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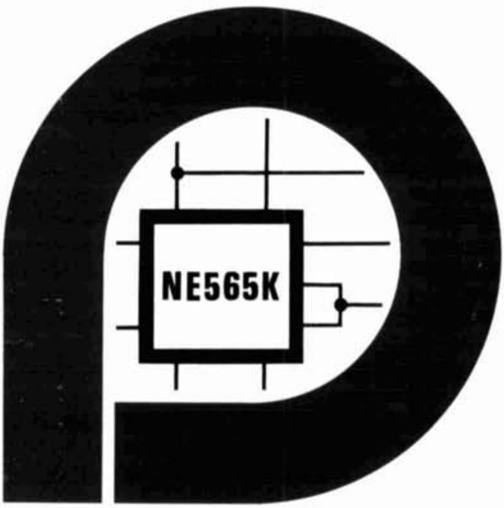

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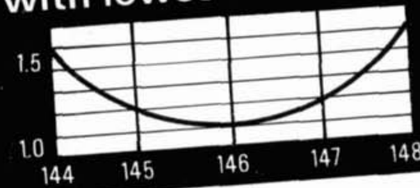

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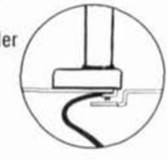

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ham radio *magazine*

contents

a second look

by jim fisk

A whole new field of electronics may eventually evolve from current research into semiconductor vacuum tubes. Sound like an April-fool joke? Well, interest in this area has been high since RCA successfully operated a silicon-cold-cathode tube several months ago. In this device the cathode is a silicon p-n junction which emits electrons directly into a vaccuum when the diode is forward biased.

The latest solid-state cold-cathode vacuum tubes use gallium phosphide as the cathode material. The surface of the gallium phosphide is coated with a layer of cesium or cesium oxide which allows the electrons to escape into the vacuum. Although the maximum current densities are presently quite small, and must be increased significantly before the solid-state vacuum tubes are practical for commercial use, technology moves very rapidly, and we should see practical devices of this type on the market within the next five years.

Because of another recent advance in electronic technology noisy cooling fans and blowers may shortly be giving way to a completely new cooling concept which uses, of all things, an electrostatic discharge. The heat is removed by the corona discharge from the negative ends of high-voltage probes — there is no arcing. According to the inventor, Oscar Blomgren, a red-hot heat sink at 1675° Fahrenheit can be cooled to a dark 975° (a drop of 700 degrees) in one or two seconds with a 30-kV, 200-μA electrostatic discharge.

Blomgren accidentally discovered the cooling phenomenon of high-voltage discharges while attempting to keep an acetylene flame from touching the inside of a pipe by using an electric field; he was trying to solve a burner-nozzle deterioration problem.

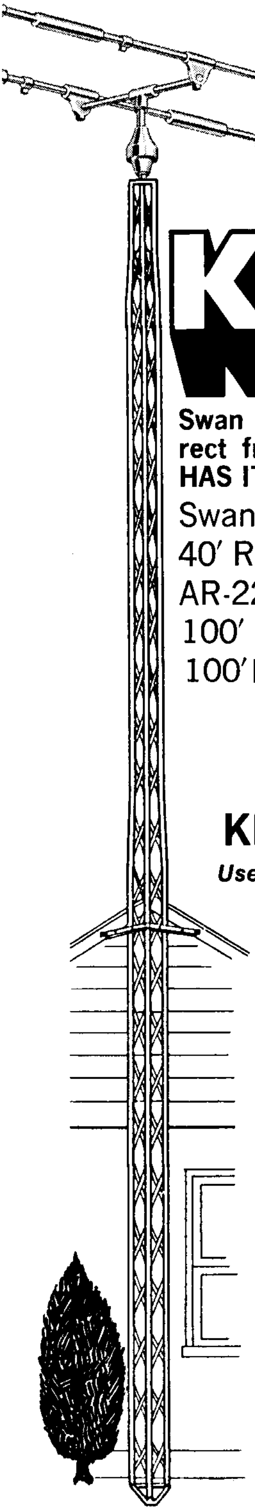
There is still much to be learned about the way the discharge cooling system works, but apparently the corona discharge or electric wind creates vortex columns in the air next to the heated surface. Normally, a thin layer of air clings to the surface; this acts as an insulating barrier which inhibits the rate at which adjacent cooling air can carry away the heat. With the high-voltage electric field, the cooling rate is increased by the swirling action of the vortex columns which pull in cooler air from outside the normal boundary area.

To compare electrostatic cooling with forced-air cooling, engineers set up an aluminum block and heated it to 250° F. With constant heat input, the temperature decreased at the rate of 8° per minute when the high-voltage was turned on. When a blower was used, the temperature dropped 11° per minute, but 14 watts were required for the blower as opposed to 3 watts for the electrostatic system.

In another experiment engineers heated two high-power transistor heat sinks to 500° F with blow torches. With the burners adjusted to stabilize the temperatures of both heat sinks to 500°, a 28-kV electric field applied to one heat sink reduced its temperature by 185 degrees; the other heat sink remained at 500°.

Amateurs who would like to experiment with electrostatic cooling need an adjustable high-voltage power supply, 20 to 30 kV. The unit to be cooled is connected to ground with the negative lead of the supply; the positive lead is connected to a pointed probe. No noticeable cooling takes place until the discharge current is greater than about 10 μA; this is controlled by the supply voltage and the spacing between the probe and the unit being cooled.

Jim Fisk, W1DTY
editor



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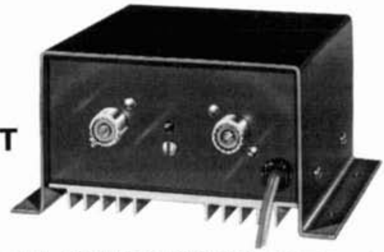

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phase-locked loop RTTY terminal unit

New design for a solid-state afsk demodulator and selector-magnet driver with the features most wanted by RTTY operators

Ed Webb, W4FQM, Post Office Box 17, Schaumburg, Illinois 60172

Upon acquiring a new teletype machine, I was faced with the problem of coming up with a terminal unit, or TU – the black box between the transceiver and the teleprinter. I didn't want to be bothered with unwinding toroids and selecting odd-ball capacitor values to adapt some of the TUs that were holdovers from the past decade. I wanted a TU that was totally new in its detection method. This TU was to be "state of the art" and thus different in design from current units.

I'd had some experience with the phase-locked loop (PLL or PL^2) in the telemetry field and knew it to be an excellent fm demodulator. However, the discrete circuitry was rather complex. While deliberating, I received a notice from Signetics announcing their new PL^2 in an IC. This announcement, together with subsequent attendance at their technical seminar, pointed the way for my new TU design – a phase-locked loop detector.* With the help of Art Fury, WA6JLJ, and his staff at Signetics, my project has progressed from a dream to reality – all in one year.

*The circuit is now patent pending, and the PC boards (available from WCI, Box 17, Schaumburg, Ill. 60172) are copyrighted.

the phase-locked loop

The PL^2 as an afsk detector is an entirely new approach to RTTY demodulation. No toroids or LC-tuned circuits are used. The entire TU occupies two 4-inch-square PC boards. The PL^2 detector will work with 6-dB or lower signal-plus-noise-to-noise ratios. No scope tuning provisions are needed; a pair of light-emitting diodes provide all tuning indications. Features of the PL^2 afsk demodulator are:

1. Automatic shift selection, allowing automatic copy of any shift from 150 to 1000 Hz without manual switching.

2. Afc, which provides automatic lock-in; signals drifting as much as ±500 Hz can be followed.

3. Automatic threshold corrector.

4. Antispace control.

5. Autostart, with solid-state printer motor control.

6. A 170-volt loop supply, coupled with extremely sharp selector-magnet pulses, and a constant-current selector magnet driver.

7. Operation with ssb audio passbands (low tones) or regular RTTY tones at the flip of a switch.

8. Squelch circuit, which prevents printing on noise.

characteristics

The phase-locked loop has an extremely linear voltage-controlled oscillator (vco) whose center frequency is set to the midrange of frequencies being detected. A simplified functional diagram of the Signetics NE565K IC phase-locked loop is shown in **fig. 1**. An RC network sets the resting or center frequency, F_{co}, of the vco. When a signal is applied to the phase-comparator input, its frequency and thus its phase is compared with F_{co}. If the vco frequency is different from F_{co}, an error voltage is generated at the phase-comparator output. This error voltage is then amplified, filtered, and fed to the frequency-control input of the vco. The error voltage causes the vco frequency to shift to that of the applied

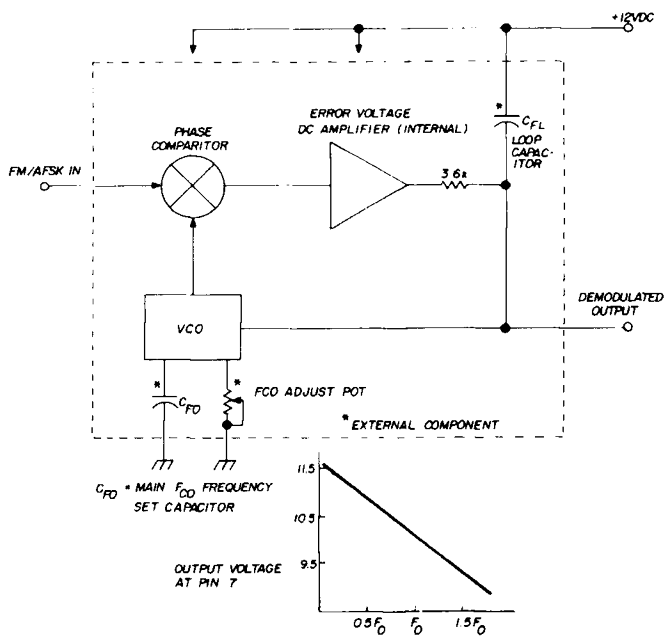


fig. 1. Oversimplified diagram of Signetics NE565K phase-locked loop. Loop 6-dB roll-off point is where X_c of C_{FO} equals 3.6 k ohms.

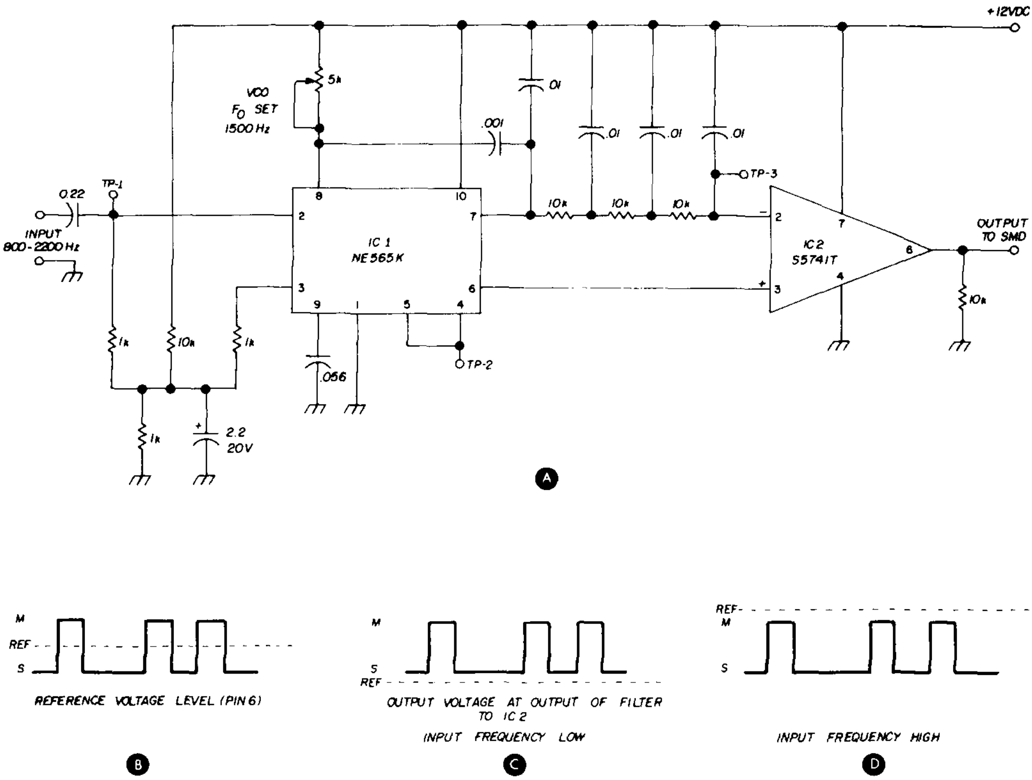


fig. 2. Trail circuit for the PL^2 afsk detector, A-waveforms at B and C represent asymmetrical tracking-comparator output due to drifting input signals.

input signal. This action nulls the error-voltage output from the phase comparator, and the loop is phase locked.

