS receiver as follows: With the receiver tuned to a station, negative-going spikes should be observable at pin 8 of U1 and U2. Pin 4 of U3B should show a low-to-high transition whenever both of its inputs (pins 5 and 6) are low. At pin 3 of U3A, you should see a low that randomly rises by a few tenths of a volt.

Turn S1 and S2 to OFF, and then turn S1 back to ON. As long as S2 is set to OFF, the EBS receiver should be silent. Connect a clip lead between common and pins 5 and 6 of U3B. The voltage at pin 8 of U3C should rise rapidly, the output of the flip-flop (pin 11, U3D) should go high, and received audio should emanate from LS1.

Final Checkout and Operation

Set S1 and S2 to ON and tune in the station you desire—one from Table 1, if possible. EBS stations test their equipment once a week, and a phone call or two should net you the date of the next test. Once you've learned the date of the next EBS test, set S2 to OFF and listen for proper operation of the EBS receiver on the test date. If all is well, the EBS attention signal should activate your EBS receiver!

The EBS receiver draws under 5 mA at 9 V. In the monitor mode (S1 ON and S2 OFF), the EBS receiver should operate for 60 hours or more with a fresh alkaline battery. If you use the EBS receiver as an AM broadcast radio, battery life will be much shorter. The EBS receiver is designed to respond to EBS attention signals even when the battery voltage drops below 7, but the sensitivity of the receiver circuit drops significantly below this level. (If the EBS receiver can't hear them, it can't decode them! Also keep in mind that RF noise from computers and similar interference sources may desensitize the EBS receiver in some cases.) If you decide to power the EBS receiver from a battery eliminator, be sure the eliminator output is well-filtered and regulated at 9 V.

Conclusion

Whether you decide to built the EBS receiver as a stand-alone unit or add its decoder circuitry to an existing broadcast-band receiver, I hope you'll find adding EBS-decode capability to your operations to be worthwhile. I'll be happy to answer any questions about the EBS receiver if they're accompanied by an SASE.

Notes

[1]The Tandy National Parts center may be able to supply some or all of the components used in the Radio Shack AM radio kit. [Some sources of direct replacements for parts from the Radio Shack kit—T1-T4 and C2 in particular—have since dried up. The Mouser equivalents to T2-T4 and C2 (see the parts list in the Fig 1 caption) should provide equivalent electrical performance, but may vary in physical characteristics from those originally used by author Williamson to design his EBS-receiver PC board.—*Ed.*]

[2]A PC-board template and parts overlay are available from ARRL Technical Department for a no. 10 SASE.

A 6-Meter Oscillator

By Dan Becker, WA4EWI
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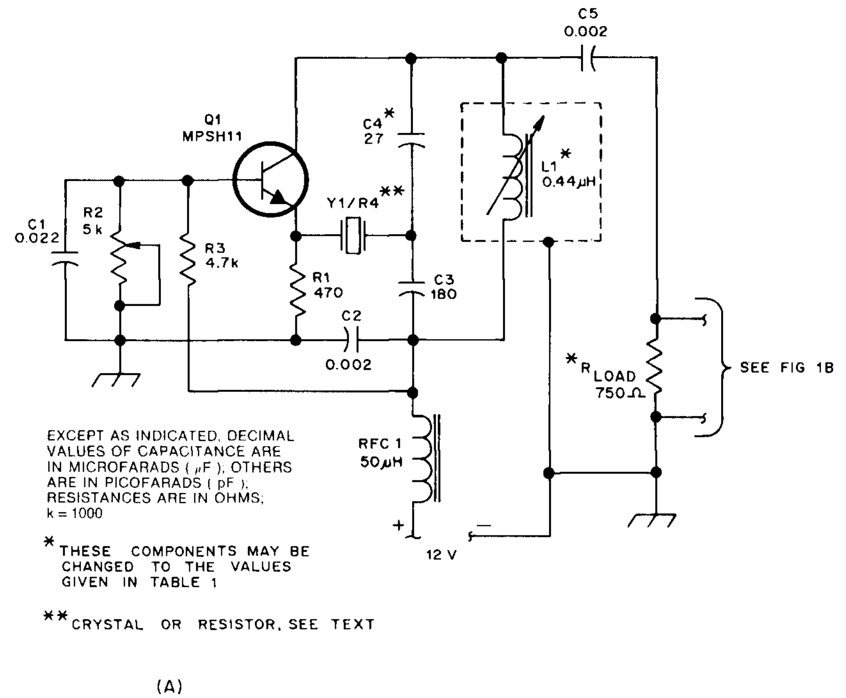
One of the best oscillator circuits for VHF service is the Butler, or bridged-T, circuit. The Butler circuit has more temperature and frequency stability than other more conventional oscillator circuits, and is easy to build. This type of oscillator uses a grounded-base transistor and is stable up to approximately 200 MHz. If a quartz crystal is coupled to the transistor emitter, its output current is sinusoidal and relatively free of harmonics. In this article, I'll describe the Butler oscillator circuit, with an emitter-coupled crystal, at the component level. This particular circuit is for 6-meter applications, but it can be modified to suit other purposes.

