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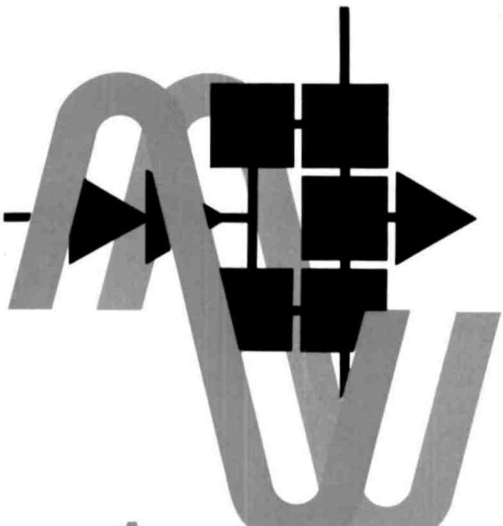
JUNE 1975

this month



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More Details? CHECK—OFF Page 94

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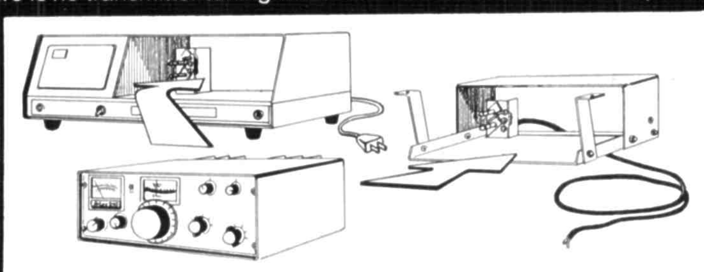

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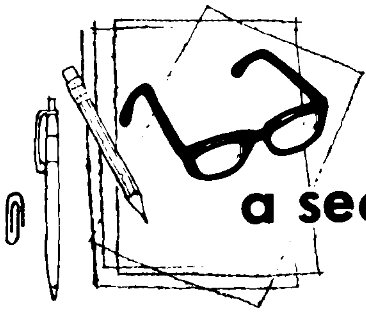

a second look

by jim fisk

As I pointed out in this space last month, the FCC is considering various new ways of determining the power limitations of amateur transmitters. These range from dc power input and power output to manufacturer's plate dissipation ratings. All of these methods, however, contain one or more variables which are subject to interpretation and policing. Dc input measurements, for example, must be done with calibrated meters at the time of operation. Output power measurements are complicated, and require accurate instrumentation. Plate dissipation ratings are aribtrary numbers established by tube manufacturers which are based upon a given amount of air and back pressure to establish a desired plate dissipation rating. However, it is conceivable that a manufacturer could rate a large tube at a *lower* plate dissipation rating, or conversely, by requiring more air flow, considerably *increase* the dissipation capability of the tube. This variation is brought about by the fact that different types of service are used in communication systems (class A, B or C); flexible data ratings for different classes of service must be established because of the variations in plate efficiency from one class of operation to another.

As has been pointed out by Jack Quinn, W6MZ, of EIMAC, there is only *one* common denominator in a vacuum tube which determines the maximum capability of that device, and that is the manufacturer's rated heater, or filament, power. This is a parameter which is very carefully established by all tube manufacturers and follows rigid, fixed laws of physics. These current/voltage relationships of the emitter cannot be increased with any degree of freedom without suffering short tube life or catastrophic failure.

Rather than establishing new amateur power limitations based upon plate dissipation ratings or publishing a list of approved tube types which must be continually maintained and up-dated, Quinn has proposed that certain *maximum filament or cathode heater power ratings* be established. For example, Extra, Experimenter and Advanced class licensees could use a final amplifier having one or more thoriated-tungsten filament tubes with a total filament power rating which does not exceed 200 watts. An amplifier with an indirectly-heated oxide cathode tube would have a total heater power which does not exceed 60 watts, according to the manufacturer's ratings. If this were done, the ratings would be based upon a common ground and good, sound, technical background. This would also be compatible with amateur equipment in common use today as shown in **table 1**.

Power levels for the General-Technician and Communicator-Novice classes could be scaled down by whatever percentage the Commission deems

(continued on page 60)

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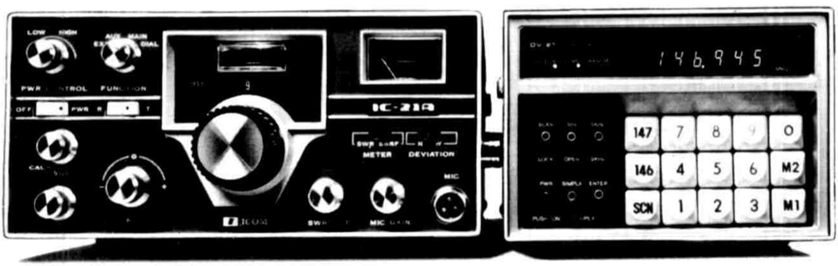

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ARRL FORUM AT DAYTON HAMVENTION in late April, led by League president W2TUK, was primarily a question and answer session. As expected, restructuring was the primary subject but, since the League position isn't officially set until the Director's meeting in May, Harry's answers had to be his own personal opinions. Other subjects included possible ARRL insurance program (under active consideration but hard to find an underwriter to cover all states), how to communicate with the FCC, protecting the ham bands from incursions by other services, and type acceptance of commercially made gear.

ARRL 20282 Survey has had an outstanding response — about 56,000 of the League's 100,000 members returned their surveys in time to be processed!

RESPONSE TO RESTRUCTURING so far received by FCC summarized by Prose Walker at Dayton. Two-thirds support 20282, one-third oppose. Most want 10 meters shared. Of the 80% discussing power, more than half are against reductions to Generals and Techs and all oppose levels offered Novice/Communicator. Measuring output power is opposed by the majority.

TYPE ACCEPTANCE of amateur gear is becoming more and more of an active issue at the FCC. The subject was discussed at the Dayton Hamvention Novice forum, which featured both Charles Higginbotham, Chief of the FCC's Safety and Special Services Bureau, and Ray Spence, W4QZW, Chief Engineer of the FCC.

Type Acceptance has some good features but some bad ones, too. It might clean up some problem-causing commercial gear and thus help reduce the RFI problem. At the same time it could prove very stifling if, for example, it forbade the individual amateur from modifying his equipment to meet his own needs.

PROPOSED NEW HF HAM BANDS won't be ours without a stiff fight in 1979. North Atlantic broadcasters would like to increase the international BC allocations between 3 and 27 MHz by another 7 MHz at the forthcoming world conference! For reference, that's more than twice what they're presently allocated.

NEW MOTOROLA COMMERCIAL FM GEAR is pushing the amateur price range — Maxar line of 150- and 450-MHz transceivers starts at $395 for a 10-watt out model with several channels. For repeaters their new Spectra-Tac voting system looks very competitive, and finally, they have a new pager receiver which shakes in your pocket when you get a call.

JA1ANG VISITED AMSAT early last week and reported JAMSAT is well along in construction of a two-meter-to-435-MHz transponder in anticipation of the next OSCAR. Other JAMSAT projects are also in the mill.

TI9DX On Cocos Island was heard on OSCAR recently, and TU2EF reports he's been quite active on Mode A — his log would make a serious 20-meter DXer drool. FY7AS, A2CJP, 4W1ED and ZS3E are samples — he reports EA8CS may also be on soon.

"Area Coordinator" is the tentative title for a position established by the AMSAT board. Purpose for the Area Coordinator, who should be an active OSCAR user, is to advise amateurs interested in getting on OSCAR and provide local clearinghouse for OSCAR activities. Active satellite users who want to help out in this capacity should contact AMSAT headquarters.

FCC TAKING A CRITICAL LOOK AT SPEECH PROCESSING if footnote at the end of Docket 20282 is any indication, but no response to the restructuring docket filed so far has even acknowledged that paragraph's existence. Since DXers are the most frequent users of processors, we better take another look at that paragraph and its implications — mushy and broad signals have all too often caused problems on the lower ends of the DX bands.

MORE NON-AMATEUR OPERATIONS THREATEN 420-450 MHz band, as TI in Dallas attempts to get a new Special Temporary Authority to continue operating a high-powered navigation system on 430 MHz. The 20 kW ERENS (Extended Range Electromagnetic Navigational System) transmitter has a range of 250 miles and has been on since last September. They have also filed requests for similar systems on Cape Cod and Montauk Point, Long Island. If permitted, these pulsed navigational systems would make a large portion of the 420-450 MHz band practically unusable.

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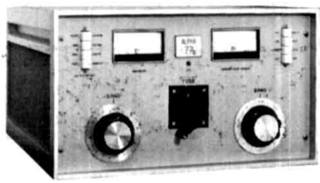

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More Details? CHECK—OFF Page 94

phasing-type single-sideband transmitter

A direct-conversion companion transmitter for the Phase II ssb receiver

G.K. Shubert, WAØJYK, 1308 Leeview Drive, Olathe, Kansas 66061

The Phase II ssb receiver described last year in *ham radio*[1] has been a moderate success and has proven worthy of a companion transmitter. The phasing method of single-sideband detection has been revived slightly, and the addition of a good ssb transmitter will even stir interest among the "filter freaks." After all, doesn't it make sense to generate just one sideband with phasing techniques rather than to generate both sidebands and remove the unwanted one with a brute-force crystal filter?

This article presents the Phase II reciter, a ssb exciter that borrows phase quadrature rf from the Phase II receiver. A 300-watt PEP solid state linear power amplifier will be the subject of a future article and will round out the Phase II system including vfo, transmit/receive switching, vox, filtering, and a regulated, low-voltage, high-current power supply.

Readers of the Phase II receiver article have indicated an interest in a more elaborate receiver with additional frequency coverage. New circuits for improving the receiver and ideas for future development will be discussed. The possibilities for the receiver and transmitter pair are far too numerous to present in full detail, so individual circuits and interconnect information will be given, leaving the final enclosure and layout to the individual builder. Layout might vary drastically between a receiver-transmitter for a single, crystal-controlled frequency, and one designed for the three lower amateur bands with vfo control.

ssb reciter

Fig. 1 is the classic diagram of a phasing-type ssb transmitter that has appeared in the electronic handbooks for three decades.[2] The 90-degree rf phase is developed in the Phase II receiver and it will be necessary to refer to the receiver article for additional information on this aspect of the circuit. Since the transmitter may be operated independently if this portion of the receiver is duplicated in the transmitter, this oscillator and phase-shift circuit are described later in the article.

Much of the research done on phasing circuits in the 1940s occurred during the development of telephone carrier systems and many of the schematics bear the Western Electric title box. Engineering texts tell us that a single-sideband-suppressed-carrier signal can be regarded as the resultant of quadrature modulation of a carrier by a pair of signals in phase quadrature, further explained with some pretty involved mathematics.[3] It is possible to switch the phase-quadrature rf to in-phase rf and generate phase-modulated signals. Perhaps this is why the phasing technique was popular in the late 1940s and early 1950s when narrow-band fm was far more popular on the high-frequency bands than the then newer mode, single sideband.

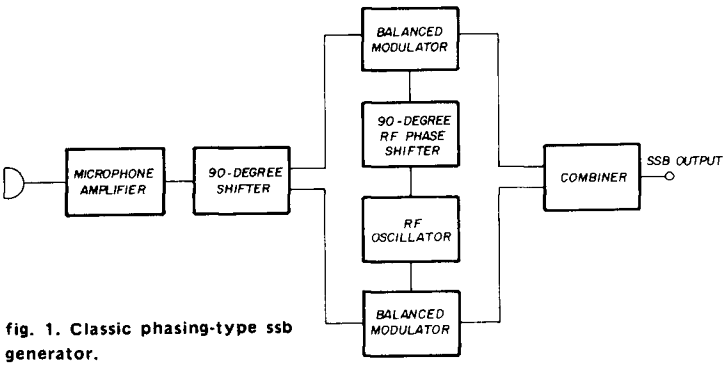


fig. 1. Classic phasing-type ssb generator.

Fig. 2 is a block diagram of the entire Phase II system. The digital phase-shifter in the receiver is used to supply phase-quadrature rf to the exciter. This means the parts cost for the exciter will be considerably less than for the receiver. The exciter uses exactly the same audio lowpass filter and audio phase-shift network as the receiver. It is better to duplicate these components in the interest of simplicity of switching and balancing circuits.

Although these components are not particularly expensive, they may be a little difficult to locate. The 1% precision film resistors are standard MIL-BEL values as are the 0.1-μF capacitors. The 0.028-μF capacitors may have to be made up by paralleling a 0.027-μF and a 1000-pF silvered-mica capacitor. Remember that ultimate sideband suppression depends upon the accuracy of these components, so be as accurate as possible.

A circuit board has not been seriously considered for several reasons. One very obvious reason is that a circuit board takes time to develop and debug, not to mention the problems encountered when you try to make modifications. The exciter is much simpler than the receiver and has fewer ICs (the digital rf phase shifter is the complicated part and it is already on the receiver board). Even the regulated 10-volt supply of the receiver may be tapped. However, if the 10-volt receiver supply is used, a larger heatsink is necessary and a heavier transistor may be needed.

A Motorola MC7812 or Fairchild

μA7812 can be used to replace the 10-volt supply in the receiver and will supply all the 12-volt current (up to one amp) that is required in both the receiver and exciter. However, a good 15- to 24-volt dc supply will be required to maintain good regulation with this voltage-regulator IC. Mobile operation with a 12-volt supply would be impossible with this IC, and the MC7808 voltage-regulator IC is a little too low.

There is sufficient room left on the 5 x 6-inch (12.7 x 15.2-cm) board (same as the receiver board) for vox or a small 10- to 15-watt PEP linear amplifier.* Remember that a transmitter needs a good, heavy, continuous ground plane under all the components. Preserving maximum ground area helps isolate the receiver from the transmitter as well as keeping the transmitter calm. The receiver is actually operating all the time but is muted during periods of transmission.

One very versatile method of making permanent breadboards is to use double-sided PC board material with push-in Teflon terminals which can occasionally be purchased on the surplus market. Press-in terminals are about twenty cents each when purchased in small quantities so you may want to use a circle cutter to isolate small islands from the board or use small pieces of PC board material cemented to the main board with a hot-melt glue gun. Layout is not particularly critical except for location of the mixers as detailed later. The large copper area provides both grounding and shielding.

circuit operation

The schematic for the reciter is shown in **fig. 3**. The microphone amplifier is a high-gain, high-impedance stage followed by an emitter follower which provides 1000-ohm output impedance to drive the audio lowpass filter. The audio lowpass filter is identical to the one used in the receiver. It is possible to get by with a two-coil filter in the transmitter but the design from the receiver was convenient and provides a little better performance. If a different filter is desired it can be designed from the available literature.[5,6] If tradeoffs are to be made in the filter, or an improvement made, the outcome can be predicted with the help of graphs.[7] Selective bypassing of the audio amplifiers also helps to roll-off the low audio frequencies. The ferrite pot-core assemblies have metal frames and are better shielded from rf fields than the toroids. If power in excess of 100 watts is contemplated, a metal rf shield may be needed to cover the 88-mH coils.

The audio agc system uses a Motorola MC1590G or the less expensive consumer products counterpart, the MC1350P. This versatile gain-controlled amplifier has its internal circuitry revealed in **fig. 4**. For layout purposes, pin 1 is interchangeable with pin 3 (pin 6 with pin 4 of the MC1350) and pin 5 may be interchanged with pin 6 (pin 1 with pin 8 of the MC1350). These terminals are the differential input and output of the amplifier. In the reciter it is being used as a single-ended amplifier because it is easier to keep it stable and maximum available power gain is not required.

The detector for this gain-controlled amplifier is at the output of the exciter where the rf power level is about 1-watt PEP. Detector drive could be obtained from a higher level stage with a voltage

*A printed-circuit board for the Phase II receiver is now available from D.L. McClaren, W8URX, 19721 Maplewood Avenue, Cleveland, Ohio 44135, for $10.50. The transformers for the receiver are still available from the author, WA0JYK (the same transformers are used in the Phase II reciter). The price will remain at $10 for the set of three required for the receiver; the pair required for the reciter is priced at $8. A complete set of five transformers is available for $16.00. This price will be valid only until the present supply is exhausted — new supplies will probably be priced 10% higher to meet the demands of inflation.

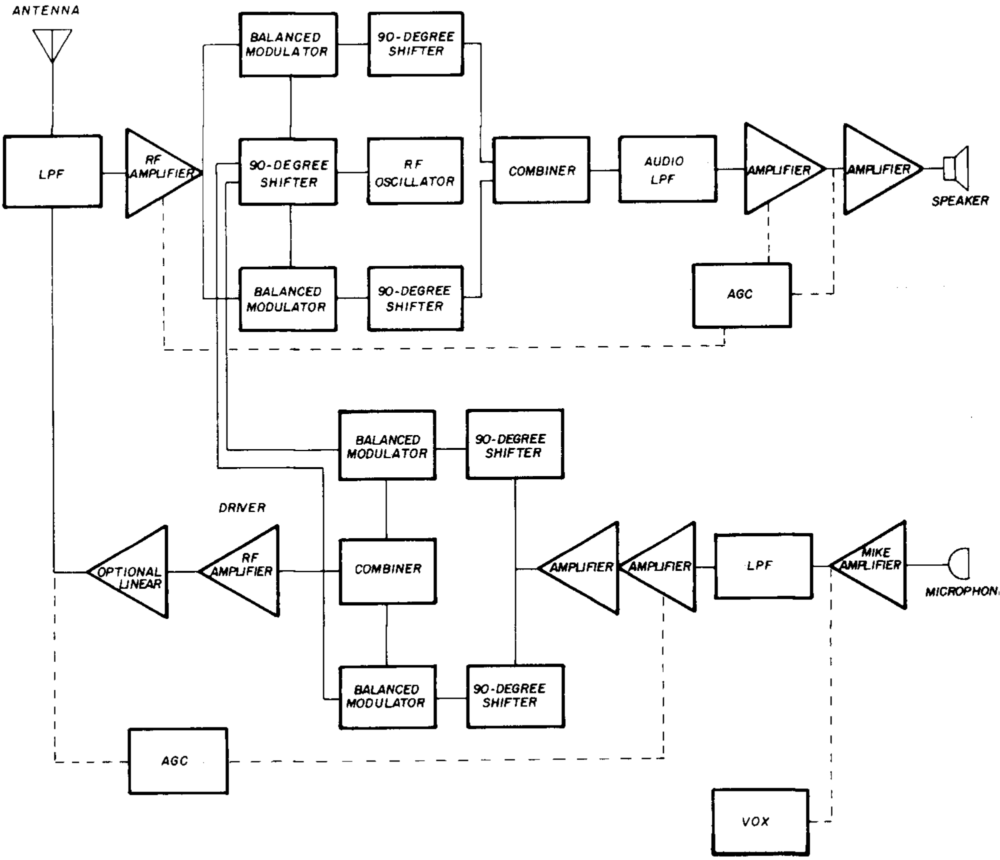


fig. 2. The Phase II ssb transceiver consists of phasing-type receiver, above, and phasing-type ssb generator, below. An optional linear amplifier is discussed in the text.

divider arrangement but it is not desirable to have too much gain in the agc loop. Any imbalance in the balanced modulators will cause some carrier to be present and will be detected by the agc detector. This carrier is interpreted by the detector to be a ssb signal caused by voice modulation and it will promptly turn down the modulation level which will, of course, reduce the level of ssb to carrier and further aggravate the situation.