If the input frequency varies within the vco frequency range, the error voltage applied to the vco is the duplicate of the frequency modulation applied to the PL^2, and is thus the demodulated output. The vco output may also be used as it has an approximately 40-dB s+n/n ratio over the input signal, and the vco tracking-response rate may be controlled by an external low-pass filter capacitor. Thus the PL^2 may be used as an fm detector/discriminator and as a tracking filter.*

development

The recommended circuit for the Signetics NE565K phase-locked loop required a dual-voltage power supply. This was contrary to my basic premise for an afsk detector; namely, to keep it simple. More reading and experimentation showed that the PL^2 would work with a single-polarity 12-Vdc supply. The recommended S5710 voltage comparator wouldn't operate with a single-polarity supply, but I found that the S5741T would. So I used a NE565K-S5741T combination for my first detector (**fig. 2A**).

The S5741T is internally compensated and develops more than 100-dB voltage gain. The NE565K provides approximately 100-mV change at pin 7 for 200-Hz frequency change at the input. This

*The phase-locked loop isn't new. In the 1950s a modified version of the PL^2 described here was used to provide phase-coherent reference signals in a tracking station at the Kennedy Space Center. This early circuit, using tubes, occupied half of a 6-foot relay rack. Two technicians were assigned full time during range operations merely to check for balanced sets of tubes! **editor.**

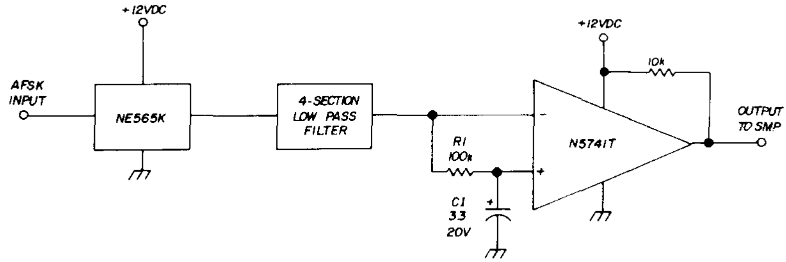


fig. 3. Integrator circuit for obtaining stable reference voltage at input to tracking comparator.

detector followed RTTY signals from 170-Hz narrow shift to 850-Hz wide shift, and even followed commercial 425-Hz-shift stations – all without switching or adjustments!

A three-section RC filter eliminated the vco carrier frequency on which the demodulated information appeared at pin 7. The one drawback to this circuit was that receiver tuning had to be just right to keep the PL^2 output swinging symmetrically on either side of the reference voltage at pin 6. If the receiver or received signal drifted, then the output from the comparator became asymmetrical, and the printer either ran open or refused to print (**figs. 2B** and **2C**).

tracking problems

The problem was clear but baffling. The reference voltage must shift in proportion to the amount of tuning error so that the comparator output remained symmetrical. If the demodulated output voltage swing could be averaged, then this voltage could be used as a reference voltage, which would move with the demodulated output-voltage swing. But this had to be done without disturbing the PL^2 output.

My approach was to integrate the total swing, thus obtaining an average, or midpoint, of the demodulated-voltage swing that could be used as a reference (**fig. 3**). This reference voltage would then shift with the voltage swing of the PL^2 output if the applied frequencies were (a) offset from the vco center frequency, or (b) different because of frequency drift in the receiving equipment.

Since the shortest RTTY pulse at 60 wpm is 22 ms, I chose integrator time-constant values that provided 15 times the shortest pulse, or 0.33 second, so that the integrator followed the average swing of about 3 RTTY characters at 60 wpm. Resistor R_1 (**fig. 3**) unbalances the input to the N5741T tracking comparator so its output remains in mark with no signal applied to the PL^2; thus the machine does not run open. The output voltage from pin 7 of the phase-locked loop was about 10.6 volts with no input.

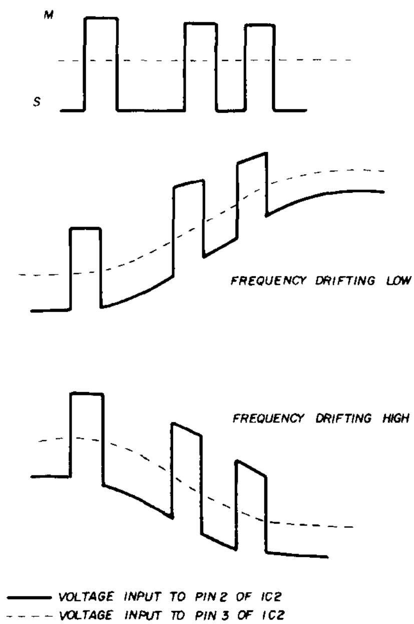


fig. 4. Dashed line represents reference point of input to tracking comparator as a result of the low-pass filter. Note that reference point is always at the midpoint of the demodulated voltage swing regardless of signal amplitude, which is proportional to frequency shift.

detector performance

The circuit of **fig. 3** worked as well as I had expected. Even slight mistuning of afsk frequencies had no effect on printer operation so long as these frequencies fell within the lock-in range of the PL^2. This range was about ±50 percent of the vco center frequency. The low-pass filter was increased to 4 sections to obtain another 6 dB of vco carrier suppression and slightly improved performance. I now had a workable detector that had a form of afc and automatic shift selection – the reference point would always be at the midpoint of the afsk input demodulated swing regardless of the demodulated swing amplitude, which is proportional to the input-frequency shift. (See **fig. 4**.)

The differential input of the PL^2 was terminated to present a 600-ohm load at the input. This termination was ac coupled to ground through a capacitor, as the inputs require positive bias voltage for normal operation. The PL^2 has very high input sensitivity and will operate on signals in the order of 100 mV p-p or less. A simple diode limiter was placed in the input to avoid overdriving the PL^2.

No predetection filtering was used because I wanted to retain the maximum bandwidth of the PL^2. Thus the only predetection filtering or input-bandwidth restrictions are those of the receiver rf-af passband and a single-section RC filter in the vco control-voltage circuit; thus the PL^2 operates as a second-order loop. Its response is limited to 450 Hz by the 0.1-μF capacitor between pin 7 and $+V_{cc}$ (**fig. 2**).

squelch circuit

Much on-the-air testing followed. The PL^2 and tracking comparator worked extremely well. However, one problem continued to annoy me. When tuning from one RTTY station to another, or when an RTTY station went off the air, random noise caused the printer to print random characters. This was because of the tracking comparator high gain and the wide bandwidth of the PL^2 and its RC filter.

A method was needed to put the printer in a nonprint or mark-hold mode in the absence of a valid RTTY signal, or in the presence of random noise. A simple noise squelch would do the job but would require another stage that could be squelched. I selected a type TAA-560 Schmitt trigger by Amperex for this circuit (**fig. 5**). The TAA-560 requires a trigger voltage of only 1.5 volts. The tracking comparator output is of the order of 10 V p-p (in the space condition), so input to the Schmitt trigger is controlled by a voltage divider.

The PL^2 noise voltage is of insufficient amplitude for use as a squelch voltage; however, the tracking-comparator output is high enough for this application. (Also, I didn't want the 22-ms TTY pulses to activate the squelch circuit.) I sampled the tracking comparator output with a differentiating circuit. This network had little response to the comparatively long RTTY pulses, which have approximately a 25-Hz rate. The differentiating network responded to pulses with a frequency of 200 Hz or higher. Its design frequency is approximately 200 Hz at the 6 dB point, and it works like a simple RC high-pass filter.

The pulses from the differentiating network are coupled to a voltage doubler circuit. The rectifier output voltage is applied to a filter capacitor with a bleeder resistor in the form of a pot across it. The combination of the 10 μF filter shunted by the 100-k pot provided a discharge time constant of about 1 sec. The charge time is limited only by the circuit impedance and is about 10 ms. The output arm of the squelch pot was also fed to the Schmitt trigger input through a 100-k isolation resistor.

When the detector is fed raw audio noise from the receiver, the squelch pot is adjusted until the machine stops chattering on noise. The negative voltage from the squelch rectifier keeps the Schmitt trigger biased off. The Schmitt output will remain in the mark condition with random noise at the PL^2 input, or when the RTTY signal fades into the noise to the point where the PL^2 unlocks. In the absence of an input to the PL^2, integrator resistor, R11, at the tracking comparator input unbalances the static positive voltage at the differential input; thus the tracking comparator output remains in mark.

post detection filtering

The tracking comparator output is fed through a voltage divider to a two-section RC low-pass ladder filter. The filter output is fed to the Schmitt trigger, which functions as a pulse regenerator. The Schmitt trigger output pulse rise time is 10 μs.

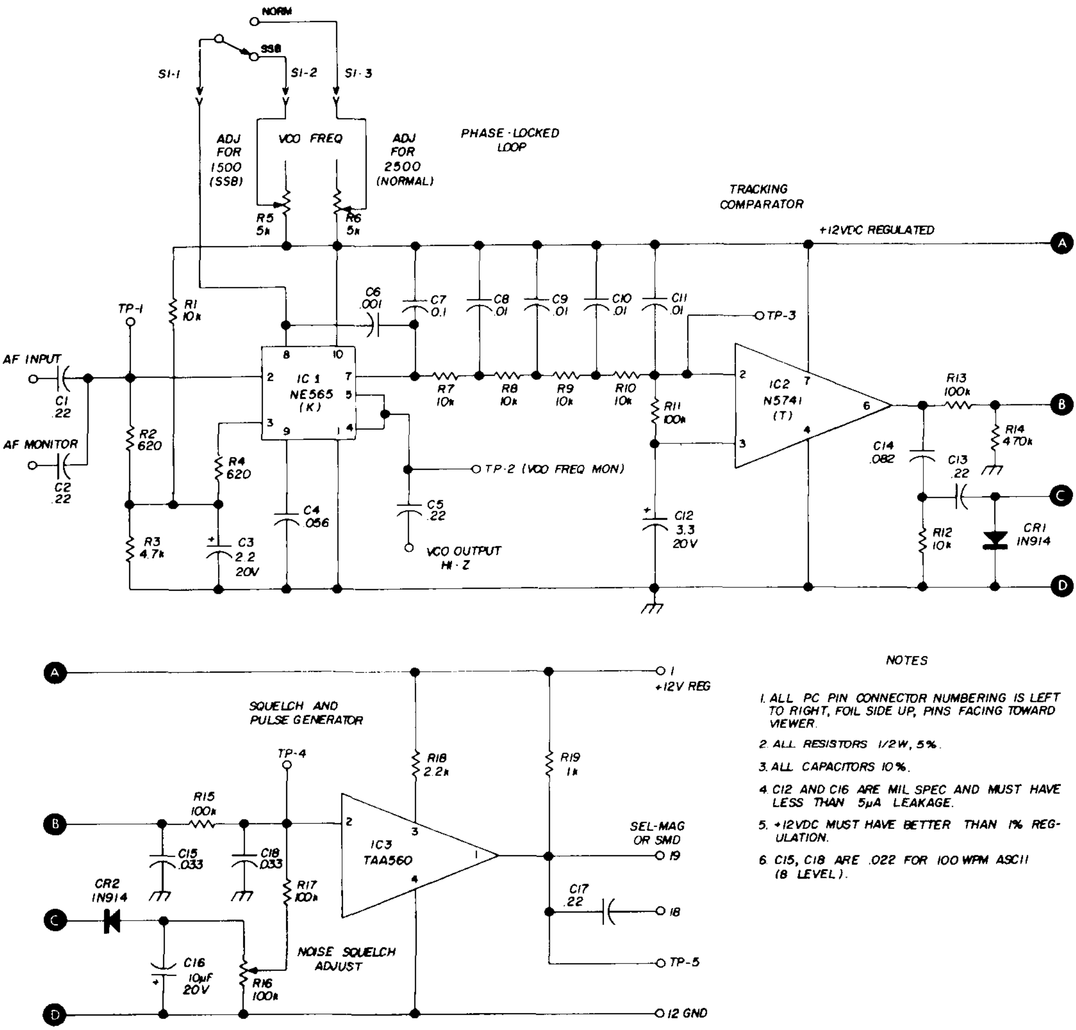


fig. 5. Schematic of the afsk detector incorporating the refinements described in the text. Circuit is Patent pending, 1971, by WCI.