The Butler Oscillator Circuit

The schematic diagram of the 6-meter Butler oscillator is shown in Fig 1A. In this circuit, resistors R1, R2 and R3 control Q1's dc bias current. C1 bypasses Q1's base to ground, putting Q1 in a common-base configuration. (A value of approximately 680 to 1000 pF for C1 will work best. Larger values for C1 can result in squegging—oscillation at more than one frequency at the same time—and smaller values may inhibit oscillation.) C2 and C5 bypass RF to ground. A 50-μH choke, RFC1, blocks RF current in the 12 V dc power-supply lead and should have a dc current rating of 20 mA or more. Y1 is a series-resonant, AT-cut, third-overtone crystal and presents approximately 40 Ω of resistance at resonance (I used a 52-MHz crystal). A 39-Ω resistor, R4, can be used in place of Y1 if you want to build the oscillator without a crystal. The frequency will not be as stable with the resistor, of course.



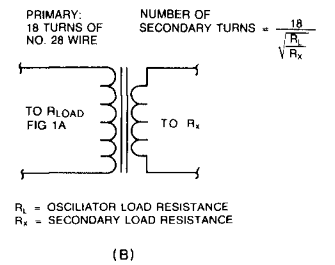


Fig 1—At A, the schematic of the Butler, or bridged-T, 6-meter oscillator circuit. Resistors can be either ⅛- or ¼-W carbon film. At B, details of an output matching transformer wound on an FT-23-43 ferrite toroidal core. For the primary winding, use 18 turns of no. 28 enameled wire; the secondary consists of no. 24 or no. 26 enameled wire. For example, a 6-turn secondary yields an impedance ratio of approximately 9 to 1.

Q1 is a small-signal, silicon NPN amplifier with a voltage rating of 25 or more. I used an MPSH11 in this design, but any transistor with similar characteristics will work as long as the substitute transistor has an f_T (current-gain bandwidth product) rating of at least 650 MHz.

C3 and C4 divide the output voltage to provide a fraction of the output signal (positive feedback) to drive Q1. The value of C3 is fixed at 180 pF, while the capacitance of C4 can be changed from its nominal value of 27 pF (see Table 1). L1 is a shielded variable (nominally 0.044-μH) inductor, with a Q of 50 (or more). (L1's shielding makes the circuit less sensitive to spurious oscillations caused by stray coupling to adjacent components.)

This circuit is designed to drive a resistive load. Capacitive and inductive reactances in the load—across L1—must be avoided (either of these reactive conditions will cause frequency changes or prevent oscillation).

Circuit performance can be altered by varying the values of C4 and L1 (see Table 1).[1] Decreasing the capacitance of C4 reduces oscillator feedback. The reverse occurs when the capacitance is increased. For resonance at a given frequency, L1 must be increased as C4 is decreased. The net result of reducing the capacitance of C4 is that the output power must increase in order to maintain an equivalent output signal (this also

[1]Component values are based on algorithms in Benjamin Parzen, *Design of Crystal and Other Harmonic Oscillators*, (New York: John Wiley & Sons, 1983), pp 250-279.

continued on page 13.

VHF+ Technology

By Geoff Krauss, WA2GFP
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As I write this (early August), I have just heard that the FCC has voted to reallocate 220-222 MHz to land mobile services (LMS). Many VHF+ ers believed this change was foretold by the Novice Enhancement frequency allocations, even though most commenters in the 220-222 MHz proceeding, including many in the LMS, were against it! What can we do? For my part, I'm sending a letter to the Democratic and Republican presidential candidates asking them to take a public position on this FCC action. I also intend to write to my senators and representative. Shouldn't you write, too?