It is possible to transmit compatible a-m by unbalancing one balanced modulator and sending one sideband with as much carrier injected as is desired. Full a-m can be transmitted by disabling one balanced modulator entirely and unbalancing the other. The combination of audio shaping with the lowpass filter and low-frequency rolloff caused by the audio transformers and selective bypassing (below 300 Hz) with audio compression caused by the agc system makes an effective built-in speech processor. There is no need for any additional speech processing since the percentage of average-to-peak power is quite high already.

The output of the agc-controlled amplifier is fed to another amplifier which has enough power capability to

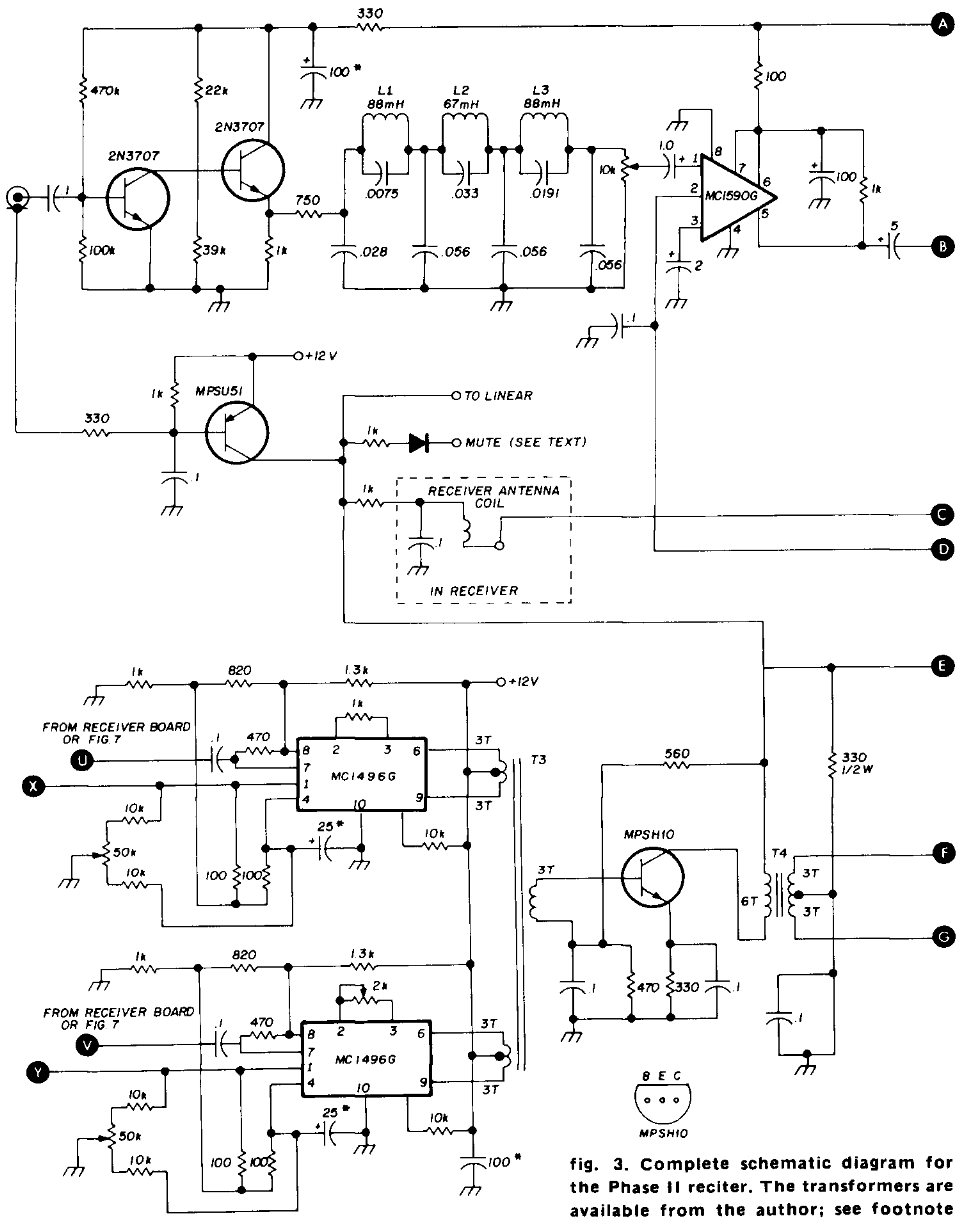
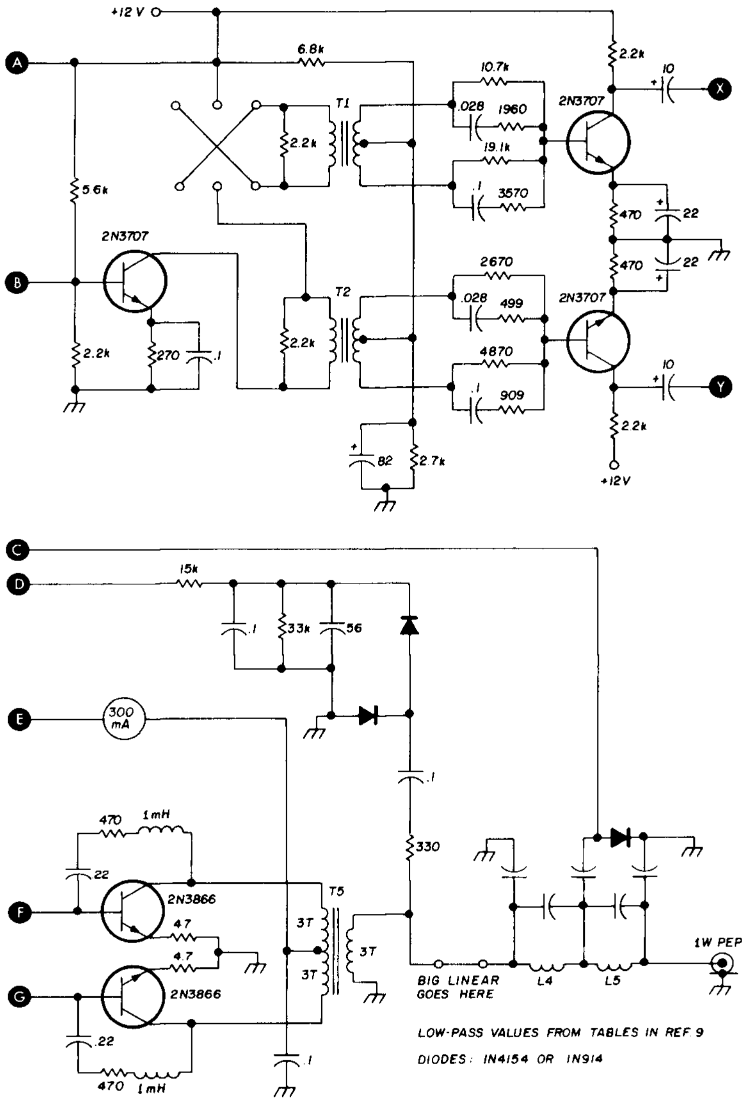


fig. 3. Complete schematic diagram for the Phase II reciter. The transformers are available from the author; see footnote on page 10.

drive the transformers and audio phase-shift networks. It might be possible to directly drive the transformers from the MC1590G ICs if special transformers were designed to do the job, but in the interest of saving time I used the same transformers that were used in the receiver.

The audio phase-shift network is also identical to the one in the receiver and it must work into a relatively high impedance. The input impedance of the



balanced mixers is low, on the order of 200 ohms (set by the bias resistors), so a low-gain buffer stage is necessary between the audio phase-shifter and the balanced modulators. The reversing switch at the primary of one of the audio transformers allows selection of the desired sideband. The switch may be remotely mounted on a panel or the edge of the board with twisted leads since the level at this point is relatively high. The receiver sideband selector switch doesn't offer this option because of the extremely low audio levels.

balanced modulators

The balanced modulators are a pair of Motorola MC1496G integrated circuits. The National LM1496H or Fairchild μA796HC may also be used. If better performance over a wider temperature range is desired, the Motorola MC1596G or National LM1596H can be used but other components should also be of premium quality. The plastic cased version of this IC should be avoided in this application. The balanced modulators should be located directly under U6 in the receiver so that 0.1-μF disc ceramic capacitors can be connected from pins 2 and 14 of U6 in the receiver, through feedthrough terminals on the exciter board, and terminating at pins 7 (or pin 8) on each of the balanced modulators.

Fig. 5 shows the internal schematic of the MC1496 which presents some possibilities for a simplified board layout. There was some confusion about the MC1496 product detectors used in the receiver because pins 1 and 4 were interchanged on the two detectors to aid in board layout. Careful inspection of **fig. 5** shows that pin 1 can be interchanged with pin 4 and pin 6 may be interchanged with pin 9 because these are the inputs and outputs of differential stages. This can be quite a help when laying out a PC board or making a breadboard and trying to minimize the number of crossover leads. This transposition of pins is similar to that mentioned for the MC1590G (or MC1350) earlier. The MC1496 is difficult enough to bias for single supply operation because of the 11 resistors, so this trick is well worth remembering.

The 50k carrier-balance pots may be run to the edge of the board for convenience. For ease of adjustment it's a good idea to use multi-turn units. If the balance pots are mounted on a panel the leads should be bypassed for rf. The metal can of the MC1496G is internally connected to pin 10 which is grounded but it is helpful to run a piece of number-18 or -16 wire across the tops of both ICs and solder it to the cans and to the board. This forms a very stiff ground plane between the input and output of the balanced modulators. Carrier suppression and noise improved 6 dB with the extra ground strap. The MC1496G is a very well balanced mixer and feed-around becomes greater than actual feedthrough.

The outputs of the two balanced modulators are summed in the rf transformer T3, an extremely broadband ferrite-core transformer. The broadband coupling eliminates any tuneup procedure but presents some other problems. The balanced modulators will suppress the carrier by 60 dB or so, but the second harmonic of the carrier is suppressed only about 30 dB. The exact amount of suppression will vary with individual units as well as with temperature, layout and frequency.

This second harmonic poses no particular threat but does point out the need for the lowpass filter following the exciter in addition to a lowpass filter after the final linear power amplifier. If the second harmonic of the carrier went unsuppressed to the antenna it would only amount to a few milliwatts but if it were allowed to pass through the solid-state linear power amplifier it would come out at about a quarter watt and, due to the agc action in the linear itself, when there was no voice modulation it could go to two or three watts.

The ferrite core used for transformers T3, T4 and T5 is the Ferronics 12-360J, an ideal configuration for small receiver and transmitter coils in the high-frequency range. Several of these cores are also used in the solid-state linear power amplifier. These two-hole ferrite beads may be wound with all leads coming out one end or with leads coming out opposite ends, depending on which is more convenient for mounting and conserving board space.

linear amplifier

Transformer T3 drives a class-A amplifier stage. A number of transistors will work in this stage but the Motorola

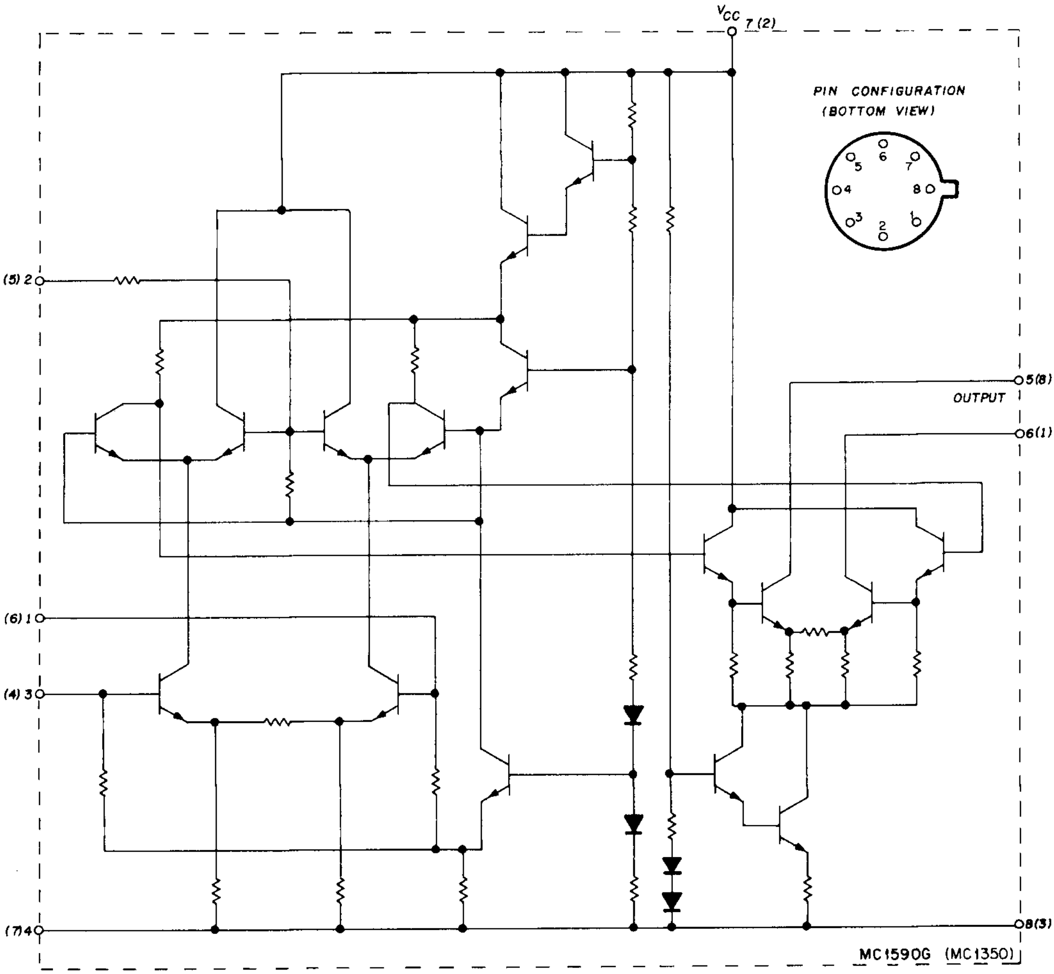


fig. 4. Schematic diagram of the MC1590G (MC1350P) gain-controlled amplifiers. Pin numbers for the MC1350P are shown in parenthesis.

MPSH-10 is economical and performs quite well. A 2N3904 will work too. The base configuration of the MPSH-10 is unconventional and is shown in **fig. 3.**

The output stage is operated push-pull to cancel the even-order harmonics and is transformer-coupled with broadband transformers. This push-pull stage is biased for pseudo-class-AB2 operation since class-B will result in too much distortion and class-A is too inefficient. The 330-ohm bias resistor may have to be adjusted over the range from 220 to 470 ohms so that the final collector resting current is between 10 and 20 mA. The final collector current will rise to 100 mA on voice modulation.

The final transistors are 2N3866s and are occasionally available on the surplus market for under a dollar. The 2N3866 is rated to frequencies as high as 500 MHz and many of them have an actual f_T of 1000 MHz, so many of the units that are factory rejects because of low

f_T or low current gain are usable in this circuit. The emitter resistors are not bypassed and parasitic suppression networks are used between the base and collector leads. More power can be coaxed from the finals by bypassing the emitter leads but there is no protection

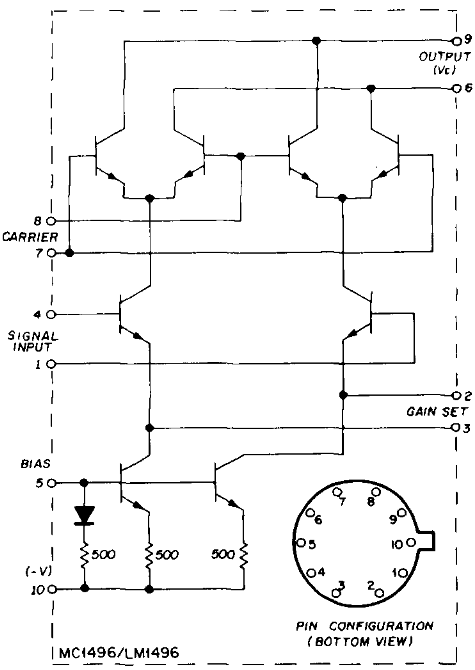


fig. 5. Schematic diagram of the MC1596/MC1496 balanced-modulator ICs.

for load mismatch so spare devices should be on hand.

About 1 watt PEP is available from the exciter without bypassing the emitters and that is a very conservative watt. However, even with an excellent signal and good signal processing it will still take perserverence and a good antenna to work stations. If your goal in life is QRPP, the mode best suited is CW, but a surprising number of stations can be worked with one watt of sideband.

The 1-watt PEP is more than adequate for driving the companion linear to a full 300 watts PEP input. As a matter of fact, a watt is too much drive for the linear and a 10-dB pad is used but the pad provides isolation that helps keep the exciter agc working properly. High-power linear transistors are still expensive but there is a flood of "illegal for class-D" linear amplifiers hitting the marketplace now and these linears are rated at more than 100-watts output. If these transistors work well at 27 MHz, they will work nearly as well on all the lower amateur bands and production quantities should be sizable judging from past reports on CB gear. In the meantime it might be well to consider a lower power linear or one with surplus vhf transistors.[7,8]

operation

The entire 1-watt transceiver draws a maximum of 800 mA on transmit and from 150 to 500 mA on receive. The power supply drain on receive can be reduced by switching the entire transmitter with the R/T switching transistor. The collectors of the 2N3866s need not be switched because they don't conduct with the bias removed. The main problem encountered in switching everything is that the bias on the balanced mixers takes about half a second to stabilize and a short burst of full carrier goes out over the air. This would be a small price to pay for portable operation and is not really noticable since the carrier is zero beat at the receiving station and would not normally be audible. However, vox operation is not recommended because the numerous times that the unit would cycle from receive to transmit would make the unit sound like slow CW with all the little bursts of carrier. For vox operation, only the bias to the last three transistors is switched. The audio and balanced mixers are left *live* and there is a signal being generated but it is isolated well enough that it is not heard.

It would be a shame to spoil an all

solid-state rig with an electromechanical monster for antenna switching. Full-fledged diode antenna switching would require standing off 80 volts or more of rf with the unit running at the 100-watt PEP output level. Where do you get 80 volts in a low voltage radio? There must be a simpler way – not a better way – just a simpler way to get around the use of complicated, noisy, unreliable hardware.

Since a lowpass filter was required anyway, it was decided to try to get some signal for the receiver from the lowpass filter. It seemed logical that one of the shunt capacitors in the lowpass filter could be lifted from ground and enough signal could be sampled to supply the receiver. Some tests were made and it was found that the middle capacitor of the filter was the best. In addition, it only requires standing off 3 volts of rf which is easily done with a single inexpensive diode. The voltage to switch the diode is fed down the coax from the receiver by inserting the voltage into the link on the receiver input tank coil and bypassing it to ground. This circuit will protect the receiver to some extent even if the dc control voltage fails. It also helps protect the receiver from strong local signals. This is a good system with multi-transmitter setups. The only bad part is the 10-dB of loss for the receiver, but the receiver is quite sensitive and signals on the lower bands are usually so strong that the rf gain is turned down to prevent cross-modulation anyway.

There may be a more elegant way of solid-state switching but this method requires only a resistor, a capacitor and a diode, about 15 cents worth of components. The 10-dB of loss could be greatly reduced if the filter were redesigned and the impedances were matched properly, but this is no trivial task and would best be done with a computer. Switching to transmit is swift and silent leaving the operator with the feeling that the rig just died, but after a few minutes on the air, confidence will be restored . . . if the 300-watt linear is being used.