If it's desired to pass a square-wave pulse through a network without distorting the pulse waveshape, the network should pass a frequency at least ten times (preferably 20 times) higher than the pulse frequency. However, when maximum signal-to-noise ratio is desired, minimum bandwidth must be used. A minimum-bandwidth filter, unfortunately, also distorts an applied square wave; so a square-wave signal from a narrow-band filter must be reshaped. Hence the TAA-560 IC in **fig. 5**.

When the pulse is regenerated great won't appear in the regenerator output. The RC low-pass filter 6-dB point, between the tracking comparator and the Schmitt trigger, is at 25 Hz. If 100 wpm operation is desired, the capacitors in the filter (C15; C18 in **fig. 5**) should be .022 μF.

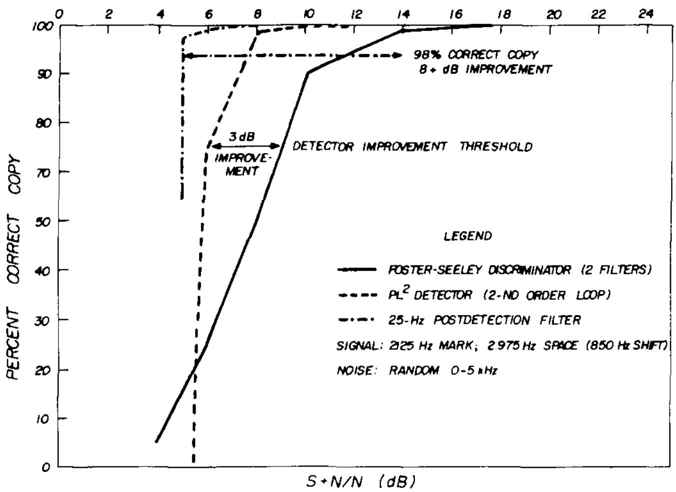


fig. 6. Comparison of the PL² and conventional Foster-Seeley discriminator.

care must be taken not to induce pulse-width distortion. The only place that a non-square-wave pulse may be sampled (for regenerating purposes) is at the 50% maximum voltage point, where the pulse rise-time delay is exactly equal to the fall-time delay. In this way the pulse is delayed because of the narrow filter bandpass, but its width doesn't change during regeneration or shaping. The regenerator output produces the exact duplicate (possibly better) of the original pulse before entering the narrow-band-pass filter; or, in this case, a low-pass filter.

design evaluation

The signal is now pure, has a square waveshape, and no noise exists except for a small amount that's within the same frequency spectrum as the desired signal. If this noise isn't of sufficient amplitude to trigger the pulse regenerator, the pulse

The PL² afsk detector has now met all design objectives:

1. Simple circuitry.
2. Copies all normal fsk shifts.
3. Mark-hold feature on random noise.
4. Works with low-frequency tones for ssb receivers and transceivers at the flip of a switch.
5. Afc circuit allows drifting or mistuned signals to be received with high-accuracy printout.
6. Tracking comparator provides anti-space function as the PL² shifts to the space frequency. If no shift, tracking comparator reverts to mark-hold mode.

TU performance data

Tests and measurements verified that the PL² provided 98% correct copy with less than 6 dB s+n/n at the input, where noise was Gaussian from 0-5 kHz. **Figs. 6** and **7** respectively show response curves and the test instrumentation used to obtain the data.

Approximately 8 dB improvement was obtained over a Foster-Seeley discriminator. The only disadvantage of the PL^2 detector was its wide bandwidth. The operational bandwidth is equal to the width, in Hz, of the fsk being received. The noise bandwidth is equal to the capture range, or about 1200 Hz. If an interfering signal 5-6 dB stronger than the desired signal falls in the PL^2 operational pass-band, it will capture the vco much like the fm capture effect. Other than this one minor detriment, everything is in the PL^2 afsk detector's favor.

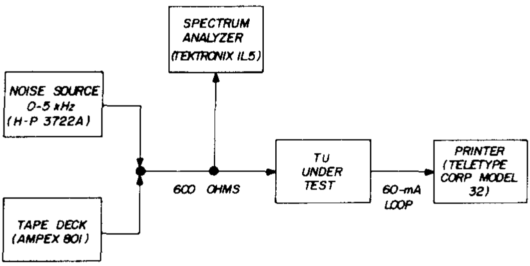


fig. 7. Instrumentation used to obtain data plotted in fig. 6. Afsk tones from tape deck, masked by noise, were received by the TU and printed on TT machine.

The vco center frequency can be set by an external resistor, so two pots and a switch were used. One pot sets the vco to 1500 Hz for use with ssb receivers and transceivers having limited audio pass-bands, thus the TU will operate on tones from 800-2200 Hz. The other pot sets the vco for 2550 Hz for normal RTTY tones, and the TU will operate on tones in the 1800-3200 Hz range. This made an afsk detector that is compatible with *any* communications receiver used for RTTY.

selector-magnet driver, autostart, and fsk

During the initial development of the PL^2 afsk detector, I used a Teletype Corporation Model 32 machine. This machine has a built-in solid-state SMD, loop-current sensing amplifier, and power supply. The SMD in the Model 32 was driven with a 12-volt, 60-mA loop supply directly from the Schmitt trigger output, with a 150-ohm resistor in the 12-volt supply to set loop current to 60 mA. (This resistor was also connected to the Schmitt trigger output via the TT loop.)

Most RTTY enthusiasts have TT machines that require an external dc-loop supply. These supplies have outputs ranging from 24 to 200 Vdc. The higher the voltage, the better will be the rise and fall times on the selector-magnet keying pulses. Thus the machine will operate on keying pulses with a wide range of distortion.

I wanted my selector-magnet driver transistor to key the loop at or very near ground potential. Also I wanted the stage to operate as a constant-current regulator so the keying-pulse waveform would be flat. I used a simple pnp transistor predriver (**fig. 8**) to develop forward bias across a pot for the SMD. This pot allows small changes to be made in loop current if TT machines are used that have different selector-magnet coil resistances.

Note that loop-voltage drop, when the loop is keyed or in mark, is obtained across an external resistor (R_{ext} in **fig. 8**). This protects the driver transistor from thermal overload.

autostart

The keyboard is connected in series with the SMD transistor emitter to ground. Isolation diodes connected to the junction of the SMD transistor emitter and keyboard allow keying of other circuits (fsk, afsk, etc.) with the keyboard. Such circuits are not disturbed when the loop is keyed in the receive mode by the SMD transistor, because the keyboard contacts are normally closed. This feature is important if you're using a transceiver with only a single vfo and you have it hooked up with the fsk circuit. When operating in this manner, it's necessary to offset receiver tuning with the incremental-tuning control to obtain the afsk tones for the TU. I wanted a simple autostart circuit that would respond only to a fsk signal, and which wouldn't respond to a steady mark tone or a slow transition from mark to space and back at a slow rate, as is the case when someone is checking his fsk shift.

motor control

In my original circuit, the Schmitt trigger output was also fed through an isolation diode to a voltage divider and RC network. The output from the network would control a relay driver. However, I didn't want to use a large contactor relay in my final design. A trip to Magnecraft Corporation proved fruitful in this regard. They had a reed-relay-controlled triac, called a "Magtrac," whose reed-relay coil is IC compatible. This device will drive TT machines with motor-current requirements of 3 amps running and 12 amps starting, which includes any Teletype Corporation printer motor in amateur service. The schematic is shown in **fig. 8**.

In my final design (**fig. 8**) I used the TAA-560 to drive the Magtrac because the TAA-560's high input impedance doesn't load the RC circuit. In fact, I had to add a discharge resistor to obtain proper autostart turn-off time. The Magtrac offers great isolation between input and output while allowing a low-level logic signal to control a fairly high ac load.

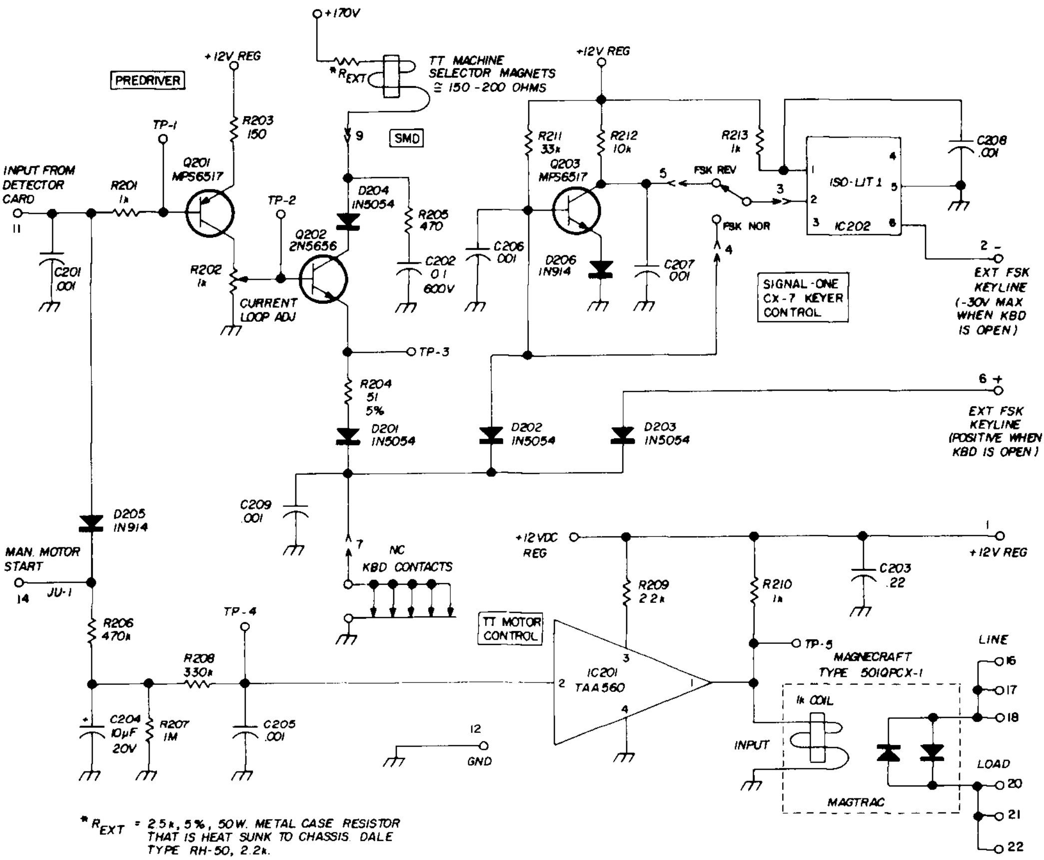


fig. 8. Schematic of selector-magnet driver and autostart circuits. Patent pending by WCI, 1971.