Traveling-Wave Tubes, Continued

Ray Harland, N6AMD, sent in copies of the data sheets for a Litton Industries TWT—type M5675B (8-11 GHz)—which he tested with a home-brew power supply to get 2 W out for 0.5 mW in at 10.368 GHz, and for a Teledyne-MEC TWT—type M5793B (7.4-12 GHz)— rated at 15W out with less than 1 mW in. Ray is still working on a supply for the M5793B, but will use the M5675B for narrow-band work in the fall ARRL 10-GHz Cumulative Contest.

I have also received a request for any available data on an Alfred 267 TWT power supply. It seems that someone needs data for almost every item of Alfred microwave equipment; I'd certainly like to hear from anyone with access to this material.

The State of the Art at 70 cm —Continued

I ended the last column by briefly describing some of the facts associated with parabolic-dish reflectors. The question under discussion was whether a Yagi beam array or a dish is the better choice for a 432-MHz weak-signal station. Since the gain of an antenna is mainly set by its signal-capture area (aperture), a Yagi array has material occupying less of the capture area than a dish with the same gain. (In addition, the Yagi array should be lighter in weight and exhibit less wind load.) On the other hand, a Yagi array operates over a relatively narrow frequency range, while a properly surfaced dish can easily operate over a full decade (10:1) frequency range. I have helped install dishes with feeds for such band combinations as 432/1296, 903/1296/2304 and 2304/3456/5760 MHz! The secret is to put the center of as many feeds as possible at the dish focus without mechanical interference. If interference exists, put the feed for highest frequency at the focus and move the other feeds progressively away. Fig 1A shows such an arrangement for three bands, with the antenna for the the highest-frequency band (1) at the dish focus and the antennas for lower bands moved off the focal point. Fig 1B shows an end-on detail of the three feed horns in Fig 1A; they are arranged in a straight line. Fig 1C shows that it may be possible

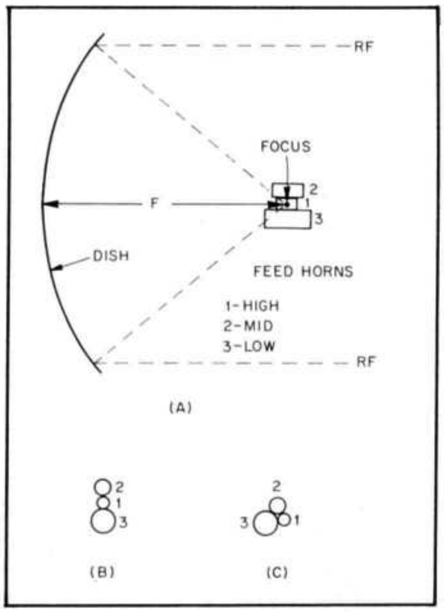


Fig 1—You can make the most out of one antenna support by mounting more than one feed horn at the dish focus. F is the focal length of the dish. See text.

to get the centers of the two outer horns closer to the focus if their centers are placed at the corners of a scalene triangle.

If at least one antenna is formed of elongated elements (like a dipole), and is not some form of horn, the popular form shown in Fig 2 can be used. This arrangement is common at 1296 MHz. The 1296-MHz horn can be excited to give circularly polarized waves with selectable rotation sense, and the 432-MHz array, which consists of dipoles (two phased dipoles each in the vertical and horizontal planes) allows reception of Faraday-rotated EME signals. The dipoles are

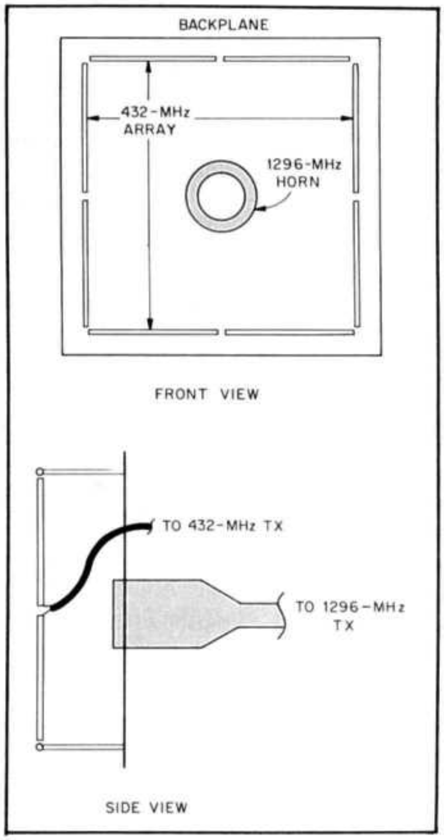


Fig 2—Feed arrangement that allows use of one dish on 432 and 1296 MHz. See text.

mounted above a backplane, through which the feed horn passes to launch its energy into the dish. Interestingly, if the horn protrudes slightly (about ⅛ λ) through the hole, the backplane can act as a choke to improve the horn pattern and gain.