The filter used to remove the harmonics output is one of the filters described in complete detail in a previous article.[9] These filters are probably more than adequate, but it is better to be overcautious. For the sake of simplicity, the same lowpass filter is repeated: once between the exciter and final power amplifier and again after the power amplifier. The filter between the exciter and final certainly could be of simpler design and still be adequate. Elliptic function filters are degraded drastically by severe mismatch and shouldn't be operated with vswr exceeding 3:1 at full rated power.

The dc voltages to the transmitter are switched by a medium power pnp transistor. As mentioned earlier, if low power consumption is desired, all power may be switched. If plenty of idle power drain can be tolerated, only the bias voltage to the last two stages need be switched. The collector voltages to these two stages may be left connected if desired. Positive voltage is sent through the primary of the receiver antenna coil, out through the receiver coax to the lowpass filter and the T/R switching diode. Positive voltage is also sent through a diode and 1000-ohm resistor to the receiver for muting.

The LM380 audio amplifier in the receiver can be muted by applying the voltage from the 1000-ohm resistor and diode to pin 2 but there will be some pop when the receiver is un-muted. If the receiver is improved by using the MC1590G (or MC1350P) to replace the Q4 stage, then the mute voltage from the resistor and diode is applied to pin 2 of the MC1590G (pin 5 if it's the MC1350P) and muting and un-muting is rapid and silent. This smooth and silent keying is a natural for vox operation. Some experimenting has been done with "instant voice interruption" but very few amateurs have actually used it on the air.[10,11]

Since speaker operation with vox complicates things, there is no anti-vox included in the simple vox circuit shown in **fig. 6**. Operation with a boom-microphone type headset was the primary objective and it has worked quite well for that purpose. Surprisingly, it works fairly well with a speaker at moderate volume and using an Astatic 10-C microphone that is only slightly directional.

It is desirable to apply a little of the receiver signal to the headphones when transmitting and the resistor in the mute control line can be increased to allow the amount of desired audio sidetone if the MC1590G or MC1350P is the controlled amplifier in the receiver. Audio sidetone is used in aircraft radios as an audible output indicator and to prevent the pilot from talking too loudly and overmodulating.

other frequencies

The transmitter is capable of operation at higher frequencies than the 10 MHz maximum limit arbitrarily imposed by the digital rf phase-shifter. The digital phase-shifter has provided the key to wideband operation and in itself will work well from the kilohertz region up to 10 MHz with nearly perfect phase quadrature. In fact, the Phase II transceiver may be the first ssb rig capable of operating on the experimental 160- to 190-kHz band. Of course, the ferrite transformers would have to be rewound with more turns (the same ratios) and a low-frequency vfo would be necessary.

At the other frequency extreme, it would be possible to use the rig at higher frequencies if phase-quadrature rf were derived from means other than digital ICs. The most promising and economical method is coaxial phasing lines similar to the phasing lines used for large antenna arrays. A quick check with a vector-voltmeter confirmed that above 14 MHz, complete phone-band segments can be covered with coaxial lines and the technique looks good for six and two meters. Coaxial lines are relatively insensitive to temperature variations that give other types of phase-shifters real problems. The coaxial line should be driven and terminated in the characteristic impedance of the line and the parallel paths of the two channels should be of the same impedance even if no coax is used in one side. Don't forget that the required quarter-wavelength line is an electrical quarter wavelength and must be multiplied by the velocity factor for the particular coaxial cable being used. For the twenty-meter band,

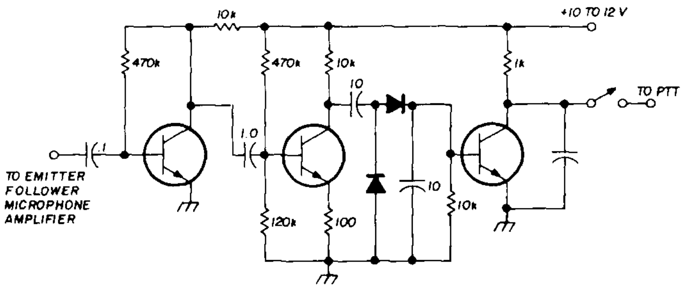


fig. 6. Vox circuit for use with headphones. Transistors are 2N3707, diodes are silicon such as 1N4154, 1N914 or similar.

and to cover complete amateur bands, it would be necessary to include a small trimmer at the termination of the coax to trim from one end of the band to the other.

alignment

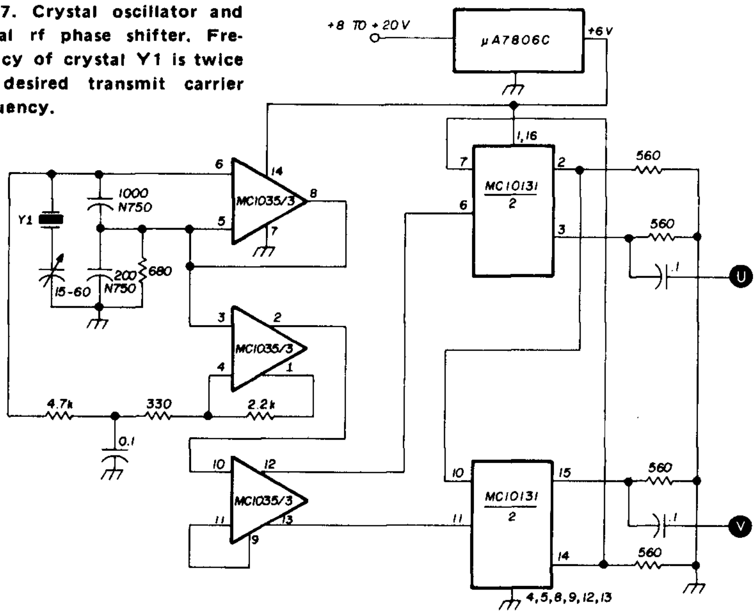
Alignment of the transmitter is very simple. Just adjust the two 50k pots for minimum carrier or minimum collector current then adjust the 2k pot on the balanced-modulator for maximum sideband suppression. It is best to use a separate receiver for both of these operations but it is possible to monitor the transmitters unwanted sideband in the receiver since the sideband selection is independent. The mute line must be disabled to monitor its own transmitter.

The carrier can be nulled by watching final collector current with no audio input or with the audio pot turned down and should be quickly checked after switching bands. Adjust the microphone gain pot (the 10k pot after the audio filter) so that some compression becomes obvious. This setting will have to be developed on an individual basis to suit each voice and amount of desired compression.

If further control of compression is desired the 15k resistor that feeds the agc signal back from the detector to the MC1590G can be altered as well as the value of the 56-μF capacitor at the detector. The 2N3866s should draw about 100 mA on voice peaks but it is possible to compress until the valleys are only about 80 mA but the audio sounds compressed at this level.

The audio sections, including the lowpass audio filter and the phasing networks, may be checked by applying the output from pin 1 of one balanced mixer to the horizontal input of an oscilloscope and the output from pin 1 of the other balanced-modulator to the vertical input of the scope. Both scope inputs should be sensitive enough to read one volt with good deflection. The

fig. 7. Crystal oscillator and digital rf phase shifter. Frequency of crystal Y1 is twice the desired transmit carrier frequency.



audio from the microphone will cause perfect, multiple, concentric circles. If the circles are slightly oblate but concentricity is good there is no problem because the gain of one balanced modulator is adjustable and will compensate for this gain error. If the circles are not concentric there is an error in the phase-shifter values or a misplaced component. If there are circles with no audio input, the unit is oscillating! Back up and try to isolate the *flying* stage. Oscillation is probably being caused by insufficient bypassing of the supply line or coupling through the power supply leads to the microphone preamplifier or the MC1590G.

If an audio signal generator is available it may be used to check the flatness of the filter response and the accuracy of the phase-shifter. One and only one circle will be present with a single audio tone fed into the microphone input. The circle should remain perfectly circular and of constant diameter with signal inputs from 300 to 2700 Hz.

performance

A great deal of time went into the breadboard just to clean up the audio and rf amplifiers and checking to make sure they were linear. Excellent signal quality has been the payoff and the ability to communicate better than the other guys who are running much higher power. A scope is a valuable tool for checking linearity, but both the rf and audio class-A amplifier stages have one simple check that can be made with a cheap voltmeter. The collector voltage should be exactly one-half the supply voltage.

An on-the-air roundtable with Collins, Heath, Swan, Drake and Phase II transceivers was recorded and the Phase II was definitely among the top two for quality. The unwanted sideband of the Phase II transceiver is garbled and unintelligible while the suppressed sideband of filter-type transmitters remains understandable even though attenuated. This leads people to believe that the sideband suppression of the Phase II is better than it actually is. It does, however, live up to the expectation of 40-dB unwanted sideband suppression.

The full transceiver with the 300-watt PEP input solid-state linear has been directly compared to a Heathkit Marauder, model HX-10, running comparable power. Input to the solid-state linear was held to 4 amps at 30 volts. Stations always rated the Phase II as "better copy" though most reported the same S-meter reading for both. Sideband suppression was equally as good as the crystal filter of the Marauder and some reports were in favor of the Phase II. When carefully questioned about the sideband suppression it usually amounts to "unintelligible."

Direct conversion is the ideal experimental transmitter for the amateur because there are fewer and more predictable spurious responses from direct conversion. The only spurs likely are harmonics and they are very effectively removed by the lowpass filtering. Conventional superheterodyne-type transceivers have possible images at the intermediate frequency or frequencies, depending upon the number of conversions. Of course, there is always a chance of parasitic oscillations in either the audio or rf of a direct-conversion transceiver, but these are more easily recognized and easier to troubleshoot with the direct-conversion method.

The thing that saves a lot of troubleshooting time is that the same spurs will appear in both the receiver and transmitter. For example, if the vfo being used has a parasitic and is effectively supplying two separate and non-harmonically related signals to the rf digital phase-shifter, two separate signals will be received and two separate signals will also be transmitted. However, don't get too excited about receiving two signals at once. Not only the two signals but the sums, differences, and an endless collection of products also enter in and make it impractical.

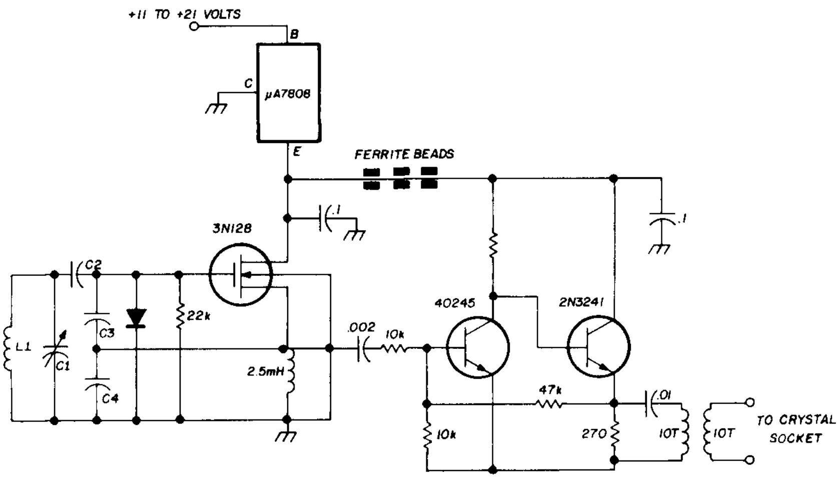
The transceiver always listens where it talks, providing the receiver input is broadband like the transmitter, but it is usually better to have a little more selectivity in the receiver to protect from out-of-band signals. It is also very important to have a clean vfo signal.

variable-frequency oscillator

Close-in noise in the vfo signal is more important in this case than the harmonics that might be present. The close-in noise on a vfo may be caused by fm of the oscillator and that in turn is caused by poor voltage regulation. Close-in noise is a particular problem when using a frequency synthesizer with a phase-locked, voltage-controlled-oscillator. The output signal tends to be fm at the reference oscillator frequency and this should be carefully investigated by those intending to use a synthesis scheme.

For those of you wishing to use the Phase II reciter as a transmitter paired with some other receiver, the rf digital phase shifter and crystal oscillator schematic is shown in **fig. 7**. The same scheme can be used with other ICs, but a dual-D flip-flop should be used to help preserve good tracking with temperature changes.

A good vfo is necessary for amateur-band use except in the rare cases when a crystal is used for net operations. The vfo shown in **fig. 8** was originally described in *QST* and has appeared in many transmitters and transceivers over the last eight years.[12] The mosfet is an



operating frequency	vfo frequency	L1*	C1	C2	C3	C4
1.8-3.0 MHz	3.6-6.0 MHz	30 turns	250 pF	470 pF	820 pF	820 pF
3.0-5.0 MHz	6.0- 10 MHz	25 turns	200 pF	390 pF	680 pF	680 pF
5.0-8.8 MHz	10 - 16 MHz	14 turns	75 pF	220 pF	470 pF	470 pF

*L1 wound on Amidon T-68-2 toroidal core; use as large wire as possible for full, single layer.

fig. 8. Variable-frequency oscillator for the Phase II reciter. Values for L1 are approximate and are determined by the exact value used at C1. Value for C1 is approximate with total made up with fixed capacitors to cover desired band segment. Toroidal core for transformer T1 is Ferronics 12-360J (or Amidon T-50-3).

extremely stable element and the addition of a toroidal inductor makes it more compact. An MC7808 or μA7808 IC voltage regulator provides stable 8-volt regulation and filtering which is important for the elimination of fm and drifting in any vfo.

The most important part of the vfo and the most difficult to locate is the variable capacitor. Good variable capacitors just are not used much in commercial equipment anymore and the really good ones invariably are salvaged from some old piece of tube-type military gear; they have plate spacings of 1/16 inch (1.5 mm) or more and are mechanical monsters. That is the price of progress. Some mechanical genius should start marketing a log-variable inductance similar to the units used in the famous Collins linear-permeability-tuned-oscillator (PTO) and solve all our problems.

Almost any value variable capacitor can be adapted for vfo use by using series and parallel silver-mica capacitors to set the range and frequency. The values given in **fig. 8** are only ball-park figures. The L/C ratio of this particular vfo can be varied quite a lot without degrading the performance. An hour or two with a slide-rule, calculator, or ouji board will allow the use of practically any capacitor that comes out of your junk box.

Also consider the use of a high-frequency vfo at 40 MHz or higher and dividing down to the desired frequency with digital ICs. The stability of the higher frequency vfo is notoriously poor but it is as good percentage-wise as the lower frequency counterpart and the frequency errors will be divided along with the frequency. The higher frequency vfo will allow use of smaller components and more readily available variable capacitors.

output filtering

A Drake TV100-LP or TV1000-LP lowpass filter should follow *any* transmitter, be it commercial or homebrew and particularly a transmitter with a broadband linear. The Drake filter does an exceptional job of suppressing TVI, is recognized by the FCC, and cannot be duplicated in the average hamshack. The lowpass filters used in the Phase II reciter are not designed to be TVI filters as such because the silver-mica capacitors used will display a resonance somewhere in the vhf region and filter performance will deteriorate rapidly. If better vhf filtering is desired from the lowpass filter, the capacitors going to ground should be made up of two or more smaller capacitors of differing values and even different types of capacitors, such as ceramic.

references

1. G. Kent Shubert, WAØJYK, "Solid-state Phasing-type SSB Communications Receiver," *ham radio*, August, 1973, page 6.
2. *The Radio Amateur's Handbook*, 48th Edition, ARRL, Newington, Connecticut, 1971, page 251.
3. *Reference Data for Radio Engineers*, 5th Edition, Howard W. Sams & Co., Indianapolis, Indiana, 1968, page 21-4.
4. E. Wetherhold, W3NQN, "An Amateur Application of Modern Filter Design," *QST*, July, 1966, page 14.
5. E. Wetherhold, W3NQN, "Modern Filter Design for the Radio Amateur," *QST*, September, 1969, page 42.
6. A.I.H. Wade, G3NRW, "Design Criteria for SSB Phase-Shift Networks," *ham radio*, June, 1970, page 34.
7. Jack Manon, W6FIG, "An HF-Band Solid-State Amplifier," *QST*, September, 1973, page 18.
8. Roy C. Hejhall, K7QWR, "Broadband Solid-State Power Amplifiers for SSB Service," *QST*, March, 1972, page 36.
9. G. Kent Shubert, WAØJYK, "Low-Pass Filters for Solid-State Linear Amplifiers," *ham radio*, March, 1974, page 38.
10. H. Rommel Hildreth, WØIP, "I.V.I.," *QST*, October, 1968, page 40.
11. H. Rommel Hildreth, WØIP, "More on Instant Voice Interruption," *QST*, June, 1972, page 19.
12. G.D. Hanchett, W2YM, "The Field-Effect Transistor as a Stable VFO Element," *QST*, December, 1966, page 11.

ham radio

converting the slim-line touch-tone handset

A telephone handset combining touch pad, microphone and speaker into a single unit

Joseph M. Hood, K2YAH, Rochester, New York

Tone signalling for amateur repeater autopatch access, repeater secondary control access, or selective calling is a rapidly expanding technique in fm circles. Many amateurs are using a touch-pad mounted in a separate enclosure as a source of these tones. While this method is acceptable, it does have disadvantages; finding a place for the bulky touch-pad enclosure and switching the associated microphone and push-to-talk circuit interfaces with the transceiver to make the touch-pad approach somewhat inconvenient.

A solution to this inconvenience is to replace the separate touch-pad and microphone elements with a unit which contains both, a *Slimline*, Touch-Tone*

*Touch-Tone is a Registered Trademark of the Bell System.

handset. The handset also has the additional advantage of an earphone, which can be used for private listening when operating with a car full of sleeping children or other persons you don't wish to annoy with the receiver audio.

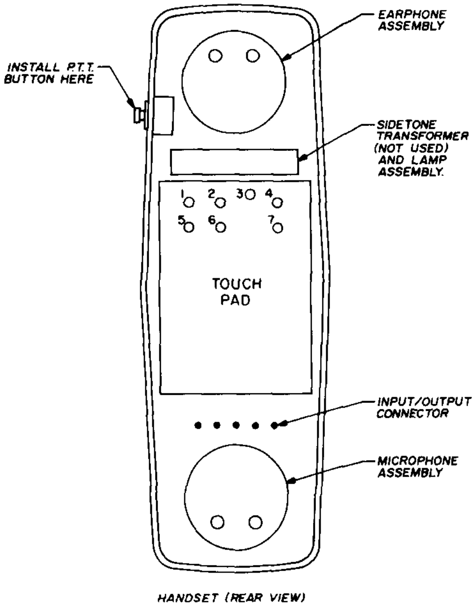


fig. 1. Rear view of the handset showing suggested location for mounting the PTT switch.

modification

The *Slimline* phone is not very useful for amateur radio use as wired for telephone service and will require some electrical and mechanical surgery to make it compatible with fm transceiver input/output circuitry. The modification is begun by opening up the unit by removing the two screws found under the removable, transparent plastic, telephone number cover. With the unit open, you can see the plastic printed circuit which contains the interwiring for the handset. This printed circuit must be removed by extracting the screws on the earpiece, touch pad, and microphone connections, and then carefully unsoldering the remaining solder connections. Don't lose the screws as they will be used when the unit is rewired.