Signal-One provisions

Out of necessity I added a circuit to key a negative voltage to operate the transmit fsk keying provision of the Signal-One CX-7 transceiver. (Several minor modifications are needed on the CX-7 for RTTY operation; but properly modified, the CX-7 works beautifully on RTTY.)

This circuit is also shown in **fig. 8**. A Litronix Iso-Lit 1, an electro-optical isolator, is used, which is a LED-controlled pnp photo transistor. A single transistor drives the Iso-Lit and also conditions the fsk signal so that mark is high in frequency on transmit and space is lower in frequency. The amount of shift is set by the front-panel fsk control on the CX-7.

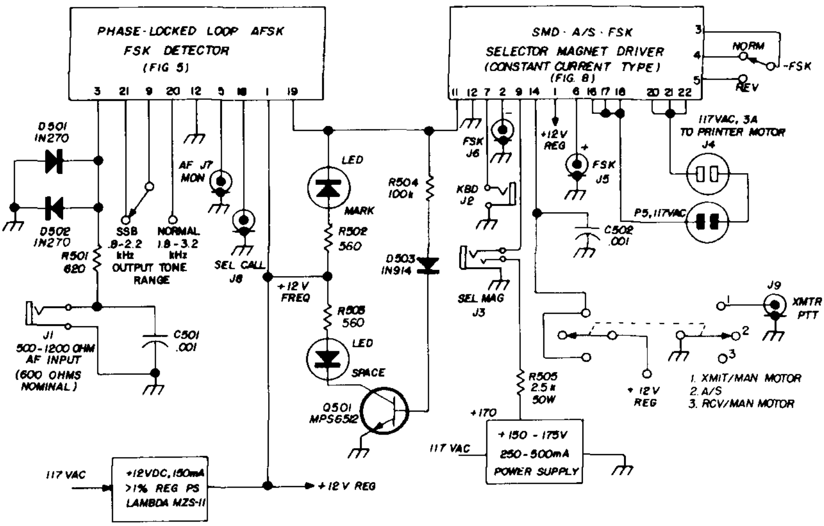


fig. 9. Main frame of the RCT-2D terminal unit. Patent pending by WCI, 1971.

construction notes

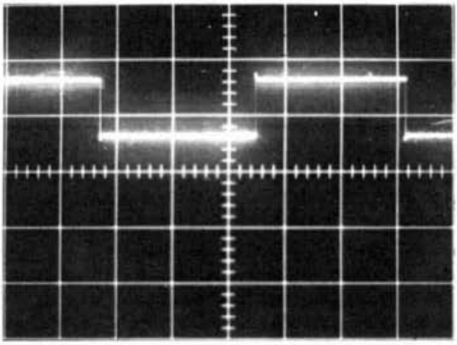
When building the PL² TU I didn't skimp on parts. Only the highest-grade commercial-quality components were used. All resistors are 5%, and capacitors are 10% tolerance. I recommend MIL-spec low-leakage electrolytic capacitors. Stick with the *exact* component values and *don't substitute!* Also don't use pull-out transistors, ICs, and diodes – use new devices that meet manufacturer's specs. You'll save yourself a lot of headaches.

The TU occupies two 4 x 4-inch plug-in PC boards. Standard 22-pin PC connectors are used, which fit a Cinch-Jones type 50-22A-20 socket. The entire main frame **(fig. 9)** of the RD-100 was built on a Bud AC-407 chassis. The unit is enclosed in an LMB CO-2 cabinet and front panel. The cabinet and panel, finished in two-tone gray, is a dead ringer for a piece of the S-line series.

The 12-volt dc power supply should be extremely well regulated with better than 0.1% regulation. I used a commercial unit with excellent performance, a Lambda Electronics Corp. Model LZS-11; quite a buy for only $38.00.

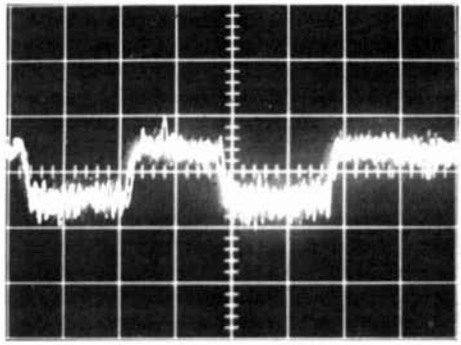
The loop supply is similar to that used by *W6FFC in his ST-6 – nice and* healthy. Voltage is about 170 Vdc, and the supply provides better than 250 mA, of which only 60 mA are used. But the voltage stays put! Even if the voltage varies slightly, the constant-current characteristic of the SMD holds the loop at 60 mA on mark.

fig. 10. Oscillograms showing response of PL^2 and SMD circuits at various test points.



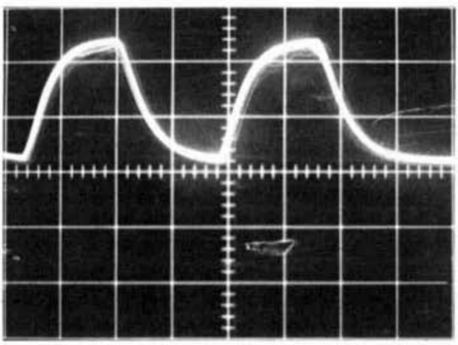
PL^2 vco output at TP2 on detector card (frequency test point).

horiz	10 ms/cm
vert	5 V/cm
F_{co}	1500 Hz
abscissa	0 Vdc



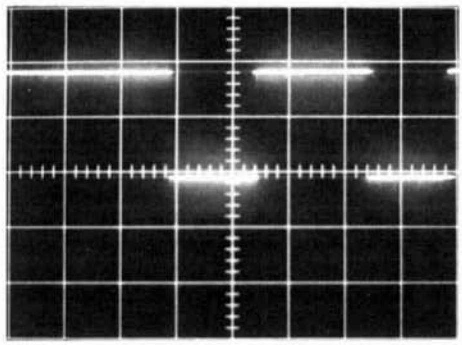
PL^2 demodulated afsk output at TP3 on detector card.

horiz	10 ms/cm
vert	100 mv/cm
ordinate	ref voltage at non-inverting input on IC2 (fig. 5)
shift	170 Hz
speed	60 wpm, 5-level



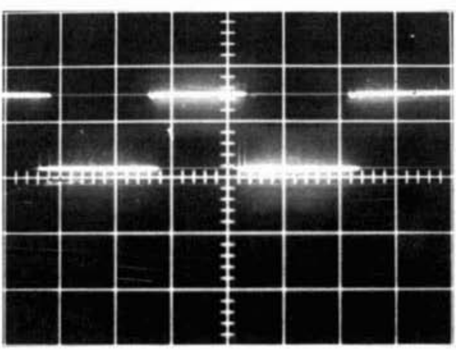
Tracking comparator output from low-pass filter at TP4 on detector card.

horiz	10 ms/cm
vert	1 V/cm
abscissa	0 Vdc



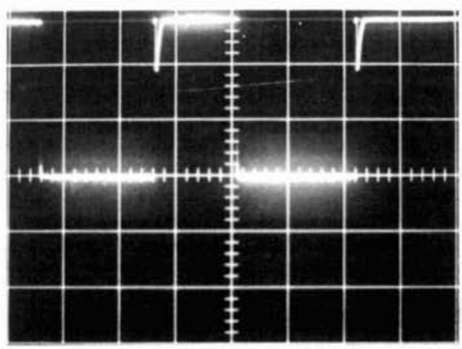
Schmitt trigger output at TP5 on detector card. (Mark low/space 10 Vdc.)

horiz	10 ms/cm
vert	5 Vdc/cm
abscissa	0 Vdc



SMD predriver output at TP2 on SMD card.

horiz	10 ms/cm
vert	5 V/cm
abscissa	0 Vdc



SMD output-current pulse (60 mA) to selector magnets.

horiz	10 ms/cm
vert	1 V/cm (or 20 mA/cm)

Resistor R_{ext} (**fig. 8**) is mounted directly on the chassis, which provides a heat sink. Be sure to use a small amount of Wakefield thermal compound to ensure good thermal contact to the chassis.

All input and machine-connection jacks are mounted on the chassis rear deck. The selector-magnet jack and plug are three-circuit types; however, only two circuits are used, as both sides of the selector-magnet coil are above ground. A grounding-type ac receptacle is also mounted on the chassis rear. This is the ac output line from the autostart, and the machine motor is plugged in here. Both power-supply primaries are fused. The 12-volt load of the unit is 50-60 mA.

initial setup and checkout

For the setup you'll need a vom and a frequency counter or oscilloscope and a calibrated af oscillator. These last two items can be used to read frequency in place of a counter. The oscilloscope can also be very helpful should you have to go "pulse hunting." The oscillograms of **fig. 10** will aid in alignment and checkout of both units.

1. Plug in the machine motor, keyboard, and selector magnets. Plug in the ac power to the RCT. Don't connect your receiver to the RCT at this time. Function switch should be in autostart; mode switch in ssb.

2. Connect a counter to TP-2 of the detector board and make sure that the mode switch is in ssb. Adjust R5 for a counter reading of 1500 Hz. This is the vco center frequency adjustment for ssb mode.

3. Place the mode switch in *NORM* and adjust R6 for a counter reading of 2500 Hz. This is the vco center frequency adjustment for the *NORM* mode.

4. Now connect your receiver 500-600 ohm audio to the RCT input. Set the volume at a comfortable level and tune to a clear frequency. The noise may trigger the autostart *ON*, but don't worry. Now adjust noise-squelch pot R16 to the point where the machine stops printing on impulse noise; ten seconds later the autostart will turn the motor *OFF*.

5. Place a 20-k/V vom or vtvm from TP-3 on the SMD board to ground, and adjust the loop-current-adjust pot for 3.75 Vdc. You now have 60 mA in the loop.

6. If you're using an ssb receiver or transceiver, enable the ssb mode and place the receiver/transceiver in lsb. Place the RCT in the ssb mode and tune to a RTTY station so that you can hear both tones. The RCT will do the rest.

If you're using a receiver with an af passband up to 3 kHz, then you can use the *NORM* mode on the RCT.

sources

1. The PL^2 (NE565K) and the tracking comparator (N5741T) are available from Signetics Corp., 811 East Arques Ave., Sunnyvale, Ca. 94086. The NE565K is approximately $11.00; the N5741T is approximately $1.50.
2. The Schmitt trigger, type TAA-560, is available from Amperex Electronics Corp., I. C. Division, Providence Pike, Slatesville, R. I. 02876. The TAA-560 is approximately $3.00.
3. The Magtrac type 501QPCX-1 is available from Magnecraft Electric Co., 5575 N. Lynch, Chicago, Ill. 60630 for $16.80.
4. The 12 Vdc regulated power supply, model LZS-11, is available from Lambda Electronics Corp., 515 Broad Hollow Road, Melville, L. I., New York, 11746 for $38.00.
5. The Iso-Lit 1 is available from Litronix Corp., 19000 Homestead Road, Cupertino, Ca. 95014, for about $4.00.