There is considerably less interaction between bands using these forms of multiband feed with a dish than there is in a system that attempts to achieve similar gain by placing the individual beams of a large Yagi array among the beams of other large Yagi arrays for other bands. Thus, if operation on several bands is desired, and only one antenna support structure can be used—or if all signals must be accurately (and perhaps even simultaneously) pointed in a common direction—a multifeed dish is probably the only realistic means of achieving such performance. If several different supports and/or targets are involved, separate beam arrays may be the best answer.

Of course, the amount of power radiated by the antenna depends on how much power reaches the antenna feed point. Cable that exhibits sufficiently low loss at 70 cm is difficult to find; many cable types cannot withstand maximum amateur power (1.5 kW) at this and shorter wavelengths. Skin effect usually necessitates a large center conductor if coax is to exhibit low loss in the VHF + realm. Such cable usually can handle high power. Thus, most topnotch 70-cm stations use ½- or ⅞-inch-diameter cables. The low loss of these cables more than justifies their cost and the problems of connector availability and installation that their use entails.

70-cm Power Amplifiers

If getting good coax is a problem, finding a power amplifier capable of pushing 1.5 kW into that cable is even *more* of a problem! A number of two-4CX250 power-amplifier designs have appeared over the years. Perhaps the most successful such design— in terms of ease of duplication—was that of Richard Knadle, Jr, K2RIW.[1] This flat-plate-line design was improved upon in 144, 220 and 432-MHz amplifiers made available by ARCOS (Amateur Radio Component Service) in ready-made or kit form. The manufacturer (Fred Merry, W2GN, founder of ARCOS) has retired. [Just before press time, we were saddened to learn that Fred passed away on September 11, 1988, at the age of 81.—Ed.] The ARCOS name was sold by Fred, and the current owner is Art Hambleton, K1LL/Ø.[2] Art is now gearing up for kits and also has a quantity of amplifier parts available. Used ARCOS 432-MHz amplifiers and/or power supplies are sometimes advertised for sale in ham magazines and journals; such an amplifier may be one way of getting about 500 W at 432 MHz.

Obtaining the full gallon-and-a-half is much more difficult. A 1.5-kW 432-MHz amplifier *cannot* be built around "ordinary" UHF tubes; such tubes just can't produce power at this level. Instead, 1.5-kW 432-MHz amplifiers often use a single RCA 7650 or 7213 tetrode (or one of their pulse-rated siblings, the 7651 and 7214). Those desiring a simpler amplifier—that is, an amplifier that does not require a screen-grid power supply—can use the Eimac 8938 triode, which looks and acts like a UHF-rated 8877. The cost of the 8938 ($1600 new) is higher than the already expensive 887X- series tubes, but the investment is worthwhile if you must run 1.5 kW.

It's far easier to realize outputs of 20 to 100 W at 432 MHz. Many tubes in the 4X150 (tetrode) and 2C39 (triode) families can be used. Solid-state amplifier bricks can easily provide powers in this range; depending on the device, these operate in class AB, B or C at nominal supply voltages of 12 or 28.

It's safe to say that most 432-MHz transmitters capable of generating 25 W or less are solid-state, although vacuum-tube transverters are still used to convert 28-MHz SSB to 70 cm. Tube units may dissipate lots of heat and require higher operating voltages and powers, but they don't have many of the IMD problems that occur in some of the solid-state transverters used at 70 cm. The fact that IMD levels tend to increase with frequency doesn't help matters at 70 cm—but state-of-the-art design practices *can* reduce the impact of the IMD problem.

Notes

[1]R. Knadle, Jr, "A Strip-Line Kilowatt Amplifier for 430 MHz," part 1, *QST*, Apr 1972, pp 49-55; part 2, *QST*, May 1972, pp 59-62 and 79.

[2]Art Hambleton, K1LL/Ø, 10004 High Meadows Dr, Black Hawk, SD 57718; home tel 605-787-4552.

A 6-Meter Oscillator

continued from page 11

requires an increase in the value of R_{load}).