Since the handset has no push-to-talk button, one will have to be installed. The first thing you will notice is that there isn't much room for one anywhere in the unit. However, a miniature pushbutton switch, available from Lafayette Radio and Electronics (part number 99P62184), will fit in the space between the earphone assembly cover and the side of the handset, as shown in **fig. 1.** Care should be taken in locating the specific spot where the switch will be mounted. When this is determined, drill a small guide hole in the handset case using a slow drill speed. Then follow with a drill large enough to allow switch mounting. Again, use a slow drill speed and exercise care in drilling. When the switch is installed the handset is ready for rewiring.

rewiring

To use the handset it must be wired as shown in **fig. 2.** This circuit uses contacts inside the touch-pad to switch the microphone element in the audio

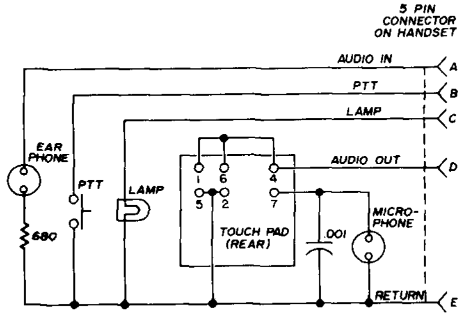


fig. 2. Internal rewiring of handset. Use an ohmmeter to check input/output connector pins for continuity.

output line when no touch-pad buttons are depressed; conversely, the touch-pad's output replaces the microphone's whenever a touch-pad button is actuated. The output connector on the telephone is a tricky area. When you view its connection points and output pins there seems to be a one-to-one, geometric association. Not true! Some of the pins do *not* connect with their most adjacent input point; use an ohmmeter to check which pin goes to which output point and you won't be fooled.

interconnecting

The rewired handset may be connected directly to any transceiver having an audio input compatible with a carbon microphone. This connection is shown in **fig. 3A**, and may also be used with transceivers designed to use dynamic microphones having integral preamplifiers. If your radio uses a low impedance (500 ohm) dynamic microphone without an integral preamp, the circuit of **fig. 3B** should work. If the rig uses a high-impedance ceramic microphone the circuit of **fig. 3C** is suggested. The potentiometer should be adjusted to give the same modulation level as the original microphone.

The input/output to the radio may be made with the coiled telephone handset cable. However, you will find this cable is very difficult to solder. The conductors are a combination of coiled copper and cotton thread; this makes them very flexible but makes soldering to them somewhat tedious. However, by carefully removing the thread and keeping the heat to a minimum, it can be done.

The connector used at the transceiver input should be one which provides effective strain relief for the handset cable. If a good strain relief isn't provided, the small coiled copper wires, which become brittle when soldered, will surely break. An Amphenol type 91-MC6M cable plug and 91-PC6F chassis receptacle are recommended.

The handset approach to fm mobile operation relieves the "where to put the

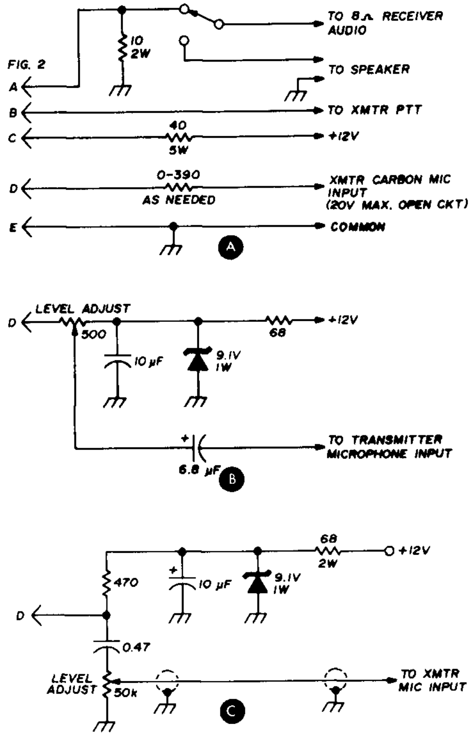


fig. 3. Interconnection wiring between handset and transceiver. For carbon microphone or amplified dynamic microphone inputs use the circuit of (A). Dynamic microphone inputs (500 ohm) require the circuit of (B). Use (C) for inputs designed for ceramic microphones. Other wiring is the same for all four types.

touch-pad" dilemma in first-class style. The carbon microphone element in the telephone produces surprisingly good audio quality, and the private listening feature is a nice bit of serendipity which is quite useful. If nothing else, the handset will enhance your "Frank Cannon" image immeasurably.

ham radio

audio-radio frequency interference — its cause and cure

Most cases of rf interference to audio hi-fi and stereo equipment can be cured — typical solutions are discussed here

Harry Leeming, G3LLL*

Having an active hobbyist's and a commercial interest in the fields of amateur radio as well as in stereo and high-fidelity equipment, I am very concerned about hi-fi interference and its possible cures. It would seem that many audio equipment manufacturers leave their products wide open to the reception of unwanted radio signals, and to determine to what extent, I decided to run some tests.

An amateur single-sideband transmitter with about 200 watts power output was connected to a center-fed dipole with a coaxial transmission line; the antenna and transmitter were located about 50 feet (15 meters) from my company's audio equipment showroom. Test transmissions were made at both 21.2 and 3.6 MHz. With no external inputs (phono pickup or tuner), half of the fourteen amplifiers tested proved susceptible to interference on 80 meters, and five suffered interference on 15. When the phono pickup

*Holdings Photo Audio Centre, Mincing Lane, Darwen Street, Blackburn BB2 2AF.

was connected the interference became quite severe on nine amplifiers, and when the tuner and antenna were connected, all amplifiers except one suffered heavy interference.

Since the tests were made in our hi-fi showroom the speaker leads were rather long, and possibly resonant near the 80-meter band, so this probably explains the greater incidence of interference on the lower frequency. Shorter leads would possibly have reduced interference on 80 meters and increased it on 15.

I think it would be fair to say that the circumstances and power used were pretty average, and it would be reasonable to expect similar results within a few doors of an amateur radio station, or within less than a mile or so of a high-powered commercial station. In all of these tests, and in some more severe tests undertaken at home, the amplifier which came out best was the Quad which, from an examination of the circuit diagram, was found to have considerable built-in RFI protection as well as being completely enclosed in a metal cabinet.

In the future, as radio transmitters for broadcasting, business radio and amateur radio multiply in power and number, and the RFI rejection of amplifiers gets worse (due to the advent of the transistor and the printed circuit), the problem needs immediate attention. Fortunately a few manufacturers are now taking note of the problem; it is to be hoped that others will soon follow suit.

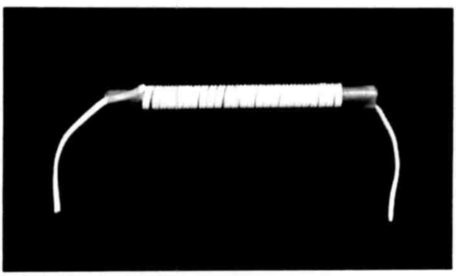


fig. 1. Loudspeaker lead can be formed into an rf choke by winding the lead around a ferrite antenna rod.

external pickup

Before delving into the equipment itself, let's see what can be done externally to help when unwanted radio transmissions are already being picked up. The first move is to determine the frequency of the transmitting station, as knowledge of this will enable you to make a more intelligent approach to the problem. Calculate the wavelength of the interfering signal and take a look at the lengths of the various leads used in the audio installation. A lead only a fraction of a wavelength long (say 1/20th) makes quite a good antenna, and any lead which is a quarter-wavelength long (or any multiple thereof) will make a very effective antenna.

If no work is contemplated inside the amplifier, the only possible approach is to try to establish how the RFI is entering the circuit. A simple step is to remove the input leads one at a time, and note which one reduces or eliminates the interference. The speaker leads are quite likely causes of trouble and hence, experimentally, they can be shortened to less than 1/20th of a wavelength, or can be disconnected in favor of a pair of headphones with short leads.

If the RFI is still present with the leads all disconnected, the trouble is due either to rf pick-up on the amplifier's internal wiring, or it is coming in through the power lines. Check for interference arriving via the ground lead by disconnecting it. To test for pick-up from the power lines simply pull the plug out quickly while the interference is manifesting itself. If RFI is entering by the ac line it will disappear the instant the plug leaves the socket; if it is being picked up in the internal wiring of the amplifier it will slowly fade away as the power-supply filter capacitor discharges.

If the interference is arriving through

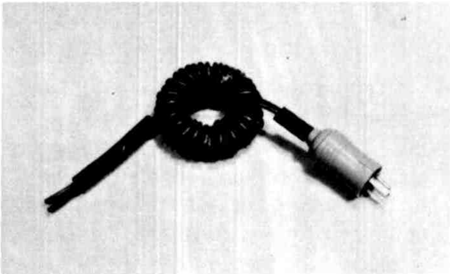


fig. 2. Ferrite or powdered-iron toroid can also be used to form in-line rf chokes with loudspeaker leads.

the ac power lines, install an ac line filter which is effective at the frequency of the unwanted transmission. This type of filter is used to suppress vacuum cleaners, electric shavers, etc., and is available from most electronic distributors. Alternatively, the hot, neutral and ground leads can be treated with ferrite cores, as is described later in connection with speaker leads.

speaker leads

If RFI via the speaker leads is the trouble, check that the leads are not a multiple of a quarter wavelength, and if they are, alter the length, preferably by shortening. If this does not cure the trouble, connect four 0.01-μF disc ceramic capacitors from plus and minus speaker sockets, with the shortest possible connections, directly to the chassis. If the interfering signal is lower than about 5 MHz, larger capacitor values may be required, but they should be used with caution in case they affect the high-frequency stability of the amplifier.

These moves should almost certainly reduce the strength of interference, but if it is still present, form the speaker leads near the amplifier into radio frequency chokes (**fig. 1** and **2**). This can be done by wrapping the lead around a ferrite antenna rod, or better still, by winding the lead around a ferrite core. About twenty turns will be needed to form an effective choke for frequencies in the range of 10 to 20 MHz, with proportionally more turns for lower frequencies.

Reception on the pickup leads themselves is only common at higher frequencies where the leads begin to form an appreciable fraction of a wavelength. If possible, the simplest solution is to shorten the leads. Alternatively, the pickup leads can be wound around a ferrite rod or ferrite core to form an rf choke (**fig. 3**). While investigating this side of the problem, check the pickup grounding as the wiring scheme shown in **fig. 4** sends any signal picked up on the ground lead straight into the phono socket of the amplifier. **Fig. 5** is a much better arrangement.

tuners

If RFI via the tuner leads appears to be the trouble, try disconnecting the fm antenna as the coaxial feedline makes an excellent shortwave antenna with the signal going to ground through the tuner leads and the amplifier printed-circuit boards. The answer here, as is shown in **fig. 6**, is to provide a 1:1 transformer in the antenna lead which will pass the vhf fm signal but isolate the lower-frequency interfering signal. **Fig. 7** shows a simple way of doing this with a slight loss of signal; if you cannot afford to lose a little signal the transformer

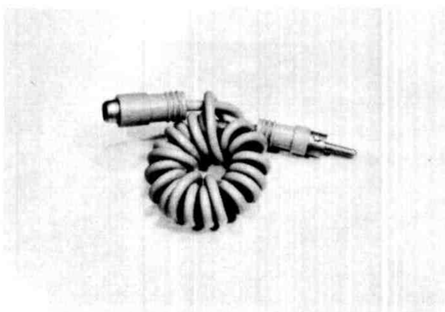


fig. 3. In some cases interference can be reduced by winding external audio input leads on toroidal cores.

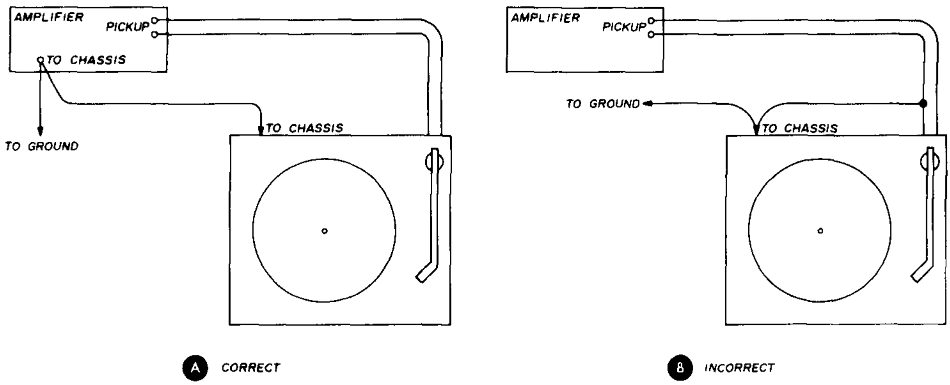


fig. 4. Correct grounding connection for external pickup is shown in (A), improper ground connection is shown in (B). In the circuit of (A) the only input signal is the desired one, while in (B) any signal picked up on the ground lead goes directly to the input socket of the amplifier.

shown in **fig. 8** can be made quite simply.

If the feedline is not grounded, a 1-megohm static discharge resistor should be connected between the primary and secondary of the transformer. If you are not able to purchase the small ferrite core, it can be obtained by dismantling a balun transformer from an old TV set.

If the interference continues, even with the fm antenna disconnected, the audio connecting leads can be treated with a ferrite core as described previously.

equipment modifications

In addition to the external connections discussed so far, I decided to see what internal modifications would be needed to improve an amplifier's performance from the RFI point of view. I quickly realized that more RFI was getting in through the shields of the input leads and through the ground side of the speaker leads than was traveling in via the live conductors. To reduce problems with hum caused by ground loops, most good quality amplifiers do not have the speaker or input connectors grounded near their mounting points, but return them to the chassis through the circuit-board panels. This arrangement is fine from an audio point of view, but does nothing to stop rf from entering the circuit.

The problem was investigated further with the use of an rf signal generator and it was soon realized that no single component was going to cure the trouble, and a "belt and suspenders" attack was decided on.

Rf interference to audio amplifiers is caused primarily by the transistor junctions rectifying, and therefore demodulating, the radio frequency energy. The answer here is to short-circuit the junction sensitive to radio frequency by the use of bypass capacitors. All the transistors in my preamplifier seemed sensi-

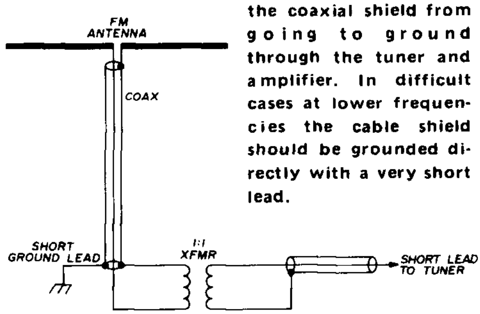


fig. 5. The 1:1 transformer in the transmission line from the fm antenna prevents the signal on the coaxial shield from going to ground through the tuner and amplifier. In difficult cases at lower frequencies the cable shield should be grounded directly with a very short lead.

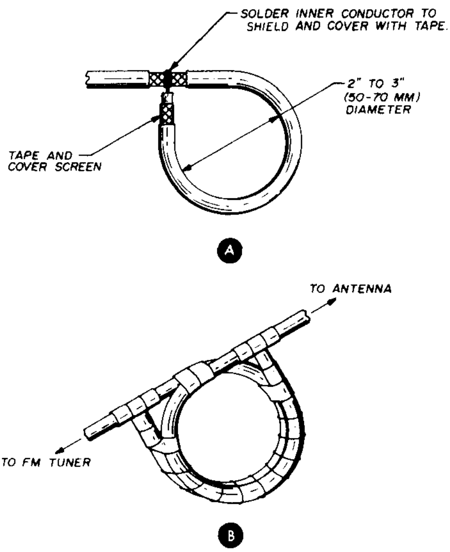


fig. 6. Details of Faraday double-loop filter are shown in (A). Two of these loops are placed next to one another as shown in (B), taking care to insulate all wires and shields. Be sure the two loops are laced or taped firmly together.

tive, and in the end it was decided that they should all be bypassed. As has been noted previously, much of the rf was entering through the shields on the phono and tuner leads, so these were also bypassed to the chassis; it was not found necessary to bypass the speaker leads once the preamplifier had been attended to.

The results of a handful of bypass capacitors were so successful that it is now possible to operate the amplifier with only very slight breakthrough with a high-power transmitter and antenna in the same room as the amplifier. Previously, with the two units 100 feet (30 meters) apart, the interference was at a deafening level.

Successful as the modification seemed from tests in my company's workshop, it was decided in the interests of science (and amateur radio) to see what happened when the equipment and transmitter were operated in my own home. When the modified amplifier was first connected, results with the transmitting antenna 20 feet (6 meters) away were rather disappointing as interference still varied between "quite loud" and "deafening," depending upon the operating frequency.

The interference was not too bad when the tuner was switched in, but was very objectionable when switched to the phono pickup. Further investigations showed that the trouble disappeared if the fm antenna (which was only about 3 feet [1 meter] from the transmitter antenna) was disconnected. The feedline to the fm antenna was fitted with a 1:1 transformer, and while I do not normally make a habit of listening to my hi-fi setup when talking to someone on the other side of the world, this would now theoretically be possible! Of course, the signal injected into the amplifier at this range is more than you would normally expect in the average home, but it does illustrate that many manufacturers could considerably improve their equipment in this respect at negligible cost.

bypass capacitors

Those readers contemplating similar modifications should remember that there is no such thing as a perfect capacitor; all have some inductance. In general, the larger the value of the capacitor, the larger its self-inductance, so the theoretical circuit of a practical

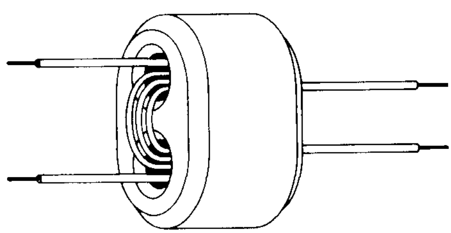


fig. 7. Simple 1:1 transformer uses two-hole ferrite bead salvaged from old television set.

capacitor appears as a series LC circuit as shown in **fig. 9**. At high radio frequencies, the inductance of, say, a metal-foil capacitor can have a reactance of hundreds or even thousands of ohms, making the capacitor useless when it comes to bypassing such radio frequencies.

If you are to effectively short out the base-emitter junctions of transistors, or bypass the shields of connecting cables to the chassis, the reactance of the capacitor you use should not be more than an ohm or two at the frequency in question. A very suitable capacitor for

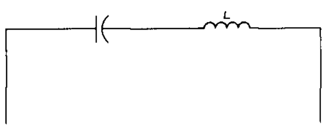


fig. 8. A practical capacitor has unavoidable inductance of leads as well as self inductance. At high frequencies inductance must be kept to an absolute minimum.

this type of work is the disc ceramic capacitor, which has a very low self-inductance. From an RFI point of view a 0.01 μF disc ceramic capacitor with minimum-length leads will present a reactance of only a few ohms from about 5 to 100 MHz.

At lower frequencies higher value capacitors may be needed, but they may affect response at the highest audio frequencies so unless the interference is severe from a transmitter on 160 or 80 meters, capacitors of lower value should be fitted between the base and emitter junctions. In practice, values between 500 and 5000 pF appear in the circuits of manufacturers who have taken precautions in this direction.

If the trouble is with breakthrough of television audio or business radio transmissions in the 50-200 MHz range, a smaller value capacitor, say 50-200 pF, may be even better; when connected with the minimum practical lead length it is possible for such a capacitor to form a series-resonant circuit to provide an almost dead short.

Whether or not a particular value capacitor will affect the audio response of an amplifier is difficult to predict, as much depends upon the impedance of the circuit. When adding components it is advisable first to modify only one channel of a stereo amplifier, so that the square-wave and frequency response can then be compared with the unmodified channel to ensure that the aduio response has not been upset.