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ham radio

introduction to microwaves

A discussion of the differences between low frequencies and the microwave domain in terms of ac-circuit theory

William L. Sullivan, W1CBY

The amateur bands above 1 GHz offer interesting challenges to the builder-experimenter and operator alike. Known as the microwave region, this portion of the radio spectrum is relatively unpopulated with amateur signals when compared to the lower-frequency bands. Many amateurs don't understand the theoretical and physical concepts of microwave work and tend to ignore this interesting facet of ham radio. Many of the devices used at the microwave frequencies were developed in laboratories by physicists; consequently the behavior of such devices is usually described in complex mathematical terms. However, by using a logical down-to-earth approach, microwave fundamentals are easily understood.

50 MHz and up

Construction technique and operating know-how in the region above 50 MHz is much different than in the "dc bands." Getting equipment to work at, say, 1296 MHz is a real test of one's ability in circuit design techniques and testing. If you like to build equipment, here's a fertile field for your ingenuity and patience. Like to work DX without the hassles and pile-ups of 20 meters? Try over-the-horizon work with narrowband equipment on 3300 and 5650 MHz.[1] Try some of the experiments with ROCLOC (relative or crystal local oscillator control), a technique developed by the San Bernardino Microwave Society.[2]

Many other activities will be found in the amateur bands above 50 MHz. Communications by tropo scatter, meteor scatter, and moonbounce are examples. Recent work by amateurs has established the practicability of communications over long paths on frequencies to at least 10,000 MHz. Interested in building equipment? Here's a remark by an East-coast microwave enthusiast, K2JNG: "You don't buy gear for this band (1296 MHz), you build it."[3]

These are but a few of the happenings in the bands above 50 MHz. Now let's look at some of the differences in techniques and technical disciplines required for microwave work as compared to those associated with the lower frequencies.

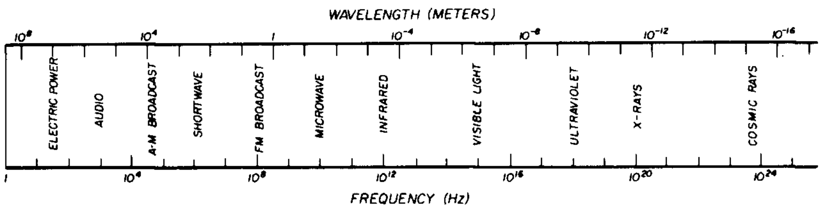

fig. 1. The electromagnetic spectrum.

background

Electricity that alternates with time, whether from power mains, radio-broadcast stations, or radar is described in terms of an alternating wave. It makes no difference whether the circuit involves vacuum tubes, transistors, transmission lines or antennas; the resulting phenomenon may be attributed to a series of waves. Scientists recognized the similarity between these various waves before the turn of the century and segregated them by frequency as shown in **fig. 1**. For reasons we will see shortly, this band of frequencies is called the electromagnetic spectrum. All waves within the electromagnetic spectrum travel at the speed of light – 300 million meters/sec or about 186,000 miles/sec. If the operating frequency is 10 billion cycles/sec (10,000 MHz) the alternating wave will go through one complete cycle in one ten-billionth of a second. Since the wave moves at 300 million meters/sec, it will move one ten-billionth of this distance during one cycle, or 3 cm. This distance is defined as the wavelength (**fig. 2**). The point is, although the speed of light may seem instantaneous, an electromagnetic wave requires a finite amount of time to move from one point in space to another. When the frequency is low, it takes longer to complete one cycle, and the wavelength is longer. At frequencies above 1000 MHz, however, the wavelength becomes relatively small, and this part of the spectrum is called the microwave region.

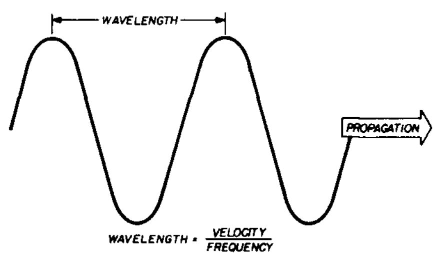

fig. 2. The wavelength equation.

The increasing use of microwaves in recent years parallels the expansion to the hf and vhf portions of the spectrum of a few years ago. In all cases the spectrum has become crowded with radio services, and it has been necessary to expand in the only possible direction, upward. Measured in cycles, the additional frequencies made available by the advent of microwave technology are several hundred times greater than all those previously available. These additional frequencies are not a panacea, however, because many of the new services require wide bandswidths. Radar, for example, requires a handwidth of 5 to 10 MHz.

bandwidth considerations

The microwave frequencies are especially important for two reasons, both based on the peculiarities associated with ultra-short wavelengths. The first is the bandwidth consideration; a radio signal consisting of only one frequency isn't practical for the transmission of intelligence, because a single-frequency signal is infinitely narrow. Information may be carried by a signal only if it occupies a restricted band of frequencies. In general, the wider the band, the more information can be conveyed per unit time. The intelligence may consist of telegraphic dots and dashes, audio or video modulation, radar pulses, etc. In each case a certain bandwidth must be assigned to provide distortion-free transmission and reception.

When the operating frequency is very high to start with, a given bandwidth constitutes a smaller percentage of the carrier frequency, and it's possible to provide more channels of intelligence. For example, if we modulated a 10-MHz radio signal with video 2 MHz wide, the bandwidth would constitute 20% of the carrier frequency. If, on the other hand, we modulated a 100-MHz signal with the same video information, the resultant bandwidth would be only 2%. In general, it's difficult to obtain bandwidths greater than about 5% of the carrier frequency.

Bandwidth becomes increasingly important when the modulating signal is characterized by an inherently wide bandwidth. This is the case with the very short pulses associated with radar and pulse-code communications systems, or where the multiplexing of a large number of video channels by a single transmitter results in economic television relay service.

antennas

The second major consideration has to do with antennas. Both the beamwidth and the gain of an antenna depend upon the ratio of the wavelength to the size of the antenna. In many applications, it's desirable to concentrate the radiated energy into very narrow cones a few degrees wide, with gains of several thousand. This can be done only when the antenna is extremely large in terms of operating wavelength and is impossible when the wavelength is measured in miles. However, extremely high-gain antennas are practical with wavelengths less than an inch.

atmospheric noise

Very low atmospheric noise exists in the microwave region. A "low-noise window" extends from 200-1500 MHz where atmospheric noise is almost non-

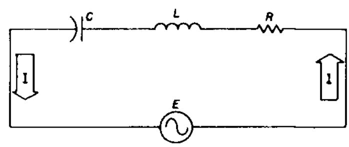

fig. 3. Concept of displacement current in an ac circuit.

existent. Additionally, the very short wavelengths associated with microwave frequencies are suited to many unique construction techniques. Hollow pipes may be used for transmission lines, cavity resonators with extremely high Qs may be used in place of LC circuits, and parabolic reflectors may replace massive directive antenna arrays.

electrical concepts

The misunderstanding and confusion surrounding microwaves is due in part to the apparently different electrical concepts that govern their operation. Actually the concepts are not so very different from those encountered at lower frequencies; it's just that the laws used at the lower frequencies are not sufficiently

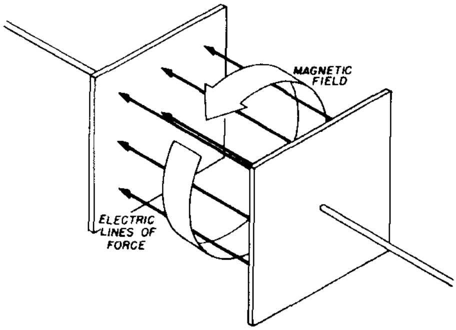

fig. 4. Electromagnetic field between capacitor plates.

general to encompass microwave circuits. This difference is comparable to the difference between dc and ac circuit theory. After studying dc circuits, it's necessary to have an understanding of frequency, phase, and reactance before ac circuits may be properly analyzed.

In dc and low-frequency communications, it's customary to consider the transmission of energy through the flow of current or electrons. In the microwave region this concept may be misleading, because it doesn't explain the transmission of energy through a hollow waveguide where conventional current does not exist. If, instead, we consider that energy is contained in an electromagnetic field, the transmission phenomenon at *any* radio frequency may be easily explained.

Many tend to forget the basic elements of static electricity and charges once the concepts of voltage, current, and Ohm's law are understood. This isn't too unusual, because these latter units are easily measured in everyday electronics circuitry. However, at microwave frequencies, the familiar quantities of voltage and current are difficult, if not impossible, to measure, and we must resort to the fundamental concepts of electric and magnetic fields to understand microwave theory.

electrical fields

Before progressing into a general discussion of fields, let's consider the concepts of electric fields and electric voltage. Actually, they are very closely related quantities, with field strength expressing the force that would be felt by an electron placed at some point in space and voltage expressing the product of this field strength and the distance over which it moves the electron. Contrary to what you might think, this is not a new idea at all. If you'll recall your first studies in electricity, you'll no doubt remember the experiments with cat fur and a rubber rod. When you rubbed the fur with the rod, you generated a static electric field. The electric field associated with radio waves differs from the electrostatic field *only* in that it varies in time; this is not unlike the difference between ac and dc.

We know, from the principles of continuity, that the current leaving the signal source E at the right in **fig. 3** is exactly equal to the current returning at the left. The current flows through the resistor and the inductor, but what happens at the capacitor? There is no movement of electrons through the dielectric separating the plates of the capacitor, so there appears to be a discontinuity in the current flow. However, from our experience in low-frequency ac circuits, we know that current apparently flows through the capacitor.

displacement current

This difficulty was recognized many years ago and was straightened out by inventing a new kind of current called displacement current. Actually, modern physicists do not feel that displacement current is so much a current as did the early researchers; nevertheless the concept is still valid. In fact, since displacement current produces the same effects as actual conduction current in describing this phenomenon.

The displacement current between capacitor plates is a function of the changing electromagnetic field between the plates (**fig. 4**). In elementary static-electricity theory, displacement current doesn't exist because the electrostatic field doesn't vary with time.

the flux equation

The magnetic field surrounding a current-carrying conductor may be expressed by

$$H = \frac{I}{2} r \qquad (1)$$

where H is the magnetic flux density at a distance r from a wire carrying a current I (**fig. 5**).

Michael Faraday (1791-1867) discovered that an electromotive force E could be generated by a magnetic field cutting the current-carrying conductor:

$$E = \frac{H}{t} \qquad (2)$$

where the induced voltage E is proportional to the magnitude of change in the magnetic flux and inversely proportional to the time in which the flux changes.*

From (1) it can be seen that the induced voltage E will increase with either a larger or faster change in magnetic flux density H. In other words, if the flux change is held constant, the induced voltage will increase with the frequency of the magnetic-flux change.

the electromagnetic field

Note that no mention is made of either conductor size or material in either of the above equations. If the size of the conductor were gradually reduced step by step, the induced voltage would remain the same, because the law states nothing to the contrary. In fact, the size of the wire may be reduced until there is no wire, but there will still be an induced voltage across the space that was occupied by the wire.

The voltage induced across space by the changing magnetic flux is in the form of an electric field. This field causes the flow of displacement current; the displacement current generates a magnetic field in direct proportion to its intensity. The electric and magnetic fields then are complementary, with one generating the other as they move through space at the speed of light. The combined effect of electric and magnetic flux form an electromagnetic field.

The electromagnetic field may be represented as in **fig. 6**, where the electric and magnetic lines of force are perpendicular to each other and mutually perpendicular to the direction of propagation. Although the electric and magnetic fields are represented by lines of force, separate E and H lines don't exist in space; rather a kind of electric or magnetic tension exists that's directly proportional to the intensity of the flux. That is, more lines of force are used to illustrate a strong field than a weak one.