The stability of this circuit depends, in part, on the temperature sensitivity of L1, C3 and C4. NP0 capacitors will improve the overall temperature stability if the circuit is crystal controlled.

As I previously mentioned, this oscillator is designed to work into a resistive load. If your application requires a different load resistance, add a matching transformer, as shown in Fig 1B.

Circuit Assembly and Tuning

I built my version of the oscillator on a 1½-inch-square piece of printed circuit board. Keep all component leads as short as possible. For initial testing, install a 39-Ω resistor in place of Y1.

The initial tune-up of this circuit is simple and easy to do. Select a load resistance from Table 1 and install a resistor of this value between C5 and ground. Connect a regulated 12-V dc power supply to the circuit and apply power. Place a frequency counter probe across R_{load}, and attach an ac voltmeter across R1. (Note: If there is too much voltage at R_{load} for your counter's input, place the counter probe across R1.) Make sure that the circuit is not oscillating. If necessary, stop the oscillation by adjusting L1. Measure the ac voltage across R1 while adjusting R2. When Q1's emitter current equals the selected value given in Table 1 (or has reached the value you require), adjust L1 to the desired frequency (for a crystal oscillator, adjust L1 so that the circuit oscillates at the crystal's frequency). Once you have determined that the circuit is working properly, remove the load resistor and connect the actual load. Check the oscillation frequency and readjust L1 if necessary. Should spurs occur, change the value of RFC1 and/or the bypass capacitors, C1 and C2.

Summary

This Butler oscillator circuit produces a clean signal and is easy to work with. Provided it is properly matched, the circuit may be used to drive anything from a mixer to an antenna. The values given in Fig 1A and in Table 1 are based on a 52-MHz design, but they can be altered for use elsewhere in the 6-meter amateur band.

Table 1

Seven variations on the 6-meter Butler oscillator circuit shown in Fig 1A. (Column 6 contains the values for the circuit detailed in Fig 1A.) Select C4, L1 and load resistance (R_{load}) (rows 2, 3 and 4) for the required Y1/R4 power dissipation (row 5), total circuit output power (row 6) and dc emitter current (row 1). Each column gives a different combination of dc emitter bias current (row 1), load resistance, C4 and L1. See text for emitter current adjustment procedure.

CIRCUIT NO.	1	2	3	4	5	6	7
DC EMITTER CURRENT (mA)	5	5	5	7	7	7	10
CAPACITOR C4 (pF)	68	33	22	82	39	27	39
INDUCTOR L1 (μH)	0.21	0.36	0.51	0.18	0.31	0.44	0.31
LOAD RESISTANCE (Ω)	470	680	910	430	620	750	620
Y1/R4 POWER DISSIPATION (mW)	0.5	0.5	0.5	1.0	1.0	1.0	2.0
OUTPUT (LOAD) POWER (mW)	3	6	9	5	10	15	20

Correspondence

Feedback

Please refer to "A Weather-Facsimile Display Board for the IBM PC," *QEX*, Sep 1988, p 5, Fig 4. The logic behind the circuit is better understood if U4A and U4B are shown as in Fig 1. On p 3, right-hand column, second paragraph, the active filter identified as U1C is actually U2C.—*H. Paul Shuch, N6TX*