At frequencies beyond 100 MHz or so, it becomes increasingly impractical to add capacitors to a circuit with short enough leads for them to be really effective. At this frequency the best approach is to fit ferrite beads on to the transistor leads. These beads increase the inductance of the transistor lead and operate as an rf choke.

summary

Since doing the tests and modifications to my own amplifier, several cases have occurred where customers have had serious trouble with rf interference, and the following modifications have always produced a cure:

1. Input connectors. Install a 0.01 μF disc ceramic capacitor from ground side of all input connectors to chassis.

2. Transistors. Install a 1000 pF disc ceramic capacitor from base to emitter of all transistors in the preamplifier.

3. Loudspeaker terminals. Install a 0.01 μF disc ceramic capacitor from the live and ground side of these terminals direct to the chassis.

While modification **3** will be found quite effective on its own, as it can often be done externally, it has not generally been found necessary when the other work is done internally.

ham radio

500-MHz decade prescaler

Using new sub-nanosecond ICs to build a ten-to-one prescaler that will extend the frequency range of your counter to 560 MHz

Wayne C. Ryder, W6URH, 115 Hedge Road, Menlo Park, California 94025

About seven years ago, using the new emitter-coupled logic (ECL), I built a 100:1 digital prescaler that extended the range of my 1-MHz vacuum-tube counter to 100 MHz. Although the prescaler stopped well short of two meters, it was a significant improvement at the time. Recently I removed the old 100:1 prescaler circuitry from the chassis and installed a decade prescaler circuit that accurately counts to beyond 500 MHz. All that was required was two ICs and about two hours of bench time.

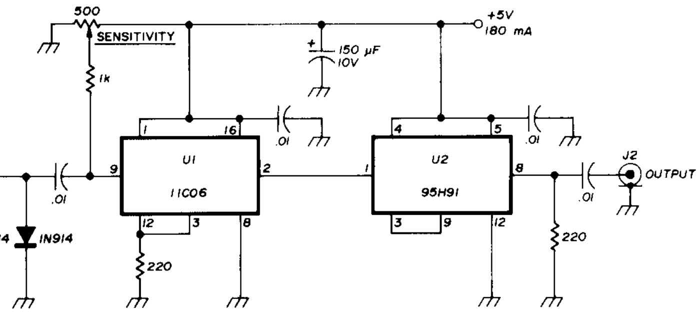
circuit

The circuit for the 10:1 500-MHz frequency scaler is shown in **fig. 1**. The first IC, a Fairchild 11C06, is a type-D flip-flop rated to 700 MHz by the manufacturer.[1] However, with the circuit layout I used, the prescaler stops counting properly at about 560 MHz. The 95H91 is a Fairchild divide-by-5 counter IC from the same ECL family as the popular 95H90.* Input sensitivity of the prescaler is less than 100 mV from 10 to 500 MHz.

The two back-to-back diodes from pin 9 of the 11C06 to ground protect the input against overload. Nevertheless, the maximum input voltage should not exceed 1 volt rms. The 500-ohm pot sets the bias voltage on U1 to about 3 volts. This control should be adjusted for maximum sensitivity. The output from pin 8 of the

*Total price of the two ICs is about $36 in small quantities from your local franchised Fairchild distributor. Motorola and Plessey manufacture similar sub-nanosecond ICs, including several that are rated to 1000 MHz.

fig. 1. Circuit for the 500-MHz decade prescaler. All resistors are ¼ watt, 5%. Circuit layout is shown in fig. 2.



95H91 is connected to a 50-MHz frequency counter. If the connecting cable is more than about 12 inches (30cm) long, a 50-ohm termination should be used.

construction

In my prescaler all the components are installed on a small piece of copper-clad circuit board about 2-inches square (50x50mm). I used point-to-point wiring as shown in the layout in **fig. 2**. Make sure all the component leads are as short as possible.

In my unit I included a regulated +5 volt power supply for convenience (see **fig. 3**). Although the prescaler requires 180 mA and the Triad T90X transformer is only rated at 100 mA, it remains quite cool, even during extended periods of operation. If you are going to use this prescaler with a TTL-based counter that has a regulated +5 volt supply with sufficient reserve, you may be able to power the 500-MHz prescaler from the existing supply. Make sure, however, that your counter's +5 volt supply can handle the additional 180 mA load.

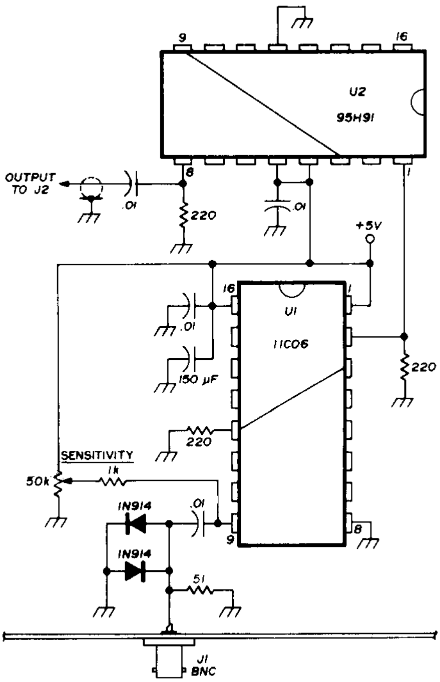


fig. 2. Component layout for the 500-MHz decade prescaler. Circuit is built on small section of copper-clad circuit board. All leads to U1 must be as short as possible.

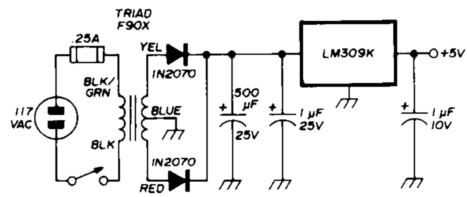


fig. 3. Regulated +5 volt power supply for the 500-MHz prescaler.

reference

1. Doug Schmieskors, WB9KEY, "1200-MHz Frequency Scalers," *ham radio*, February, 1975, page 38.

ham radio

stable
crystal oscillators

A selection of stable crystal-oscillator circuits for 50 kHz to 80 MHz which minimize the influence of the transistor and the crystal's series resistance

Ulrich Rohde, DJ2LR, 14 Gloria Lane, Fairfield, New Jersey

Crystal oscillators are commonly used wherever stable frequencies are required. The crystals selected for these circuits are not always completely known so far as their inner parameters are concerned, and many radio amateurs run into difficulties with the crystal's equivalent series resistance, R_s (if it is too high, many published oscillator circuits do not operate properly).

Since there is no practical oscillator circuit which will cover the entire frequency range from, say, 50 kHz to 150 MHz, it is the purpose of this article to describe some circuits, using transistors, which are fairly independent of crystal losses and will give extremely stable frequencies. Almost any general-purpose rf transistor may be used in these circuits provided that the transit frequency, f_T, is higher than 250 MHz.

500 to 800 kHz

Fig. 1 shows an oscillator circuit which can be conveniently used in the range from 50 to 800 kHz. The only requirement for the crystal is that it must be operated in its fundamental series mode. The adjustable trimmer capacitor permits enough pulling range, and the 0.7-volt rms output is more than adequate for most requirements. In most cases the frequency range of this oscillator can be easily extended to 100 kHz, using crystals widely found in calibrator circuits.

1 to 20 MHz

Fig. 2 shows an oscillator circuit which exhibits extremely low power dissipation in the crystal, thus giving ultimate frequency stability. Capacitors C1 and C2 must be selected according to the frequency range as shown. While most designers use almost the same value capacitor at both C1 and C2, the capacitance of C1 should be substantially higher than C2. This reduces the influence of the transistor on the stability of the circuit by more than five times. For some unknown reason, only a few people are apparently aware of this advantage.

In the circuit of **fig. 2** the output voltage is taken across the parallel RC circuit made up by capacitor C3 and resistor R1, a 22-ohm resistor. Together with the crystal R1 and C3 form a low-pass filter which suppresses the second harmonic by 60 dB.

In cases where high stability must be combined with the selection of many channels, the oscillator circuit and diode switching scheme shown in **fig. 3** is highly recommended. In this circuit the crystals are used in their series-resonant mode, and depending upon the parallel capacitance of the fixed trimmer capacitor, 39 pF in the schematic, the individual frequencies may differ substantially from crystal to crystal. In this circuit, as well as in the others presented here, the influence of the external components is minimized.

harmonic oscillators

Harmonic oscillators are used for higher frequencies. It is very difficult to build stable crystal oscillators using 5th or 7th overtone crystals because these crystals are usually BT cuts which result in very poor temperature coefficient characteristics. It is much more convenient to use an AT-cut, third-overtone crystal and take advantage of the inherent frequency-doubling capabilities of the transistor. These harmonic oscillator circuits are often found in mobile radio systems where a number of channels are required.

The circuit in **fig. 4** shows a switchable overtone oscillator. The crystals, third-overtone types, may oscillate between 20 and 80 MHz. The series inductance, not required for each crystal, must be selected so that it is series resonant with 10 pF at the crystal's operating frequency. The total number of switchable channels may be as high as twenty, and the circuit will still remain stable without showing any uncontrollable oscillations.

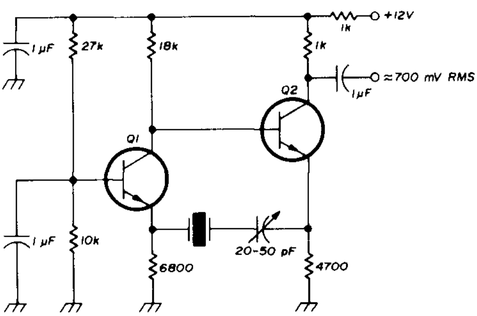
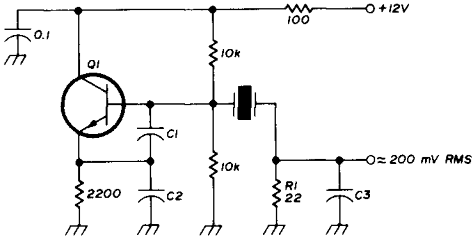


fig. 1. Crystal oscillator circuit for use over the frequency range from 50 to 800 kHz. Transistors Q1 and Q2 are types 2N708, HEP50, BC108 or similar.



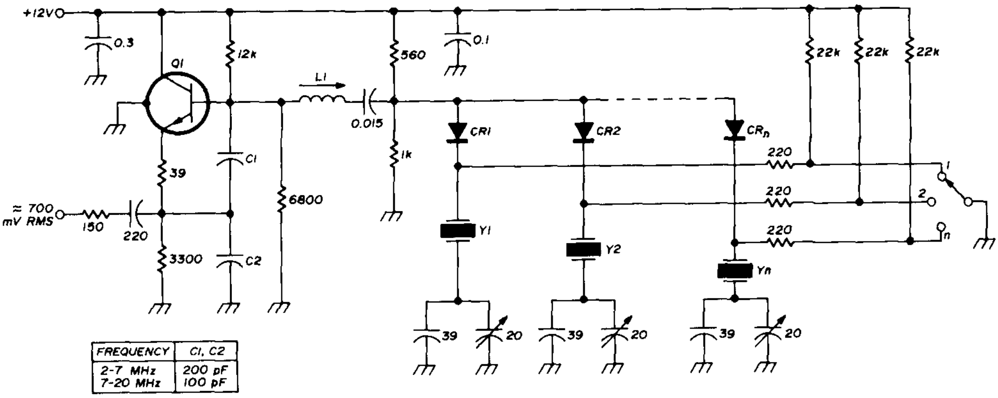
FREQUENCY	C1, C3	C2
800 kHz 4 MHz	2200 pF	560 pF
4 MHz 20 MHz	390 pF	100 pF

fig. 2. Crystal oscillator circuit for the frequency range from 800 kHz to 20 MHz uses series-resonant. Fundamental-mode crystals. Parallel circuit made up of R1 and C3 suppresses second harmonic by 60 dB. Transistor Q1 is a 2N708, HEP50, BC108 or similar.

The tuned circuit in the output of **fig. 4**, which can easily be modified into a bandpass filter from the single-tuned circuit, will provide about 500 mV rms into 50 ohms at two times the crystal frequency. If a bandpass filter is used at the output, subharmonic suppression will be greater than 60 dB.

Fig. 5 shows an overtone crystal oscillator circuit which can be either modulated or used as a very stable vcxo. In circuits where the final frequencies are derived by mixing one oscillator output with another, frequency adjustments can be made externally by applying a dc voltage.

For example, assume a single-conversion receiver is to be built for the 144-MHz band which will work only at



FREQUENCY	C1, C2
2-7 MHz	200 pF
7-20 MHz	100 pF

fig. 3. Switchable crystal-oscillator circuit for use over the frequency range from 2 to 20 MHz uses series-resonant, fundamental-mode crystals. Inductance at L1 should be about 30 μH at 2 MHz, and about 1 μH at 20 MHz. Transistor Q1 is a 2N708, HEP50, BC108 or similar rf npn type. Diodes CR1, CR2 thru CRn are switching types such as the BAY67.

the ssb portion. Most ssb stations operate near 144.1 MHz, so if a 58-MHz oscillator is used and doubled in frequency to 116 MHz (for use with a 28-MHz i-f) the electronic tuning (pulling) range is about 60 kHz, more than enough range for typical two-meter ssb operation. There is practically no noticeable sacrifice in frequency stability if the tunable frequency range is not extended beyond 60 kHz.

Similar oscillators may be useful in portable high-frequency transceivers where the pulling range may be slightly less but still sufficient to cover the CW portion of an amateur band.

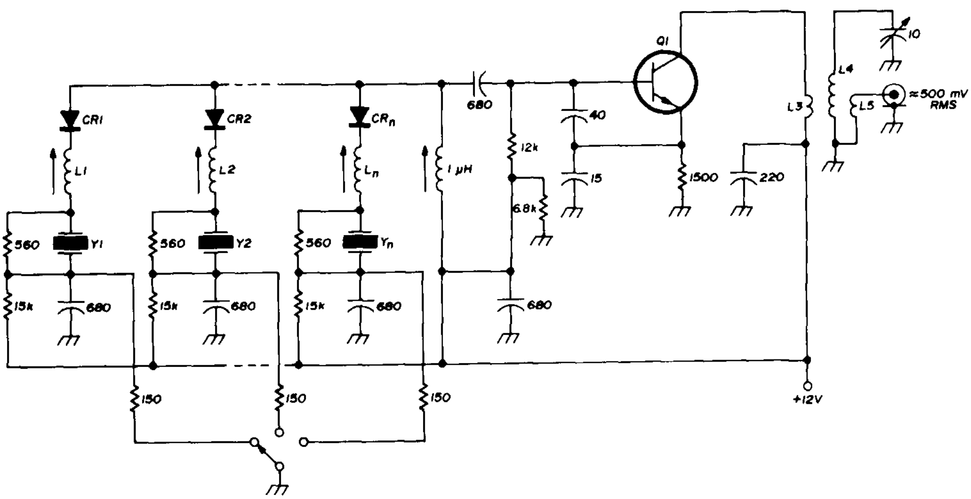


fig. 4. Switchable overtone oscillator uses third-overtone crystals in the 20 to 80 MHz range and frequency doubles in the transistor. Inductors L1, L2 thru Ln are series resonant with 10 pF at the crystal frequency. Inductor L4 in the tuned circuit at the output is resonant at the desired output frequency with 10 pF; the input and output coupling inductors, L3 and L5, have one-third the number of turns as L4. Transistor Q1 is a 2N918, BF115, HEP709 or similar. Diodes CR1, CR2 thru CRn are switching types such as the BAY67.

summary

The crystal-oscillator circuits discussed here are highly recommended for new designs since they do not require special crystal parameters. Even older crystals, which the amateur may find in his junk box, will provide extremely good results. The other major advantage of these circuits is that the influence of the circuitry surrounding the crystal is minimized.

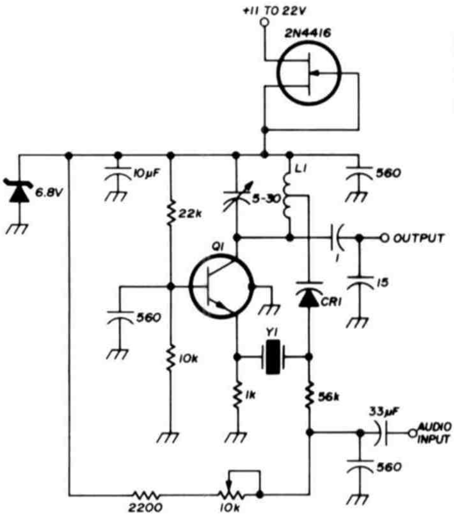


fig. 5. Overtone oscillator circuit which frequency doubles in the transistor and can be frequency modulated or used as a stable vcxo. Tuning range with a 70-MHz third-overtone crystal is typically 30 kHz at the crystal frequency (60 kHz at the output). L1 is resonant with C1 at the desired output frequency; varactor tap is at ¼ the total number of turns. Transistor Q1 is 2N918, BF115, HEP709 or similar. Varactor diode CR1 is BB142 or Motorola BB105B.

Where more expensive crystals are used, perhaps in a heated oven, the stability of these circuits will be superior to most of the oscillator circuits which are usually used in amateur equipment. This is because of the special design and the use of slightly larger capacitors across the transistor which minimize its influence on circuit stability.

ham radio

rf speech processor

for the Heath SB-102

Construction details for an rf speech processor which operates at the 3395-kHz i-f and provides up to 20-dB clipping

Timothy A. Carr, W6IVI, 452 Highland Avenue, San Mateo, California 94401

The circuit of the popular Heath SB-102 sideband transceiver, shown in **fig. 1**, lends itself to the addition of an rf speech processor. Capacitor C22 couples the output of the balanced modulator transformer, T1, to the cathode of the 6AU6 filter isolation amplifier, V2. Since C22 is mounted on the foil side of the modulator circuit board it may be easily disconnected from V2 and used to reroute the ssb signal to the speech processor. The processed ssb signal is returned to the cathode of V2. This arrangement works out very well as it does not affect any of the receiving circuitry. The 470-ohm resistor is added to the circuit so that transformer T1 is terminated with essentially the original load.

speech processor

The circuit of the rf speech processor I use with the SB-102 is shown in **fig. 2**. Although this circuit was designed specifically for use with the SB-102, it could be easily adapted to other sideband exciters which require a processor with the sideband selection filter at or near the input prior to signal processing (FL1 in **fig. 2**). The existing sideband filter is used to filter out the clipping products.