*The classic definition of the relationship between magnetic flux and magnetic flux density is complex. An introduction to these and other elements of magnetostatics appears in reference 4. *Editor.*

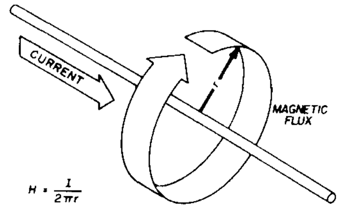

fig. 5. The flux equation, which describes the magnetic field surrounding a current-carrying conductor.

the microwave domain

The fact that a changing magnetic field induces a voltage across space is the concept needed to understand microwave circuits. In other words, at ultra-high frequencies the current flows not only in conductors; it may flow as displacement current between points in space. In a sense there is still a circuit, but the paths are no longer well defined.

One of the outstanding events in the history of microwave theory was the recognition of the similarities between the effects of different electromagnetic field configurations and those in inductive, capacitive, and resistive elements – the circuit components familiar at the lower frequencies.

When the basic circuit elements are viewed from the fundamental concept of energy, it becomes obvious that the

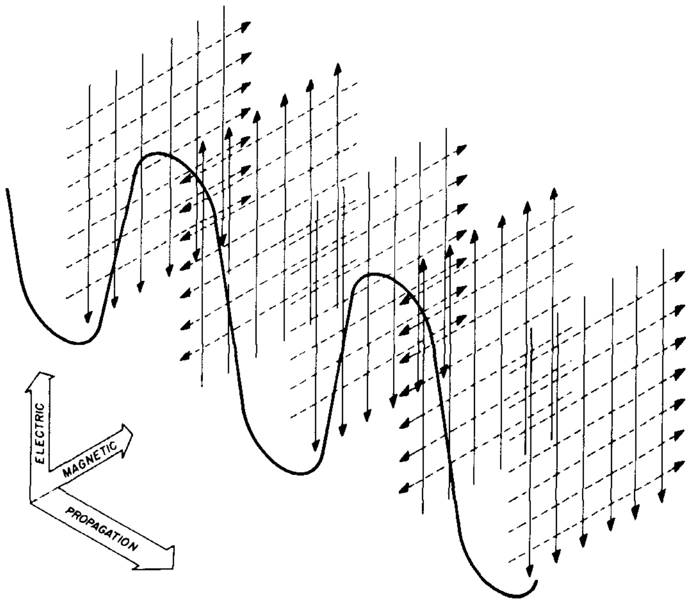

fig. 6. Electromagnetic field associated with an electrical wave varying in time, magnitude, and direction.

energy of an inductor is always stored in a magnetic field, and the energy of a capacitor is always stored in an electric field. Therefore, any microwave component that stores energy by the virtue of an electric field is regarded as having capacitance. Conversely, any component storing energy in a magnetic field is considered to possess an equivalent inductance. When microwave energy is dissipated in terms of heat, the effect is similar to a resistive component in a low-frequency system.

With certain reservations, the impedance associated with a microwave circuit may be related to the R, L, and C elements in exactly the same way as at the lower frequencies. In a low-frequency circuit, where the wavelength is many times larger than that of the individual circuit elements, no anomaly exists. However, in a microwave system, the wavelength is comparable to *each* of the circuit elements, and the magnitude of the R, L, and C components is dependent upon wavelength. Therefore, an inductive or capacitive value may be assigned to a microwave component only when the *frequency is held constant.* However, in practical circuits where bandwidth is relatively narrow, this concept allows one to use his knowledge of low-frequency ac theory to increase his understanding of microwave circuit with a minimum of error.

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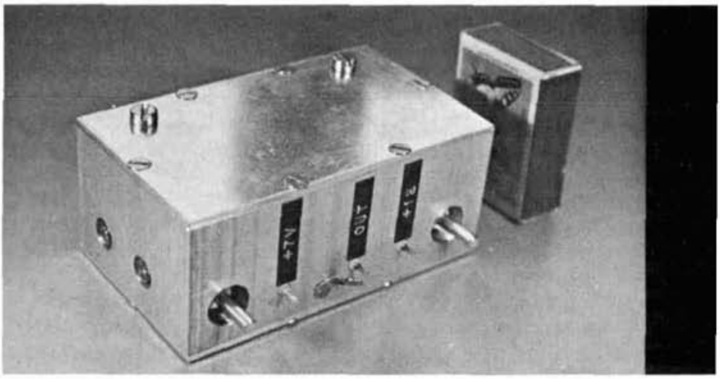


high-stability variable frequency oscillator

This high-frequency 5.0- to 5.5-MHz vfo provides excellent stability and maximum low-harmonic output with a minimum number of components

Veikko Aumala, OH2CD, Helsinki, Finland

The highly stable vfo described in this article has evolved over several years. It features sufficient output for any mixer configuration, is very solid, has small size and exhibits excellent spectral purity. It tunes the frequency range from 5.0 to 5.5 MHz with ±150 kHz overlap.

The basic oscillator circuit is the inherently stable Seiler type. In the Seiler circuit the transistor and tank circuit are very lightly loaded, resulting in excellent frequency stability. The tuning capacitor is a small type used in fm broadcast receivers; it has a built-in 3:1 spring-loaded drive mechanism. With the dual tuning capacitors used in this design (see **fig. 1**) either one of two output frequencies may be selected by relay K1.

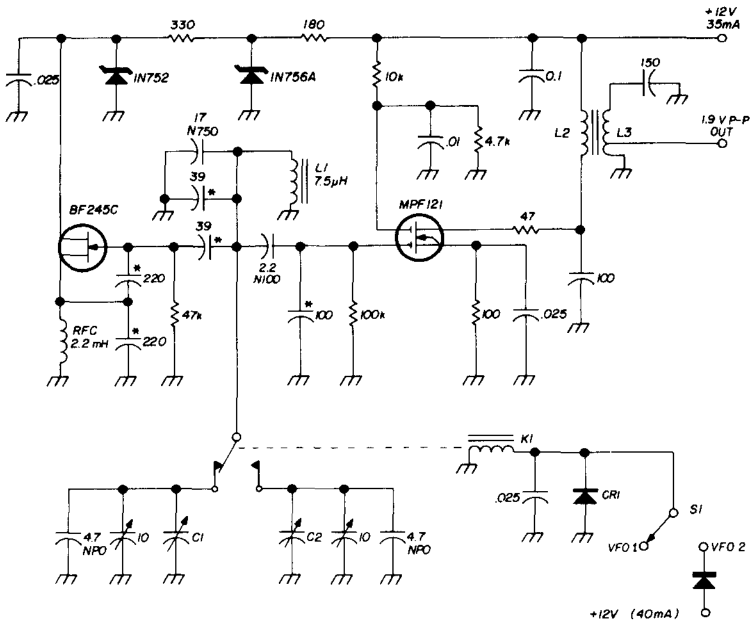
The vfo circuit is housed in a very solidly built aluminum box approximately 4 inches long, 2½ inches wide and 3/16-inch thick. This construction provides a high thermal integration constant so ambient temperature variations have little effect upon the oscillator frequency.

circuit

In the circuit in **fig. 1** the lower limit of the variable tuning capacitance is approximated by

$$C = \frac{\Delta C}{\left(\frac{\Delta f}{f - \Delta f}\right)^2 - 1}$$

where C is the required minimum tuning



Capacitors marked with asterisk are mica; NPO capacitors are N750 ceramic types.

C1, C2 3-section 3.2 to 18.5 pF variable, parallel connected

L1 7.5 μH. 13.5 turns 0.5 mm enameled (no. 24) in 2 layers on ferrite pot core

L2 30 turns 0.2 mm enameled (no. 34), honeycomb wound, 4 mm (0.16 inch) long, on 65 mm (1/4 inch) slug-tuned form

L3 30 turns 0.2 enameled (no. 34), honeycomb wound, 4 mm (0.16 inch) long, on same form as L2 (see text)

fig. 1. Schematic diagram of the high-stability vfo. One of two output frequencies is selected by K1. If K1 is controlled by a multivibrator two receiving channels may be monitored at the same time.

capacitance, f is the upper frequency limit, Δf is the frequency change and ΔC is the total tuning capacitance variation.

The unused tuning capacitor has some affect upon the output frequency although it is isolated by the small capacitance (about 4 pF) of the open relay contacts. The greatest effect occurs at the upper frequency limit when the main tuning capacitor is at minimum capacitance. This effect can be minimized by making the minimum tuning capacitance as large as possible by sharing the fixed capacitors in the tuned circuit.

If you already have a stable regulated 12-volt supply you can eliminate the 1N756A zener diode and the 180-ohm resistor. Power consumption is 35 mA with the zener circuit, 25 mA without it.

Use a fast, reliable relay to switch the tuning capacitors. The rf voltage at this point in the circuit is 30 to 40 V p-p. A high-quality reed relay is recommended. The diode across the relay coil eliminates the negative voltage transient when the coil is de-energized.

If you want two-channel control for your receiver use a multivibrator circuit to control the relay. Try a multivibrator frequency between 10 and 300 Hz. In addition to the two desired channels there will be adjacent sidebands with spacings equal to the multivibrator frequency.

In a circuit of this type the vfo signal is usually taken from the source of the oscillator fet. On a good oscilloscope the waveform at this point is very close to a

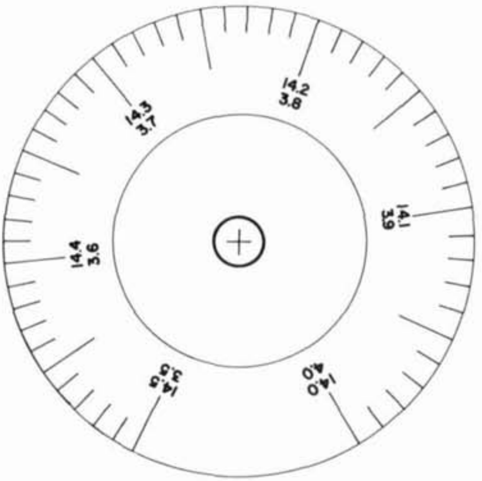


fig. 2. Full-size dial for the 5.0 to 5.5-MHz vfo.

true sinusoid. However, a check with a spectrum analyzer will reveal that the second harmonic is only 20 dB down. Since the output signal should be as clear of harmonics as possible, in **fig. 1** the oscillator output signal is taken from the frequency-determining circuit. At this point in the circuit the second harmonic is more than 50 dB down.

The vfo input signal to gate 1 of the MPF121 amplifier should not be greater than 0.9 V p-p. The MPF121 is an inexpensive, zener-protected mosfet and will provide all the needed amplification with good isolation between input and output. The drain current of the MPF121 is set to 10 mA by selecting the source resistor; this current level results in maximum linearity.

The 47-ohm resistor in the drain circuit of the MPF121 prevents vhf parasitic oscillations. I found that the gate-1 lead inductance and drain lead inductance resonated with the 100 pF capacitors to form a tuned-drain, tuned-gate oscillator around 800 MHz. This parasitic oscillation is effectively damped by the 47-ohm resistor in series with the output tuned circuit.

Inductors L2 and L3 are both honeycomb wound. One of the coils may be moved along the coil form to control coupling. The output bandpass of this circuit should be tuned with a sweep generator to obtain optimum performance. Output from the sweep generator is terminated with a 50-ohm resistor and fed to gate 1 of the MPF121. The vfo output is connected to 50-ohm coax to the input of the sweep generator, terminated by a 75-ohm resistor. This is approximately a 30-ohm load. With this arrangement output is flat within 0.1 dB from 5.0 to 5.5 MHz; attenuation at 10 MHz is about 50 dB.

A hot-carrier diode ring mixer requires about 10 mW of rf injection, much more than other mixer arrangements. The output of this circuit is just sufficient.