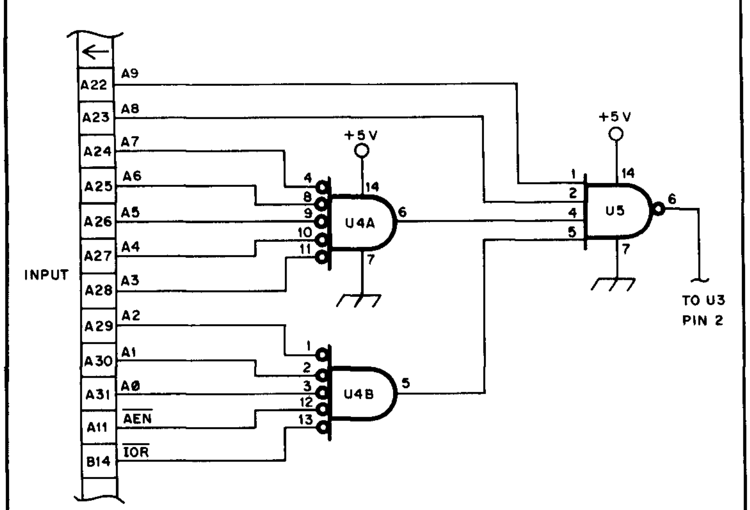
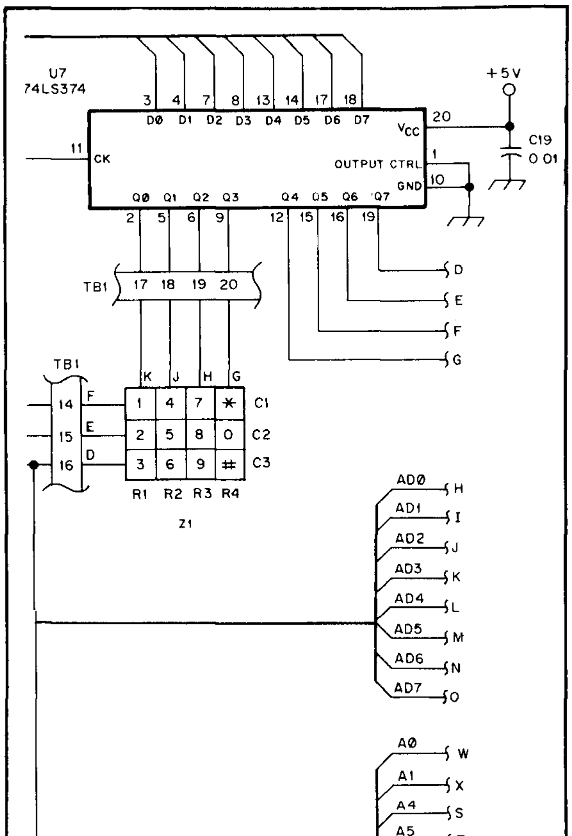


Fig 1—Schematic correction for "A Weather-Facsimile Display Board for the IBM PC."

There is an schematic error in the "8052AH-BASIC Micro Project Controller," *QEX*, Oct 1988, p 5, Fig 1. The connection points associated with DS1 (connections 1 to 13), Z1 (connections 14 to 16) and U7 (connections 17 to 20), were incorrectly identified as P1; this terminal block is TB1 as shown here in Fig 2. —*Tom Francis, NM1Q.*



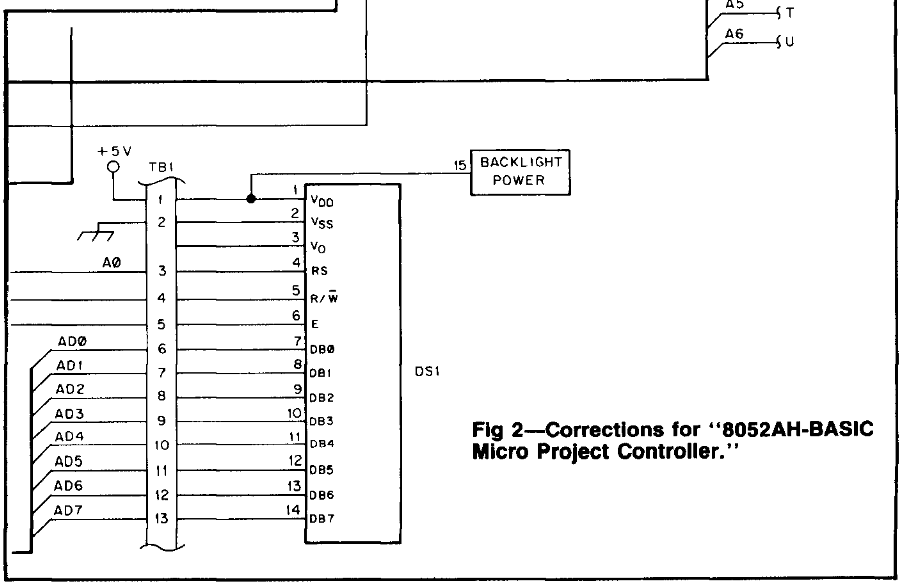


Fig 2—Corrections for "8052AH-BASIC Micro Project Controller."

Bits

NEC High-Gain Heterojunction FET

The NE32084 is a low-noise, high-gain heterojunction FET that is available in a sealed, stripline package. Its characteristics make the device suitable for LNA and gain-stage applications. The NE32084 exhibits a typical noise figure of 1.3 dB and gain of 10 dB at 12 GHz.

For more information and pricing, contact Tom Costa, product Marketing Manager, California Eastern Laboratories, 3260 Jay St., Santa Clara, CA 95054, tel 408-988-3500.—*Paul K. Pagel, N1FB*