Transistors Q1, Q2 and Q3 provide the necessary signal amplification along with proper terminations for the Heath filter and automatic gain control for the two amplifier stages. The agc system is

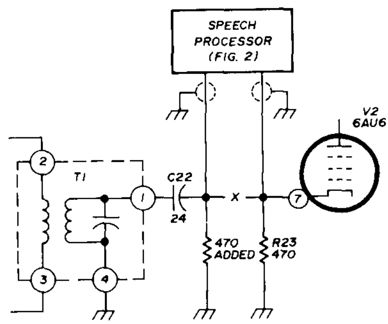
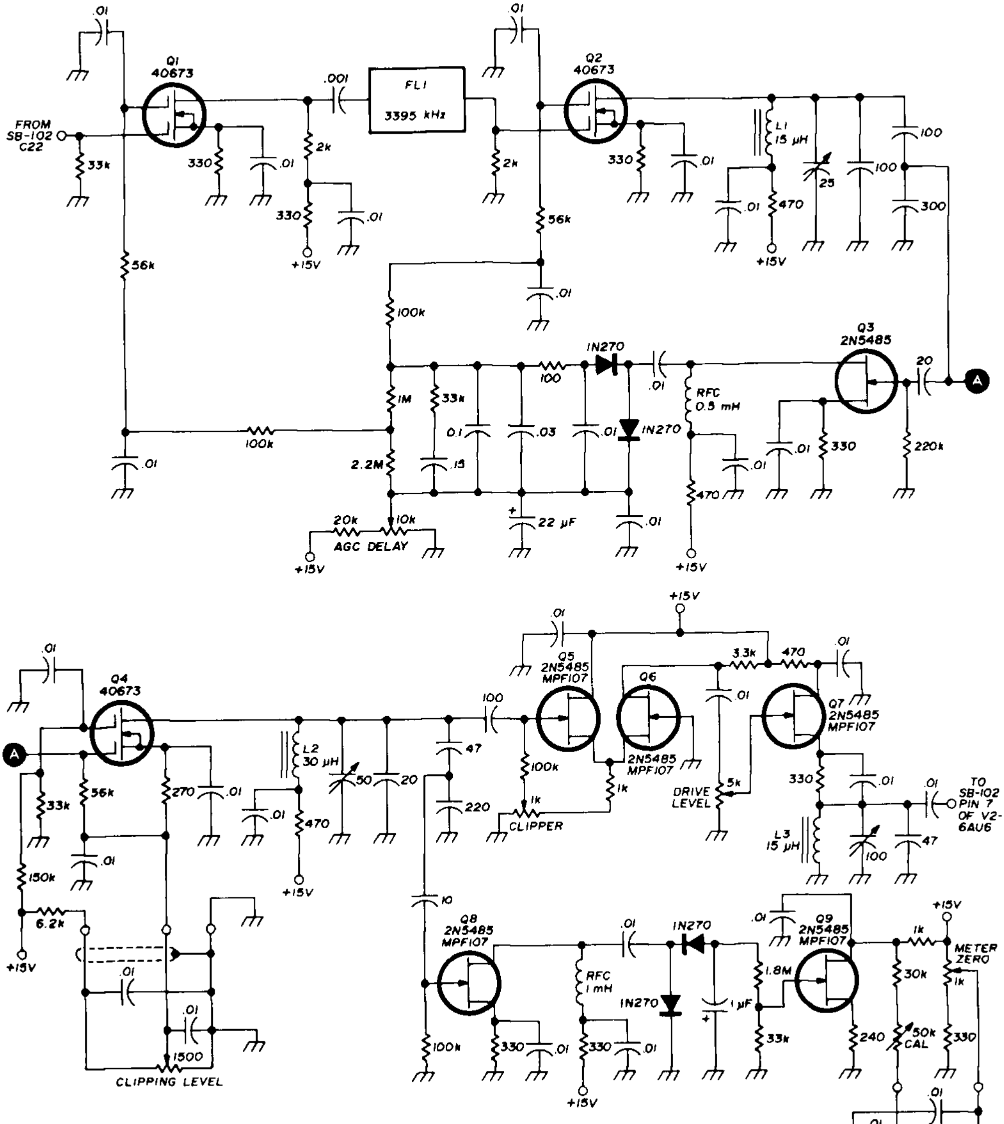


fig. 1. Rf speech processing unit for the SB-102 is inserted between the balanced modulator transformer, T1, and the filter isolation amplifier, V2.



L1,L3	15 µH. 29 turns no. 22 on Amidon T-50-3 toroid core
L2	30 µH. 41 turns no. 22 on Amidon T-50-3 toroid core

fig. 2. Circuit diagram for the rf speech processor. Filter FL1 is the same as that used in the SB-102. The existing sideband filter in the transceiver is used to filter out the clipping products.

very effective and provides a reasonably stable signal level before the actual signal processing takes place.

Transistor Q4 is a manually-controlled gain stage which allows setting of the desired clipping level, transistors Q5 and Q6 form the clipper, and Q7 is a source-follower output stage to drive the cathode of the 6AU6. The metering circuit (Q8 and Q9) measures the relative amplitude of the signal prior to clipping; the meter is calibrated in voltage ratios (dB) above the initial clipping voltage level.

The clipper is actually a fet version of the old vacuum-tube dual-triode clipper which was popular years ago. This clipper circuit offers a high-impedance load to the preceding amplifier stage so it does not appreciably attenuate the signal prior to clipping. Gate rectification does not occur until the signal input is well above that required for 20 dB clipping. The variable tap on Q5's source resistor provides easy adjustment of clipping symmetry while Q6's drain load resistor determines the amplitude of the clipped signal.

construction

The three stages of amplification used in the processor described here result in a rather sensitive high-gain chain that is susceptible to internal feedback, oscillation and the transmitter signal pickup. When building this circuit, therefore, it's a good idea not to miniaturize the layout to the extent that you develop unwanted signal coupling between components. In addition, use toroid-cored coils to minimize inductive coupling, be liberal with bypass capacitors and decoupling resistors in the 15-volt supply line, and use plenty of shielding.

In the speech processor I built the two-stage amplifier and feedback circuit (Q1, Q2 and Q3) as well as the sideband selection filter, FL1, are located in a separate enclosure mounted toward the front panel. The gain-controlled amplifier, clipper, output source-follower and metering circuit are in another enclosure toward the rear of the chassis. All input and output connections are made through shielded cable.

The speech processor is easily connected to the transceiver. A miniature two-lug terminal strip may be installed on the mounting screw adjacent to solder point 15 (see pictorial 3-4 in the Heath SB-102 manual). Capacitor C22 may then be unsoldered from point 16 and this lead reconnected to the new terminal strip with the added 470-ohm resistor. Miniature coaxial cable (RG-174/U) may be routed from point 16 (and from the new terminal strip) through the small cutouts in the center shield adjacent to the new terminal strip – the other end of these shielded cables are connected to spare phono jacks A and B on the rear apron of the transceiver. Since no holes have to be drilled in the chassis of the transceiver, and no components are removed, the equipment can be immediately restored to original, if desired.

Kits such as the Heath SB-102 offer an economical approach to amateur radio, and this same approach was used in the construction of the speech processor circuit. More than 100 components are used in the processor, but with the exception of the 3395-kHz crystal filter, the transistors and the toroidal cores, all components were removed from surplus units of various kinds. Some of the component values are not optimum, but the circuit is not overly critical and there is more than enough gain available that some leeway is permissable – you can probably use the components you already have in your junkbox.

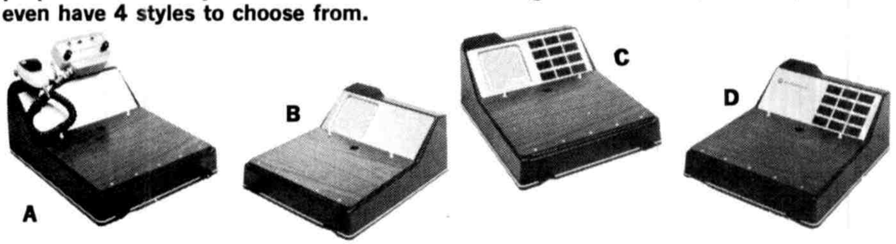
summary

Both the pre-clipping agc and the metering circuit have proven to be welcome additions to the speech processor. The unsolicited reports I have received on the quality of my ssb signal have, without exception, ranged from favorable to flattering, and have easily justified the construction of the unit.

ham radio

DRESS UP YOUR MOBILE

Dress up your mobile installation with these multi-function mobile consoles by Motorola. You can place them on the seat right next to you or mount them on your transmission hump. The console can house a speaker, control head, etc., and provide storage space as well as a hard surface to write on. Plus with appropriate switches you can even control such things as dome lite, flashers, etc. You even have 4 styles to choose from.



control heads, mics, speakers & switches shown for illustration purposes only

A . . . Console with blank panel
B . . . Console with cut out for speaker
C . . . Console with cut out for speaker & switches
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estimating the noise figure of your vhf system

A simple method of getting a handle on your vhf system noise figure

Norman J. Foot, WA9HUV, 293 East Madison Avenue, Elmhurst, Illinois

The vhf and uhf mixers and rf preamplifiers used by amateurs come in assorted sizes, colors and noise figures. Some are homebrew, others are commercially made. In either case, unless you happen to be lucky enough to own or have access to laboratory type noise generators, you probably don't know positively what your vhf system noise figure really is.

The title of this article is not intended to suggest a quick way to accurately determine your particular receiving system noise figure. However, if you will take the time to read on, and then perform a few simple experiments, you can determine in what ballpark your vhf converter and preamp are playing.

You need two things to play the game: first, a signal source, preferably remotely located, providing a signal which can be picked up on the antenna and fed into the shack; and, secondly, a receiver with a well calibrated S-meter. The latter can be accomplished by inserting a step attenuator* in the i-f circuit between the converter output

*Such as that manufactured by Hewlett-Packard, Kay and others.

and the receiver input. If left in the circuit, the attenuator can be used as a calibrated i-f gain control. In any case, 1-dB accuracy is desirable.

the experiment

Fig. 1 shows a family of curves for a preamplifier with a 3-dB noise figure. The curves correspond to preamplifier gains of 4, 6 and 9 dB. Part of the experiment is to measure rf gain so you will know which curve to use. The curves show the signal-to-noise ratio improvement ΔS/N, with the preamplifier, in terms of mixer noise figure.

If that last statement is confusing, don't give up. First, ask yourself, "What do I *think* the noise figure of my mixer is? 8 dB?" Okay, then perform the following experiment:

1. With the antenna connected to the mixer and the receiver tuned away from the signal, set the i-f gain so the noise level registers zero S-units on the S-meter. This is the reference.* Now tune in the signal and note the S-meter reading.

2. Now add the rf stage. Note the new S-meter reading. the gain of the rf stage in dB will be the difference in the S-meter readings in dB with and without the preamp. Assume it is 6 dB.

3. Next, tune away from the signal and reset the i-f gain so the S-meter is back at the original reference setting.

4. Finally, tune the signal in again and note the final S-meter reading. The improvement in signal-to-noise ratio, ΔS/N, is the difference between this reading and that of the mixer alone. Assume it is 3 dB.

5. Locate the ΔS/N = 3 dB point on the 6-dB gain curve (**fig. 1**). Reading down from this point, you find that you guessed quite well – the mixer noise figure is about 8.5 dB.

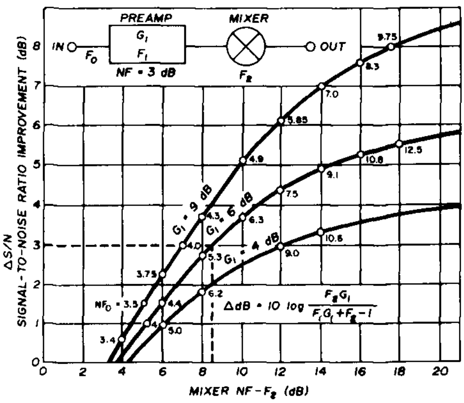

fig. 1. Overall noise-figure improvement with single preamplifier ahead of mixer (curves assume preamplifier noise figure = 3 dB). Derivation of curves is explained in appendix on page 44.

This is fine and dandy, you say, but how do I *know* the preamp noise figure is 3 dB? Very likely you don't, but you probably know what it *should* be. Assume for example that the noise figure is 6 dB, not 3 dB. Using the 6-dB noise-figure curves shown in **fig. 2**, locate the ΔS/N = 3 dB on the 6-dB gain curve. Reading down from this point, you see that the corresponding mixer noise figure is about 12 dB. If preamp noise figure is *really* 6 dB, you ought to do *something* about the mixer noise figure.

At this point you're learning that there are all sorts of interesting possibilities to this game. For example, if the mixer noise figure is truly low, say 5 dB,

*Any convenient S-meter reading can be used as the reference, but it should be close to zero so that signal readings will fall in the region below S-9 where reasonable accuracy can be obtained. Also, to perform the experiment, the receiver must have sufficient gain so that noise will produce an S-meter reading.

then signal-to-noise improvement with the preamp is harder to come by. The ΔS/N is less than 1 dB if the preamp gain is 6 dB. On the other hand, if preamp gain is 9 dB, then the noise figure improvement can be as high as 1.5 dB. But it can't be 2 dB. This is a good example of how the game is played.

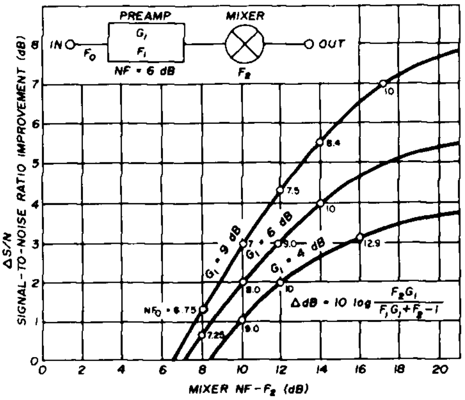

fig. 2. Overall noise-figure improvement with single preamplifier ahead of mixer (curves assume preamplifier noise figure = 6 dB).

Suppose that the improvement in S/N is negative (viz: the S-meter reading with the preamp, after resetting the noise reference, is less than the reading with the mixer alone). Your preamp noise figure is obviously greater than the mixer noise figure, regardless of what gain it has. You better do something about that, or don't use the preamp.

system noise figure

Before we end our guessing game, note that the small numbers along the curves represent overall noise figure of the mixer and rf amplifier together. These numbers are the most important of all because they represent your overall system noise figure.

Suppose ΔS/N is very large, say 8 dB, and the rf gain measures 9 dB. This means the mixer noise figure is 17.5 dB. Note that in spite of the low preamp noise figure (3 dB), the poor performance of the mixer degrades the overall noise figure to 9.75 dB!

Note also that if you use two rf amplifiers, you can still use the curves. Treat the rf amplifier feeding the mixer as the "mixer" and repeat the steps outlined above, adding the other rf amplifier to the combination.

summary

You may not be able to determine your overall receiving system noise figure accurately based solely on the instructions presented here, but if there is something seriously wrong in your system, you should be able to recognize it at once.

And remember, when you play this game, that a small ΔS/N is a sign of one of two things: a mixer noise figure almost as low as the rf stage noise figure or an rf stage noise figure almost as high as the mixer's noise figure.

appendix

The curves of **fig. 1** and **2** were developed from the following equation:

$$\Delta dB = 10 \log \frac{F_2 G_1}{F_1 G_1 + F_2 - 1}$$

This equation is derived by subtracting the overall noise factor F_o from the mixer noise factor F_2 as follows:

$$F_o = F_1 + \frac{F_2 - 1}{G_1}$$

$$NF_o = 10 \log \left[F_1 + \frac{F_2 - 1}{G_1} \right] dB$$

$$NF_2 = 10 \log F_2 \; dB$$

$$\Delta NF = 10 \log F_2 - 10 \log \left[F_1 + \frac{F_2 - 1}{G_1} \right]$$

$$\Delta NF = 10 \log \left[\frac{F_2}{F_1 + \frac{F_2 - 1}{G_1}} \right] dB$$

$$\Delta NF = 10 \log \left[\frac{F_2 G_1}{F_1 G_1 + F_2 - 1} \right] dB$$

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More Details? CHECK—OFF Page 94

reducing warm-up drift in the Collins S-line

Pre-heating the S-line PTO considerably reduces warm-up drift — the same technique may be applied to other equipment

Marv Gonsior, W6VFR, 418 El Adobe Place, Fullerton, California 92635

The warm-up drift of the Collins S-line may be substantially reduced by means of the relatively simple circuit addition of a two-dollar resistor, without any drilling or other circuit modifications. Applications to other receivers may be readily accomplished by experiment. All that is required is one Dale type RH-25, 25-watt, 1000-ohm resistor, or equivalent. This resistor is only about one inch (2.5mm) long, and is attached to the center of the rear vertical panel of the 70K-2 oscillator enclosure with a very small amount of cement. These resistors are designed for flat-surface, chassis mounting to assure proper heat dissipation, so they are ideally suited for the job.

The modification functions only in the receiver's *off*, inoperative mode. The resistor, R1, is wired across the power switch terminals on the receiver's control switch, S5, as shown in **fig. 1** so that a few watts of energy are heatsunk to the PTO enclosure. Once the receiver is turned on, the switch, S5, automatically shorts R1 and the PTO resumes its normal operating temperature. In the pre-heat mode, the receiver's S-meter will move slightly up from zero, and an almost imperceptible glow will be noted in the dial lamp. The power transformer will be absolutely cold. The PTO enclosure should then remain at about the same temperature, whether or not the receiver is in operation. The mechanical configuration for the installation of R1 is shown in **fig. 2**.

There are two alternative procedures for mounting the resistor. First, clean

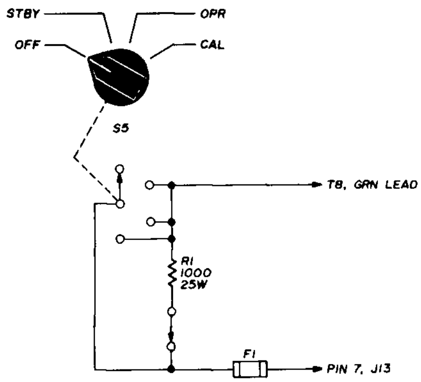

fig. 1. The 1000-ohm pre-heating resistor, R1, is connected into the circuit of the Collins receiver only when it is turned off.

the mating surfaces thoroughly with pure acetone or equivalent. Then spread a very thin film of transistor thermal compound, such as Wakefield's 120, on the resistor, taking great care to fully avoid the two mounting ears. Place a very small amount of epoxy cement in the mounting holes and on the bottom of the ears of the resistor and set it in place with a wedge against transformer T3 until the epoxy cures. Hobby-type, five-minute epoxy works well.

The second method is to coat the bottom of the resistor with a very thin layer of a thermally conductive adhesive, such as Wakefield's 151-1-A, and attach it to the PTO in the same manner.

Wire the resistor according to good practice, using shrink tubing or equivalent on its terminals, since it is directly involved with the 117-volt ac line. A miniature spst switch may be mounted on the power switch and wired in series with the resistor to inactivate it during extended standby periods or, alternatively, the power cord may be unplugged.

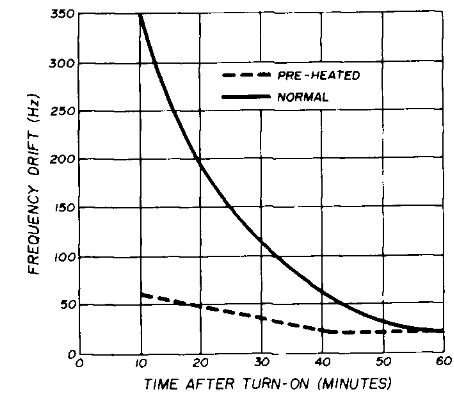

fig. 3. Warm-up drift of the Collins S-line is reduced considerably when the PTO is pre-heated by the added power resistor. This data taken at an ambient temperature of 20°C.

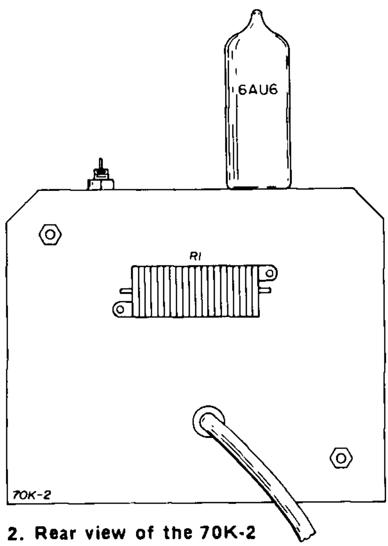

fig. 2. Rear view of the 70K-2 PTO in the Collins receiver, showing the mounting of the Dale 25-watt, 1000-ohm resistor used to stabilize the temperature of the PTO.