When aligning the vfo be careful not to overdrive the MPF121; 0.9 V p-p is enough. More drive will not increase the desired output signal but will produce considerably more harmonics.

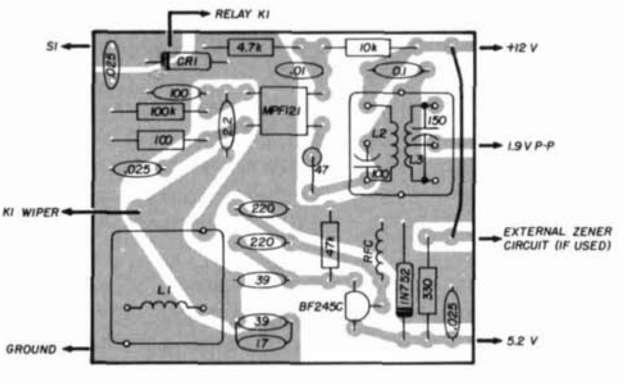
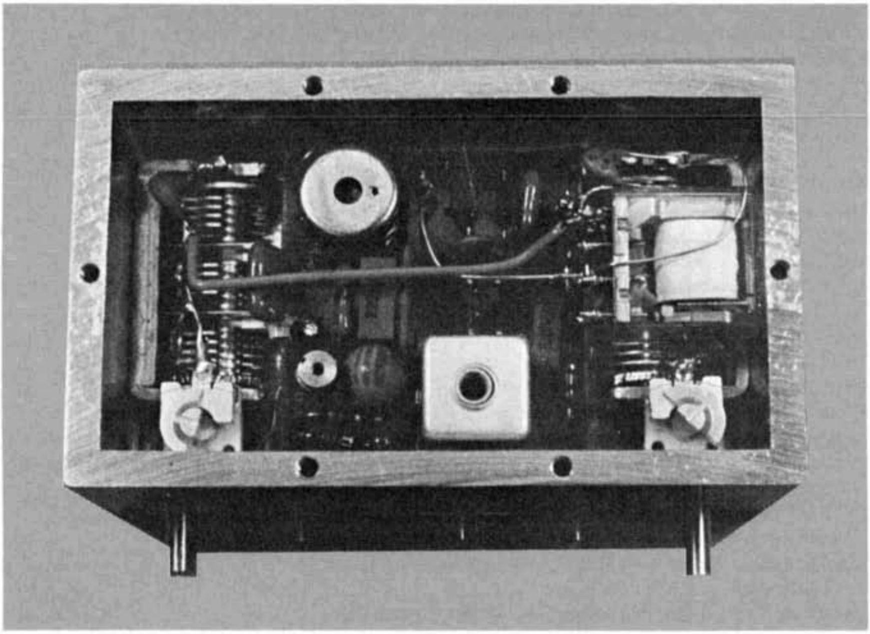


fig. 3. Full-size printed-circuit board layout for the vfo.



The high-frequency vfo is built into a rugged aluminum chassis. Layout is shown in fig. 4.

construction

The high electrical stability of this circuit cannot be realized unless the actual physical construction is mechanically stable. The temperature delay through the 3/16-inch sides of the cast-aluminum chassis shown in the photos is about ten minutes.

For maximum rigidity the two tuning capacitors are screwed to the sides of the chassis. Distance between shafts is 75 mm (2-7/8 inches); therefore, two 70-mm (2-3/4-inch) dials can be used (see **fig. 2**).

The printed-circuit board shown in **fig. 3** is soldered directly to feedthrough inserts and grounded in two places with metal straps. Both sides of the board are easily accessible.

If a ferrite core is used in L1, the relay should be placed as far away as possible. The magnetic field around the relay coil affects the ferrite; magnetic shielding may be necessary.

The gear drives to the tuning capacitors are left outside the aluminum chassis. I have not found a single reliable planetary drive mechanism; spring-loaded gears are preferred. A ratio of 10:1 is sufficient; this provides about 50 kHz per turn. I found a 36:1 drive from Semcoset in Germany which gives about 15 kHz per turn.

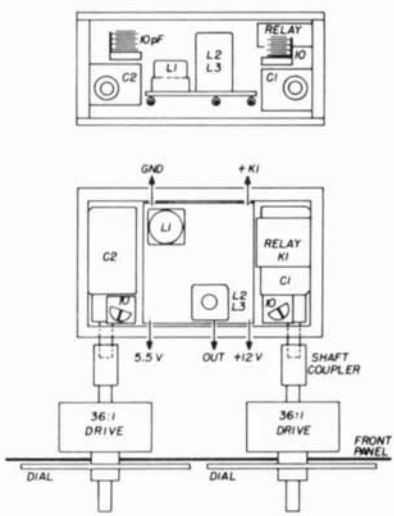


fig. 4. Mechanical layout of vfo.

table 1. Operating characteristics of the high-stability vfo.

frequency range	4.850 to 5.650 MHz
frequency used	5.000 to 5.500 MHz
output level	1.9 V p-p ±0.5 dB into 35 ohms
stability	15 Hz per °C 5 Hz per volt (9 to 20 volts)
output open/short circuited	20 Hz difference
harmonic content	more than 70 dB down
mechanical shock	less than 100-Hz frequency change with several successive hard shocks
supply voltage	10 to 18 V, 12 V nominal
power consumption	35 mA (relay, 40 mA)
size	100 x 60 x 46 mm (3.9 x 2.4 x 1.5 inches)

summary

The complete operating specifications of this vfo are given in **table 1.** Several similar units have been built, and all exhibit the same operating characteristics.

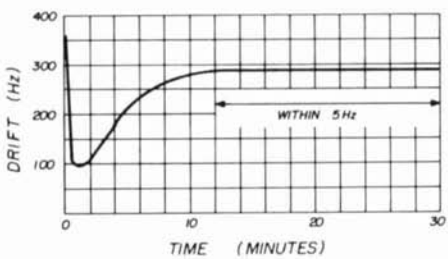


fig. 5. Frequency drift characteristics of the vfo when turned on from a cold start.

This is by no means an exceptional device, but it is a good answer for the modern amateur. When using a hot-carrier diode ring mixer in a bilateral transceiver this vfo uses the minimum number of componenets for the features it provides.

ham radio

adding 160-meter coverage to the HQ125 receiver

This simple modification should add rather than detract from the resale value of your HQ125. No metalwork surgery is required

Stuart Meyer, W2GHK, 4000 Wingate Drive, Raleigh, North Carolina

Although the Hammerlund HQ215 has a number of positions on the bandswitch for additional 200-kHz segment coverage on the various bands, the receiver's design does not permit such frequency ranges below approximately 3.4 MHz. After studying the problem of 160-meter coverage, the following relatively simple modification was devised. It can be accomplished with reasonable skill, without tearing apart any of the existing circuitry and without the need for drilling any of the metalwork.

An additional crystal is required to cover the range of 1.8 to 2.0 MHz. Crystals for several receivers modified by me were obtained from the International Crystal Manufacturing Company.* The appropriate pages of the Hammerlund manual were forwarded to International Crystal so the crystals would correlate and calibrate properly. The frequency of

*International Crystal Manufacturing Company, Inc., 10 North Lee, Oklahoma City, Oklahoma 73102.

the crystal required for this modification is 4.9550 MHz. The various fixed and trimmer capacitors called for at the end of the article should also be on hand when the modification is started.

Complete coverage of the 160-meter band is not possible with a single position of the band selector due to the relatively small value of available capacitance change compared to the large values to be added by this modification. Therefore, it is necessary to split the band segments into two segments of 100 kHz, each covered by separate positions (B and C) of the bandswitch, to obtain optimum sensitivity over the entire band. Tuning of the second oscillator stage, however, will cover the entire 160-meter band regardless of the setting of the bandswitch with respect to position B or C.

Two sections of instructions follow which will allow you to cover either segment as a complete operation, or, by completing both section, to cover the entire band.

It is assumed that the receiver to be modified is in normal working order and does not require service. Remove the top, bottom and the side panel nearest the bandswitch in accordance with the instructions in the HQ215 service manual. Note: The following procedures assume that the receiver is upside down on the workbench with the front panel closest to the operator.

1.8 to 1.9 MHz

Install a 4.9550-MHz crystal into position C (not B) of the crystal deck. Positions 5 and 6 of section D of switch S-101 should be shorted by soldering a short length of number-18 or 20 solid tinned wire across the switch tabs. Do not attempt to insert the wire into the eyelet holes, simply lay the wire on top of the tabs. Be sure that no solder droppings or bits of wire fall down into the receiver. Pins 5 and 6 of section D are on the wafer closest to the rear of the receiver, and in several units I have checked these pins have green and yellow wires.

Trimmer capacitor C127 (refer to figure 4-3 of the HQ215 manual) should be adjusted to its maximum capacity (maximum clockwise tension on the screw) but be sure to not apply so much tension as to strip the threads. When operating properly, it should be possible to hear a loud spurious signal between 3 and 5 kHz below 1800 kHz. This is a normal "birdie" for the frequency conversion scheme used in the HQ215. It may be necessary to parallel C127 with a 220-pF silver-mica capacitor if the resultant note at 1.8 MHz using the *calibrate* position is not clean. Readjust C127 to obtain the cleanest sounding marker signal.

Although the schematic in the manual shows trimmer capacitors C120, C125 and C130 connected to contact 6 of S101A, B and C, respectively, a physical examination of the bandswitch reveals that they are actually connected to terminal 5, with jumpers to 4 and 6. Very carefully cut the jumpers between terminals 5 and 6 of the three front (A, B and C) sections, leaving terminal 6 clean and ready for the additional padders to be installed. Extreme care must be used at this stage of the conversion to insure that the bandswitch is not damaged and that no solder droppings fall into the receiver. If this does happen, they should be shaken loose and removed completely before proceeding.

Next, prepare the three variable trimmers (310-700-pF, Electromotive type PC4215) as follows: For switch section A, wire a 1000-pF silver-mica capacitor across the variable trimmer. For switch section B, connect a 1500-pF across the trimmer, and for section C (the first mixer circuit) use a 1000-pF capacitor across the trimmer. The leads on the fixed capacitors should be carefully trimmed and wrapped around the tabs of the trimmers and soldered to hold the leads near the base of the tabs.

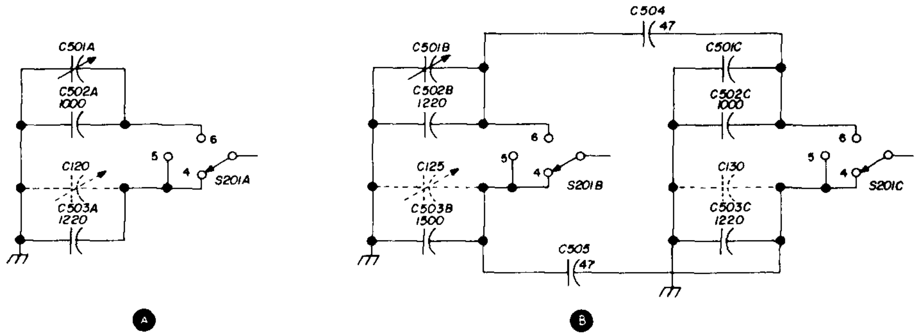
Before installing the new padders, place them in approximate position and note the spot on the grounding shield between switch sections where one side of the trimmer will anchor. Tin this area of the shield and then install the padders between the appropriate pins and the tinned spot on the shield. Be careful not to force the switch tabs out of their normal position so there will be no strain on the switch when this operation is completed.