The frequency measurement data at 14 MHz were taken on a H-P model 5381A, a seven-digit frequency counter in combination with a precision external time base. This was used in conjunction with a Rec-Counter.[1] The Δ_f curves shown in **fig. 3** reveal the relative improvement in my 75S3-B; a worthwhile four-to-one warm-up drift reduction, in the first hour, for chasing DX on cold winter mornings.

reference

1. K. Macleish, "The Rec-Counter," *QST*, May, 1971, page 11.

ham radio

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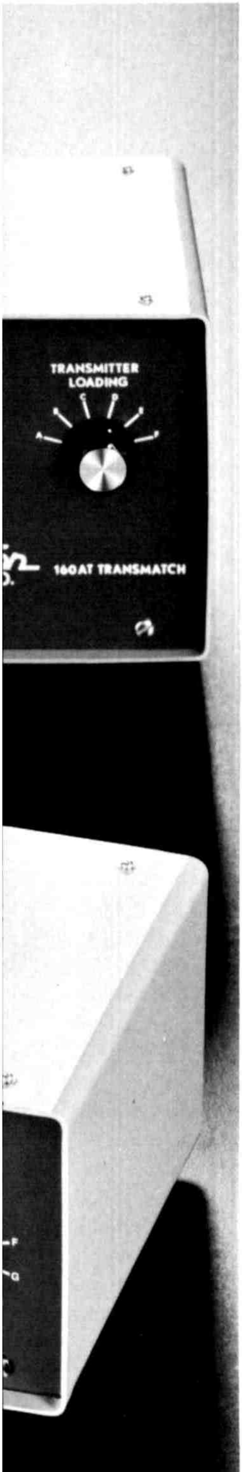

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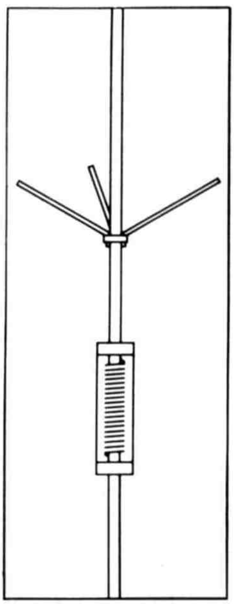

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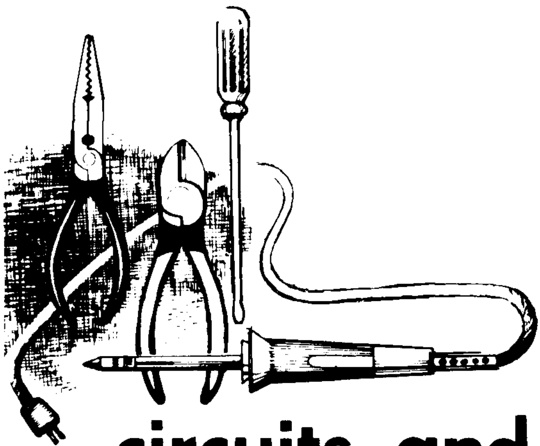


circuits and techniques

ed noll, W3FQJ

experiments and projects — cosmos

In the months ahead this column will be devoted primarily to two subjects: power generation using solar energy and wind, and new solid-state technology. My plans for generating electrical power with solar energy and wind have been previously discussed in this column. A 200-watt wind generator has been ordered, and by the time you are reading this I hope to have the system in operation. The amateur station and workshop at W3FQJ will be powered completely by solar and wind energies.

The second major subject, solid state, will include discussions of bipolar, fet, mosfet, integrated-circuit and cos/mos technologies. Electronics, more than many other industries, has always been interested in the conservation of electrical energy. Solid-state devices are a revealing example. Their low operating voltages and lack of current-demanding filaments and high-voltage power supplies make them ideal for powering with the non-polluting sun and wind. Radio amateurs are to be commended for their leadership in these endeavors. In fact, their enthusiasm for QRP operation and the use of minimum power in the sustaining of any QSO are exemplary.

Many amateurs would like to take these devices on mentally, but have procrastinated or take little pleasure from learning the theory of a device without doing some practical experimentation. While it is true that many amateurs have built complex solid-state devices following detailed construction information supplied with kits or in magazine articles, what happens within the device and circuit is often vague. There are a good number of amateurs who, as yet, have not built their first solid-state stage. Perhaps this column will be able to lead you to a better understanding of device function and circuit.

The plan is to combine individual projects with experimental steps (which I call *expros*). First you will experiment with the device, learning about its innards and external operating characteristics. Then you will build a project using the one or several of the devices. **Expro 1** will be the jfet and will conclude with the construction of a two-stage QRP transmitter. Most expros will be built on perf boards which, if desired, can be used over and over again.

cosmos logic

In previous columns there have been basic presentations on the fabrication and general operation of most solid-state devices. One which was overlooked was the cosmos. Fundamentally, the cosmos device incorporates enhancement-mode mosfets into integrated circuits. Uniformity, balance, stability, versatility, reliability and compact size are the reward of IC fabrication. The special star of the cosmos device is its conservation of power.

The enhancement mode of mosfet operation, integrated fabrication and complementary symmetry circuitry combine to form the increasingly popular RCA series of cosmos integrated circuits. These devices require very little power (standby power measured in microwatts), operate over a wide supply

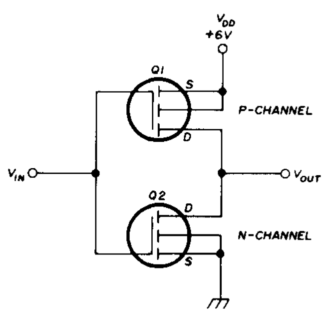


fig. 1. Two enhancement-mode mosfets in complementary symmetry.

voltage range (less than 2 to more than 15 volts), a wide temperature range and have the high input impedance characteristic of all mosfet devices. Cosmos devices are ideally suited to logical, digital and switching, as well as linear applications. Typical package dissipation is 200 milliwatts.

What is complementary symmetry? It is the basic circuit that makes cosmos tick and be so conservative in power demand. It is the jewel of the modern watch.

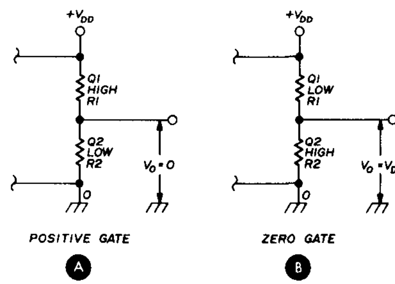


fig. 2. Equivalent operation of a complementary-symmetry pair (see text).

Field-effect transistors come in two forms, n-channel and p-channel. One type is the complement of the other. The channel charges move in opposite directions. When two such devices are connected in parallel, **fig. 1**, unusual operating conditions arise. The top transistor is a p-channel enhancement-mode mosfet; the bottom transistor, an n-channel type. A positive voltage applied to the parallel gates causes the n-channel device to conduct. The p-channel unit remains off.

What is the output of the complementary symmetry stage? Assume that the gate voltage is made positive by the amount of the supply voltage V_{DD} (6 volts). The lower transistor, Q2, conducts, presenting a low-resistance path (perhaps one to several thousand ohms) between the drain and common. The top transistor, Q1, is cutoff. The resistance of its path is in the thousands of millions of ohms. Under this condition what is the output voltage, assuming that the load placed on the output is the gate circuit of a second high-impedance enhancement-mode mosfet?

As shown in the equivalent circuit, **fig. 2**, a two-resistor voltage divider is set up. Inasmuch as the top resistance is very high in comparison to the lower one, there is practically no voltage drop across the lower one and the output is in effect zero volts (ground or common potential). Furthermore, very little current is drawn from the supply line because of the extremely high resistance of the series combination of R1 and R2.

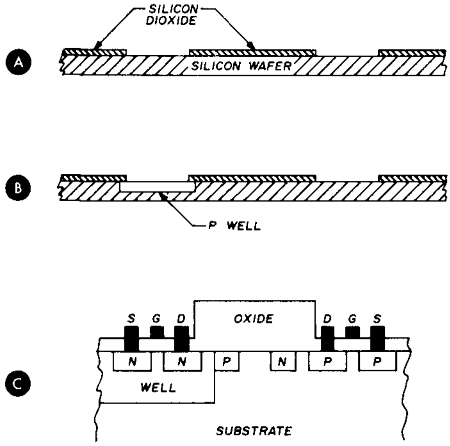


fig. 3. Basic construction of a mos integrated circuit.

If the gate voltage is zero (common potential), transistor Q1 conducts while a cutoff bias is applied to transistor Q2. Why does transistor Q1 conduct with zero voltage applied to the gate? Note that its source is at positive potential so the gate of the p-channel device is negative in comparison to the source; therefore, it conducts. In **fig. 2B** the upper transistor presents an approximate 1000-ohm path between V_{DD} and output, while the path between the output and common is in the millions of ohms.

Now the high value resistance is in the path between output and common; the low value between the supply voltage and output. Consequently the output voltage is positive and essentially the same value as V_{DD}. Again the summation of the two resistances is extremely high and there is little current demand made from the supply source.

In summary, swinging the gate voltage between the supply voltage value and zero causes the output to change between zero and the supply voltage value. This is an ideal situation for digital and switching applications.

It should be noted that in both cases the resistance of the path between supply voltage V_{DD} and common (assuming no low-resistance load is placed on the output) is in the millions of ohms. Therefore, for both steady-state conditions, the resting power demand is exceedingly low. This is great for logic circuits. Logical zero and logical 1 states make the same low power demand on the supply.

In fact, the only time that any significant power is drawn occurs when the gate voltage is in transition between the two steady states. Furthermore, the higher the speed of the transition (rate of rise and fall of the leading edges), the lower the power demand made on the supply. This is to state that the power demand will be less when an incoming signal is a steep-sided pulse or square wave; more if the incoming signal is a sine wave.

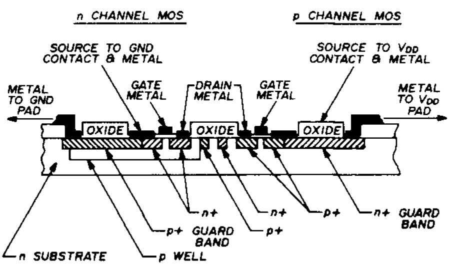


fig. 4. Fabrication plan of RCA cosmos devices.

The complementary symmetry circuit is basic to the cosmos device. Why the need for integration? In practice it is difficult to obtain exact symmetry between n- and p-channels. The greatest advantage of the complementary symmetry connection can be made when it is applied to integrated-circuit technology. In the single monolithic chip, uniform and balanced channels can be processed using the diffusion procedure.

A basic RCA cosmos device begins with a silicon substrate and silicon dioxide islands that have been deposited on its top surface using heat deposition and photolithographic procedures, **fig. 3**. Diffusion steps are then used to form the various elements and isolating barriers. When using the n-type substrate it is necessary to first diffuse a p-type well in that substrate to serve as the base needed in the formation of the n-channel transistor. The basic makeup of the two-transistor complementary devices is shown in **fig. 3C**. On the left, in its well, is the n-channel unit. On the right, diffused directly into the substrate, is the p-channel unit of the complementary pair.

The complete RCA package arrangement is shown in **fig. 4**. In addition to the complementary stages there are guard bands which surround and protect the separate mos devices, well, diodes,

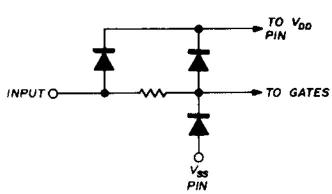


fig. 5. Protective input diodes.

etcetera. They provide isolation and prevent leakage. Guard bands also provide conduction paths to the external supply voltages.

Included as a part of the fabrication are protective diode systems. The input diode arrangement, **fig. 5**, protects the device from static charges and input voltage transients. This diode clamping keeps the device and extraneous volt-

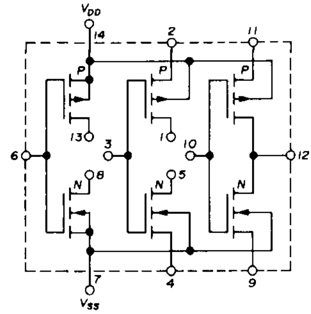


fig. 6. RCA CD4007A cosmos IC consists of two complementary-symmetry stages plus an inverter.

ages at safe levels. Nonetheless, the device must be handled carefully in accordance with the usual mosfet precautions.

The complementary symmetry circuit, when connected as shown in **fig. 1** and included in the cosmos integrated circuit, is called an inverter. As mentioned, a positive voltage applied to its gate results in a decrease in the output voltage. A positive change at the input results in a negative change at the output.

In terms of logic language, a logical 1 input (+ voltage) causes a logical zero output. A logic inversion has taken place. Conversely, with the logical zero input, there is logical 1 output.

Three complementary symmetry circuits are built into the RCA CD4007A cosmos integrated circuit, **fig. 6**. The first two configurations are referred to as complementary symmetry circuits. Note that separate drain terminals are brought out (pins 1, 5, 8 and 13). This provides versatility in interconnecting the two stages into various forms of complementary-symmetry-stages. The third stage is the basic inverter and its circuit is identical to that of **fig. 1**. It differs only in that the two drains are connected together internally at pin 12.

One complementary pair and the inverter can be connected into a monostable multivibrator as shown in **fig. 7**. In a resting state the p-channel mosfet of the stage on the left is biased off; the n-channel on. As a result the C output is low and the inverter D output is high because the output of the first stage is connected to the gate of the second.

When a negative pulse is applied by way of capacitor C1, the p-channel mosfet is turned on and the n-channel off. Capacitor C2 begins to charge to the supply voltage and this positive voltage on the gate of the inverter drives output D low. This happens very quickly aided by the feedback path between output D and the input of the n-channel section of the input pair, eventually shutting off the n-channel of the first stage.

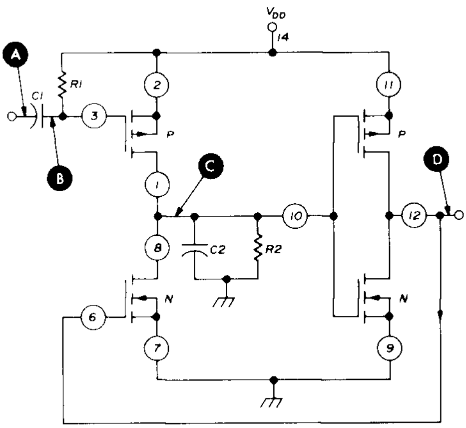


fig. 7. Using the RCA CD4007A cosmos IC as a multivibrator. Operation of this circuit is described in the text.

Capacitor C1 now begins to charge to the supply voltage, V_{DD}, through resistor R1. The p-channel mosfet remains on until the charge interval is such that the p-channel device is shut off by the declining negative voltage on capacitor C1. However, the n-channel device of the first inverter also remains off until capacitor C2 discharges sufficiently through resistor R2 toward common.

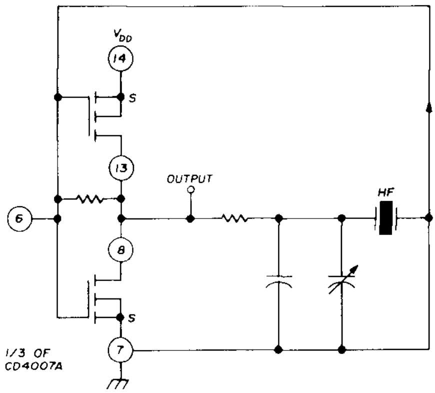


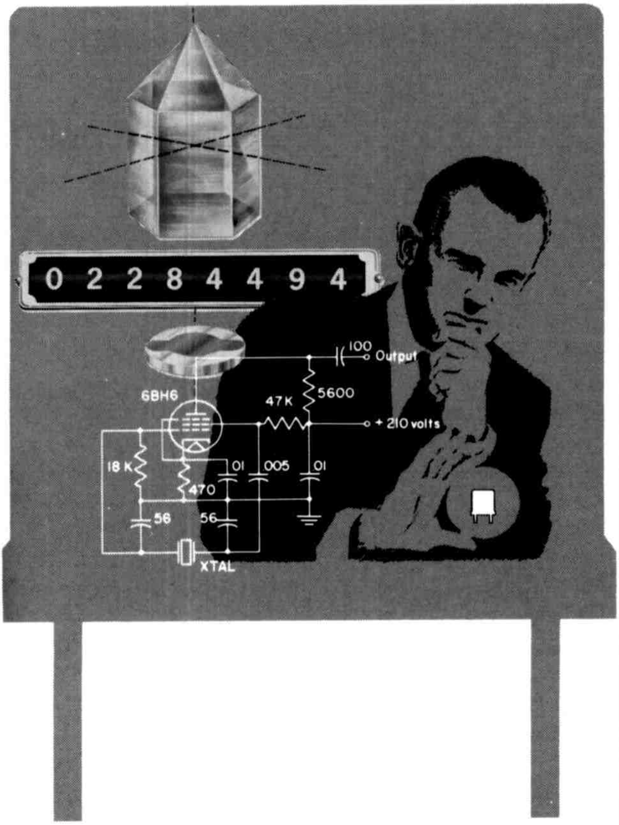
fig. 8. High-frequency crystal oscillator circuit is based on two stages of an RCA CD4007A IC.

When the turnover or threshold voltage of the p-channel transistor of the inverter is reached, the device is turned on. The output voltage at D then begins to rise and the n-channel device of the first stage is switched on, providing a low resistance discharge for capacitor C2. This causes the operation of the first stage to go from high to low and the cycle is completed. The multivibrator then remains in its resting state until another negative pulse arrives at point A.

The circuit of **fig. 8** shows how a single complementary pair can be connected as a high-frequency crystal oscillator. The output is taken at the common drain circuit. The feedback arrangement is Pierce-like in the form of a lowpass crystal filter that is connected between the drain circuit and gate input. The small trimmer capacitor permits fine adjustment of the crystal oscillator frequency.

ham radio

There Is a Difference In Quartz Crystals



Space age communication equipment demands a crystal that meets all standards of technical advancement. Crystals that were acceptable some years ago do not meet present day specifications. As a general rule, your crystal must be selected from the best quartz . . . (no throw off cuts). Tight tolerances demand selected angles of cut. The x-ray is important in making this selection. The crystal should be preaged with stress cycling. It should be checked for frequency change vs temperature change. It must be checked for optimum spurious response. It should be calibrated to frequency with the correct oscillator. International Crystals are manufactured to meet today's high accuracy requirements. That's why **we guarantee all** International crystals against defective materials and workmanship for an unlimited time when used in equipment for which they were specifically made.

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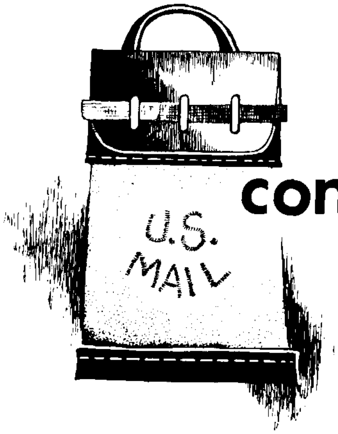
More Details? CHECK–OFF Page 94



comments

Dear HR:

While interest in speech processing is understandably high, I wonder why the same degree of interest is not shown for the CW mode. Perhaps as amateurs we are convinced we know all there is to know. A little research can, however, raise some interesting questions. Consider the question of minimum bandwidth requirements which are expressed by Shannon's formula in terms of bits per second per Hz of bandwidth as

$$\log_2 (1 + s/n)$$

where s/n is the signal-to-noise ratio. For 50-bit words and Morse code at 25 wpm the bit rate is close to 20 bits per second. With an arbitrary signal-to-noise ratio of 15 the formula gives 4 bits per second per Hz, or 5-Hz bandwidth for this example.

Unfortunately, we cannot achieve this signaling rate in practice, and for a two-state amplitude-modulated signal such as CW the bandwidth requirements would be approximately three times the theoretical minimum (15 Hz in this case). Since bandpass audio filters with this degree of selectivity are easily built, why are filters of 100 and 150 Hz in common use, and filters of 50 Hz or less very unusual?

One reason is that some CW operators rely almost exclusively on their personal selectivity built into their ears and brain. I believe there is a lot to learn in this area, but in my own particular case, the better the signal-to-noise ratio reaching my ears, the better I copy. The most common reason for the rarity of minimum-bandwidth filters is the phenomenon of filter ringing. I cannot recall seeing a single article on this aspect in the amateur magazines, and the purpose of this letter is to stimulate some correspondence on this subject.

My own knowledge is inadequate, but it appears that filter ringing arises basically from two effects. First, the filter's group-delay characteristic, and second, the filter's transient response. From experience with active bandpass filters I believe that the delay characteristic can be adjusted for minimum distortion of the keyed audio envelope so bandwidths of about 50 Hz can then be used. The question of transient response remains, and at the moment I don't

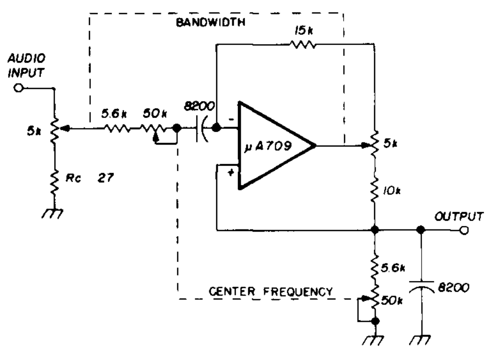


fig. 1. Variable-bandwidth, variable-frequency audio filter. With circuit values shown center frequency can be tuned from 300 Hz to 3 kHz. (A 741 op amp would be somewhat better over this frequency range.)

have an answer, although I have hopes of minimizing this, too.

In the commercial world of data transmission many signaling modes other than two-state a-m have been evaluated. Generally they succeed in trading signaling rate for immunity to interference. Some of these signaling modes may well have amateur applications. Also, the technique of coherent detection seems promising. The question of spectrum shaping has been studied and optimum relationships between transmitter and receiver filter characteristics have been established. Perhaps in our case we should pay more attention to the optimum design of key-click filters and receiver audio filters.

For anyone who has not yet tried a variable-frequency, variable-bandwidth audio filter, I would recommend the circuit shown in **fig. 1**. Or, more simply, the IC package made by Kinetic Technology, Inc.* Their FX60 active bandpass filter requires only one fixed and two variable external resistors and costs about $6.00.

Ron Skelton, 6Y5SR
Kingston, Jamaica

memory keyer mods

Dear HR:

I found in my memory keyer that the 1101A random-access memories (used in place of the 25L01s) would play back a message erratically. This can be cured by placing a 1000 ohm, 1/4-watt resistor from the *data output* (pin 12) of the 1101 to ground. Note that pin 12 of memory A is connected to pin 12 of memory B. The resistor can be soldered to the foil side of the PC board. Put insulating tubing on the resistor leads to prevent the leads from shorting to the foil.

A feature which will increase the versatility of the keyer when using it as a straight electronic key without a memory is to replace the *memory select* switch, S3, with a center-off spdt switch. Placing S3 in the center position will not allow either memory to send an output to the keying transistor. The keyer can then be used as a normal electronic key without worry that the memories will inadvertently trigger and send an output to the keying transistor.

I would like to thank my friend Bob Thing, WA3WKJ, for the ideas presented here.

Sam Guccione, W3GVP
Camden, Delaware

information needed to update RSGB history

Dear HR:

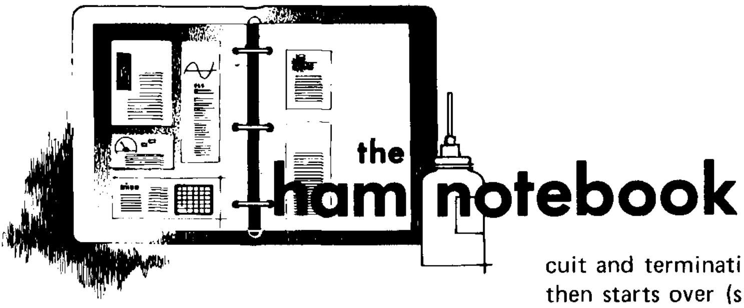
Many readers of *ham radio* are also members of the Radio Society of Great Britain, and are familiar with the book, *World at Their Finger Tips*. This book was written by the late John Clarricoats and covers the history of the society and the work of many of its members from 1913 to 1963.

The RSGB has honored me with the task of writing a sequel to this book in order to bring the society's historical records up to date. During the past decade the RSGB and numerous members have contributed to the tremendous advance in all fields of radio communications throughout the world.

In order for me to make a success of this book, and do the society justice, I must have information, therefore I appeal to RSGB members who read *ham radio* to send me details of their radio achievements during the past ten years. I would like to have this information as quickly as possible because there is a lot to do, and I hope to have the work completed within a couple of years.

Ron Ham
Faraday, Greyfriars
Storrington, Sussex
RH20 4HE England

*Kinetic Technology, Inc., 3393 De La Cruz Boulevard, Santa Clara, California 95051.



fm equipment interface problems

In trying to use two current pieces of fm equipment, a 10-watt transmitter (Regency HR-2) and a 100-watt amplifier (Dycom), it was found that the two pieces would not work together. To begin with, the transmitter is well designed and has excessive standing wave protection – a very good move, especially if the wrong antenna is inadvertently connected, or left disconnected. This safety device will probably save replacement of expensive power transistors.

The amplifier has an "automatic switching" feature, meaning that dc power is applied at all times, and as rf excitation is applied, the unit turns itself on. When the transmitter is turned on (microphone button pressed), rf appears across diode CR1 (see **fig. 1**), and a dc voltage appears at point A. The rf choke isolates the rf voltage at point A and conducts dc to the base of transistor Q4, placing a positive bias on the base, and transistor Q4 turns on, picking up relays K1 and K2. Unfortunately, the moment K1 and K2 start to transfer, the back contacts open, opening up the line from the transmitter, and the swr protection circuit in the exciter cuts in, shutting off the power. The relays then open, remaking the exciter output circuit and terminating the line. The cycle then starts over (since the transmitter is still on). The relays just sit and vibrate like an old fashioned door bell – a revolting state of affairs.

The fix is ridiculously easy. Just connect a 500-μF capacitor (12 volts or more) between the base of Q4 and ground. As diode CR1 conducts, the 500-μF capacitor, C4, is charged and holds its charge long enough for the relays to pull completely in. Once the relays are picked up, the line from the transmitter is terminated by C2-C3-L1, usually with less than 1.2:1 vswr, particularly if adjusted carefully.

Capacitor C1 series resonates with the interconnecting leads and relay elements to allow maximum receiver performance and proper transmitter operation when the amplifier is not in use. Power may be switched from the 100-watt amplifier to low power only by opening the circuit at the fuse.

The changes suggested in these notes should make the use of the equipment much more satisfactory and enjoyable.

Dave Chapman, W9DPY

Heath SB102 modifications

I have two Heath SB102 transceivers and both have shown the same two difficulties, which appear to be generic: First, objectionable audio hum level,

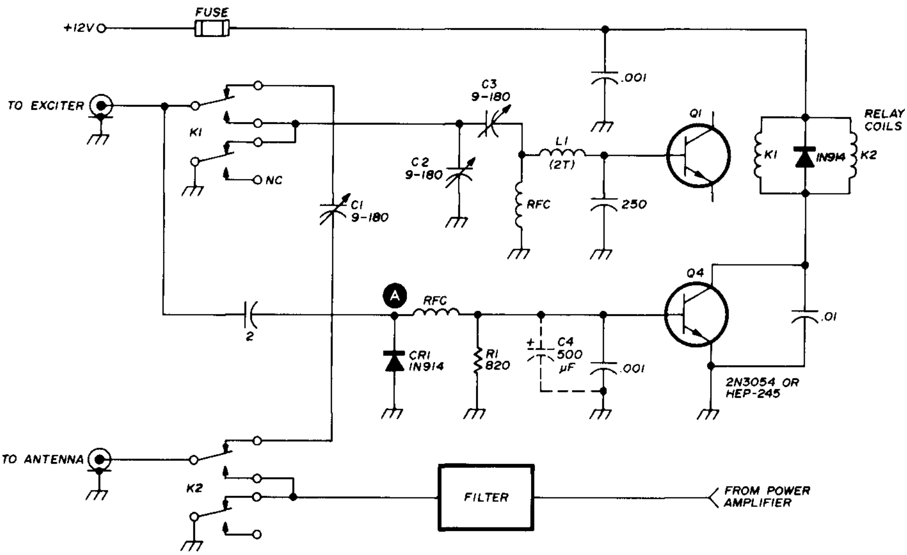


fig. 1. Added 500-μF capacitor allows automatically switching relays to be picked completely up before the swr protection circuit drops them out.

and secondly, one resistor that runs hotter than it should. As for the hum, an additional filter did not help, and shorting the arm of the volume control had no effect. As a part of the cable harness there is a shielded lead from the arm of the volume control to capacitor C308 which couples the signal into the grid of V14A, the audio amplifier. Replacing this lead with a *separate* shielded lead eliminates the objectionable hum level.

Resistor R955 is a 100k, ½-watt resistor which avalanches down in value and burns up. Replacing it with a 1 or 2 watt, 100k resistor clears up this problem.

Lowell White, W2CNQ

zener-diode noise

Recently I was asked to convert some vhf preamplifiers and replace the original 417A tube with a low-noise transistor. This required the addition of a zener diode to provide the correct voltage for the transistor. The zener was originally mounted very close to the low-noise transistor and a noise generator was used to determine the noise figure. The results were nearly the same as when the original tube was in use. The zener was then mounted away from the transistor, near the power source. A noise figure measurement indicated a noise reduction of 2 dB.

Vern Epp, VE7ABK

short circuit

The 67-pF ceramic capacitors used in the lowpass filter described in the March, 1975, issue of *ham radio* have all been sold. An alternate capacitor is the 140-pF APC capacitor available for 50 cents from CPO Surplus, Box 189, Braintree, Massachusetts 02184. Remove one plate for 136 pF, fully-meshed capacitance. Since CPO Surplus has a handling charge of 50 cents on orders less than $3.00, the two capacitors for the lowpass filter can be obtained for $1.50, postpaid.

a second look (from page 4)

table 1. Partial listing of power amplifier tubes in current use on the amateur bands.

tube type	number	total filament/heater power (watts)	equipment manufacturer
thoriated tungsten filament			
572B	2	51	Heathkit
811	4	100	Collins 30L1
813	2	100	
833A	2	200	
3-400Z	2	140	Henry
3-500Z	2	140	Drake, Heath
3-1000Z	1	157	BTI
3CX1000A7	1	152	
3CV1500A7	1	152	
4-125A	2	65	
4-250A	2	140	
4-400A	2	140	E. F. Johnson
4-500A	2	204	
4-1000A	1	157	
4CX1500A	1	200	Henry
indirectly-heated oxide cathode			
8072	1	17	CX-7A
8122	2	35	National
8873	2	40	Heath, Henry
8874	2 or 3	40 or 60	ETO, Henry
8877	1	50	ETO, Henry
4CX1000A	1	57	Collins 30S1
4CX1500B	1	60	

desirable. If the 6-dB differences proposed in Docket 20282 are used, then one-quarter and one-eighth, respectively, of the above emitter wattages would coincide.

If a filament power limitation for each class of license were to be adopted, Quinn has suggested that no input or output power limitations be imposed upon the amateur service. The filament power limitation would predetermine maximum operation conditions as the tube could only be driven up into plate current saturation. The individual operator could exercise his own initiative and technical ability, using any tube which fell within the authorized emitter power limits. This is the same sort of initiative which prompts some amateurs to build large antenna systems to enhance their signal strength, and adds to the competitive spirit of the hobby and advances

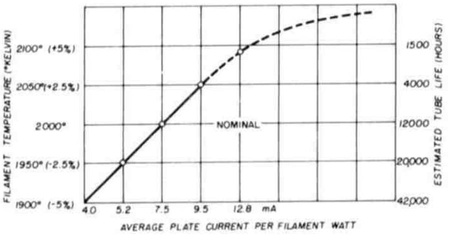


fig. 1. Approximate comparison of filament temperature and emission life vs average plate current (mA) per filament watt for thoriated-tungsten power amplifier tubes. Note that if one or more maximum tube ratings are used simultaneously tube life is severely decreased.

the technical achievements in amateur radio.

The establishment of total emitter power for amateur linear amplifiers would automatically establish a maximum power, as shown in **figs. 1** and **2**. The dotted regions shown on these curves represent diode operating conditions only. In actual practice, if a tube were operated in this area under rf conditions, it would probably fail within a few hours due to either control or screen grid failure, excessive internal anode temperature, or oxide cathode evaporation, etc. In view of this, the estimated tube life shown would not be representative at the upper current levels because the tube would probably fail catastrophically, rather than from loss of emission.

There will, of course, be those operators who will obtain a few more watts and minimize short tube life by reducing filament power during standby, and increase filament power during rf drive conditions, or increase plate voltage, to maximize plate efficiencies. However, as the old saying goes, "You can't get something for nothing," and equipment and tube manufacturers can tell upon inspection if their product has been abused. One or two dB would not be worth the effort.

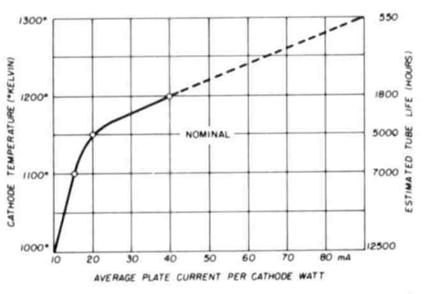


fig. 2. Approximate comparison of cathode temperature and emission life vs plate current (mA) per cathode watt for power amplifier tubes with indirectly-heated cathodes. Note that if one or more maximum tube ratings are used simultaneously tube life is severely decreased.

Presently, it is very difficult, if not impossible, for the FCC to monitor and police amateur power limits. If the technique suggested by W6MZ were adopted, and an amateur was found to be using a power amplifier which used tubes with manufacturer's filament/heater ratings in excess of the maximum specified wattages, it would be a simple black or white infringement of the rules.

Jim Fisk, W1DTY
editor-in-chief

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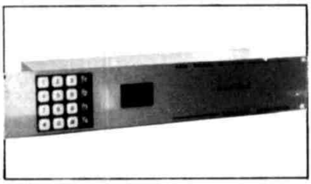

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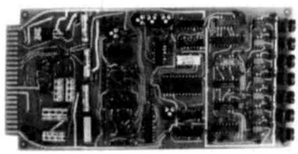

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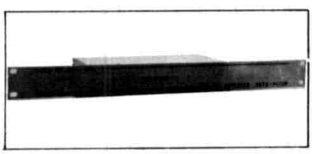

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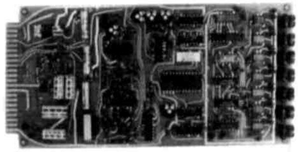
More Details? CHECK—OFF Page 94

TOUCH TONE TO DIAL PULSE CONVERTER



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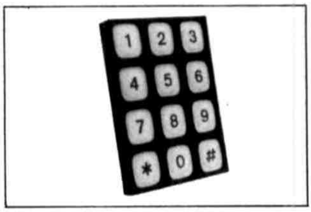

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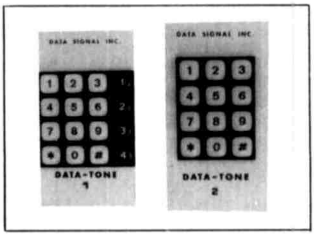

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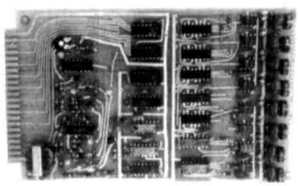

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new products

electronic keyer

Data Signal recently introduced a new printed-circuit electronic keyer which is offered in two versions: one for TTL, the other for CMOS logic. The keyer is complete, including potentiometers, a large speaker and all mounting hardware. The user must supply an enclosure, a keying paddle and a small 5-volt power supply for the TTL version or a 9-volt transistor battery for the CMOS version.

The keyer circuit includes fully automatic, self-completing dots, dashes and spaces. Each dot and dash is provided with its own jam-proof space, eliminating any chance of jamming dots and dashes together. At the instant the paddle is closed, the start-stop oscillator starts sending the code element. Key closures extending to the end of the dot-dash space are allowed with assurance of no additional dot or dash. This wide keying tolerance makes this keyer extremely easy to use, for beginners and old timers alike. A variable weight ratio control is provided to allow the operator to adjust the dot-dash to space ratio of each character. The built-in audio system includes a full-range audio oscillator, volume control, tone control and speaker. Keying speed is adjustable from 5 to 50 wpm.

These keyers eliminate the number-one source of keyer failure – the output keying relay. The reed relays used in many electronic keyers are subject to pitting, sticking and breakage. In the Data Signal unit output keying is accomplished with specially selected high voltage, high current transistors. These heavy-duty transistors require a small amount of current for operation and are designed to handle the two most often used keying systems – grid block keying and solid-state transmitters.

The two versions of the keyer, TTL and CMOS, allow the user to select the keyer best suited to his own requirements. The TTL version is ideally suited for home stations where a common 5-volt supply is available, while the CMOS version requires very low current and is just right for QRP or portable operation.

The TTL version of the electronic keyer, model TTL/PCK-1, is priced at $19.95 wired ($14.95 kit); the CMOS version, model CMOS/PCK-1, is $24.95 wired ($19.95 kit). For more information, write to Data Signal, Inc., 2212 Palmyra Road, Albany, Georgia 31701, or use *check-off* on page 94.

500 MHz frequency counter

The new UHF 500B frequency counter from Levy Associates features laboratory accuracy in a portable instrument

More Details? CHECK—OFF Page 94

at an inexpensive price. This counter, which uses the latest state-of-the-art advances, provides all of the features of instruments costing three times as much: built-in nicad battery with charger for easy portability, 7-digit display, high sensitivity, high-stability temperature-compensated crystal oscillator, and response to at least 500 MHz (575 MHz typical). The bright LED displays and polarizing filter make reading easy in high ambient light conditions. Adjustable display storage provides for minimum transmitter *on* time.

The sensitivity of the new UHF 500B frequency counter is 35 mV or less to 50 MHz; less than 150 mV from 50 to 500 MHz. With the uhf preamp option ($85) the sensitivity is 30 mV or less to 500 MHz. Other options include 1000 MHz capability ($195), high-stability time base with ±0.0001% accuracy from zero to 40°C ($50), and green or yellow displays [red is standard] ($15). The standard UHF 500B is priced at $525. For more information, use *check-off* on page 94 or write to Levy Associates, Post Office Box 961, Temple City, California 91780.

specialized communications techniques for the radio amateur

This new book from the ARRL was written by those experienced in each of the fields which it covers. The seven chapters provide practical details on communications techniques, amateur television, slow-scan television, facsimile, RTTY, space communications and advanced techniques.

The chapter on amateur television contains circuit details and applications information for television cameras, transmitters and receiving techniques. The section devoted to facsimile in-