One last operation is left. Install a 47-pF silver-mica capacitor from terminal 6 of S101B to terminal 6 of S101C. This capacitor parallels C105 only with the bandswitch in position C, and is necessary to increase the coupling and compensate for the large shunt capacitance required to hit resonance at 1.8 MHz. This completes the modification required to permit the rf tuned circuits to cover the range of approximately 1.8 MHz to 1.9 MHz, with the exception of alignment.

1.9 to 2.0 MHz

Prepare two 1220-pF capacitors by wiring a 1000-pF and a 220-pF silver-mica in parallel. Install one of these 1220-pF capacitors across C120 (switch section A) in *Section 1.* Install a 1500-pF silver-mica capacitor across C125 (switch section B) and the other 1220-pF unit across C130 (switch section C). Also, as in *section 1,* install a 47-pF silver-mica between terminal 5 of S101B and terminal 5 of S101C. This completes the required rework except for alignment.

Before continuing with the alignment it's a good idea to be sure no loose bits of wire or solder are inside the receiver, and



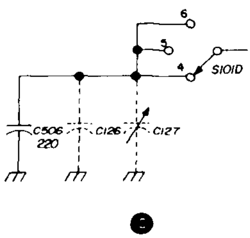


fig. 1. Simple circuit modifications put Hammarlund HQ215 receiver on 160 meters. Higher values of fixed capacitance are used on the higher-frequency 160-meter segment (1900 to 2000 kHz) because of the lower value of trimmer capacitance which is factory installed at position 5 of the bandswitch.

C501A,C501B, C501C	310 to 700 pF trimmer (Electromotive PC4215)	C503B	1500 pF, 5% silver mica
C502A,C502C	1000 pF, 5%, silver mica	C504,C505	47 pF, 5% silver mica
C503A,C502B, C503C	1220 pF, 5% silver mica (1000 and 220 pF in parallel)	C506	220 pF (see text)

that all other bands still work properly. Make necessary repairs by correcting any wiring errors, etc.

alignment

The *calibrate* function of the receiver may be used in lieu of a signal generator. Just remember to keep the rf gain control set so the S-Meter reads somewhere between S-5 and S-9. Final touch-up may best be performed "on-the-air." The reciver agc switch should be set to *fast agc.*

Set the preselector tuning knob to *9* and the main tuning dial to *0*. Set the bandswitch to C; this should represent 1.8 MHz. Turning the *calibrate* switch on and off should result in a signal easily identified. Leave the *calibrate* switch on, and by using the S-meter adjust the three trimmers just installed in *section 1* for maximum reading. Repeat the adjustment two or three times to be sure you have the correct adjustment. Move the tuning dial to *100*, which represents 1.9 MHz, turn the preselector knob to *1*, and noting the positions of each of the three trimmers carefully touch up the adjustments and again note the position of the trimmers. There should be very little difference between the two settings. Leave the trimmers set to the center of the two settings.

If you do not hear the 100-kHz marker tone at *100* on the dial, your crystal may not be oscillating on the proper frequency. Recheck the wiring of the rear section of S101 and readjust the trimmer capacitor (C127). This completes the adjustment of the 1.8-1.9 MHz segment of the 160-meter band.

The bandswitch should now be placed in position B and the main tuning dial to *200*, which represents 2.0 MHz, and the preselector tuning knob to *1*. Again, you should hear the *calibrate* marker signal, and it should sound clean – no hum or roughness. Peak trimmer capacitors C120, C125 and C130 for maximum S-Meter reading, repeating two or three times to be sure of the best settings and taking into account the precautions mentioned previously regarding overloading the receiver. Set the main tuning dial to *100* again, set the preselector knob to *9* and follow the procedure mentioned above to optimize the trimmer settings.

If desired, you may simply peak up the trimmers "on-the-air" for those portions of the band which you prefer, although very little difference in performance has been noted on the several receivers with which I have had experience. It should be remembered that moving the bandswitch from position C to position B will not affect the incoming signal tuning, as far as the *frequency* is concerned, but only from the viewpoint sensitivity. Extremely strong signals will be heard even though the preselector is not tuned to resonance with the incoming signal, but weak signals will be lost. There will, of course, be some overlap between the two segments near the 1.9-MHz portion of the band.

conclusion

This modification results in a receiver capable of good performance on 160 meters, and will provide all the sensitivity that can normally be used in most locations. Some operators may feel that an external preamplifier might be useful, but this is true only if the receiving location is extremely quiet and atmospheric noise is very low.

The sensitivity of the receiver I modified measured better than a half microvolt for a 10-dB signal-plus-noise-to-noise ratio. This was on both the CW and ssb modes of operation. This sensitivity should be sufficient for even serious DXing on 160 meters.

With a little study and a few easily obtainable parts this entire project can easily be completed in one evening's time and adds greatly to the usefulness and the pleasure of using the HQ215. I would like to thank George Faatz, K4KH, who proofread these instructions while performing the modification on his own HQ215.

ham radio

compact tone-burst keyer for fm repeaters

This simple tone-burst oscillator circuit provides high performance in a miniature package

R. B. Shreve, W8GRG, 2842 Winthrop Road, Shaker Heights, Ohio 44120

As two-meter fm repeaters multiply across the country, more of the groups operating them may be expected to turn to some form of tone-guarded input, not to exclude non-members, but simply to eliminate accidental sporadic keying of the system by stations using the same input frequency in another area.

With the decision to install a 2000-Hz single-tone decoder on the 146.34 MHz input to the WB8CQR repeater this past spring, I started looking for a replacement for the tone generator I built a year ago for my occasional visits to Chicago and other areas with controlled-access repeaters. That unit, a Colpitts-type transistor oscillator using an 88-mH toroid, keyed manually with a push button, worked perfectly but was bulky and awkward.

What I sought was an oscillator that would: key automatically with the push-to-talk circuit, provide a frequency-stable tone on at least two switch-selected frequencies, be small enough to mount inside one of the compact transistorized transceivers, such as my Varitronics IC-2F, and draw minimum current to avoid undue drain on a portable's power supply. The answer was found in a Motorola application bulletin.[1] It is a saw-tooth generator using two diodes and a capacitor, switched by a modified monostable multivibrator which can be triggered by the microphone push-to-talk circuit. The circuit is shown in **fig. 1**.

circuit operation

Operation is as follows: When the PTT switch is open (the receive condition) the microphone PTT circuit is ungrounded and a positive voltage appears at terminal 3. Applied to the base of Q1 through diodes CR4 and CR3, this voltage turns Q1 off, which turns Q2 on. It also charges C1.

With Q2 on, approximately 12 volts is applied to CR2, a Motorola field-effect diode (also known as a current-limiting diode or current Zener). Basically this device is a field-effect transistor with the control gate and source internally connected to the substrate; it has the interesting characteristic that when reverse biased it will conduct an almost constant current regardless of the applied voltage. This current ranges from 0.22 mA for the 1N5283 to 1.60 mA for the 1N5303; the circuit shown uses a 1N5299, rated at 1.20 mA ±10%.

The constant current through CR2 charges the capacitors at a constant rate, increasing the voltage across them and diode CR1. Diode CR1 is a four-layer or pnpn diode. It has two stable states: off, in which it exhibits resistance of a megohm or more, and on, in which its resistance is only a few ohms. Transition from off to on is controlled by the voltage applied; as the capacitors charge the diode remains off until its breakover voltage is reached, at which time it turns on, discharges the capacitors practically instantaneously and turns off again. The frequency of oscillation is thus determined by three factors: The current conducted by CR2, the value of the capacitors and the breakover voltage of CR1. A vernier adjustment is obtained by connecting a resistor across the capacitors to bleed off part of the charging current.

The oscillator runs constantly as long as the PTT switch is open and positive voltage is present at terminal 3. When the transmitter is keyed by closing the PTT switch and grounding terminal 3, the oscillator continues to run, and a tone is transmitted until capacitor C1 discharges.

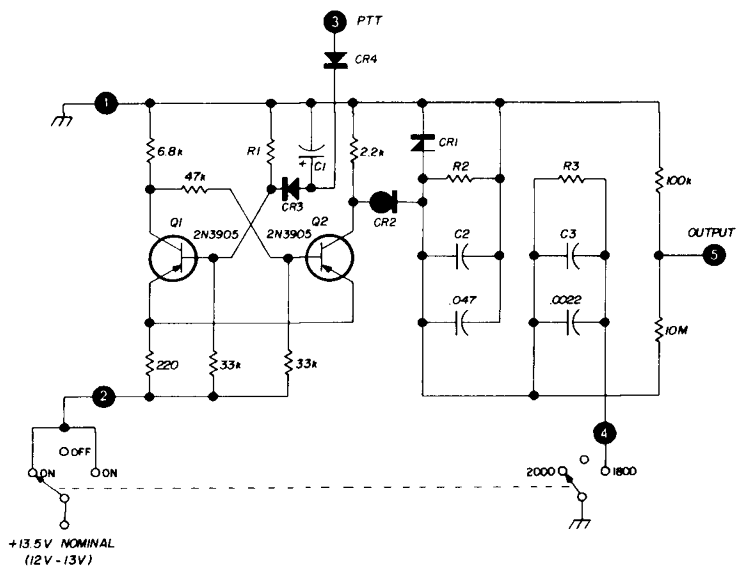


fig. 1. Simple tone-burst oscillator circuit provides tones of 1800 and 2000 Hz. Diodes CR3 and CR4 are general-purpose diodes. R1 and C1 are selected for desired burst duration; for value of C2, C3, R2 and R3 see text.

C1 and R1 thus control the burst duration; values of 30 μF and 100k ohms give about ¾ second. When C1 is discharged, Q1 turns on, Q2 is turned off, the voltage at CR2 is reduced to approximately 1 volt. The oscillator stops until the positive voltage is restored to the base of Q1 by release of the PTT switch.

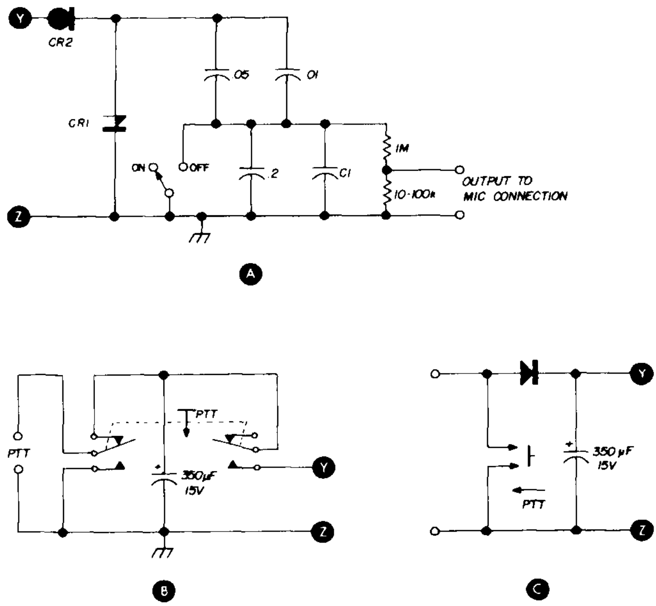


fig. 3. Most simple tone-burst oscillator can be built into a microphone. The circuit is powered by a charged 350-μF capacitor; as the capacitor discharges, the tone drifts downward. Capacitor C1 is approximately 0.02 μF (select to desired frequency).

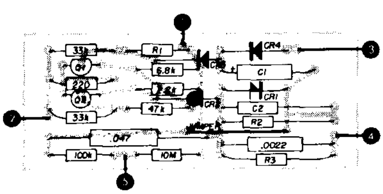


fig. 2. Full-size circuit-board layout for the compact tone-burst oscillator.

The unit draws approximately 6 mA with the oscillator running (1.2 mA through CR2 and the rest through the 2.2k load resistor connected to Q2). It draws less than 2 mA when the PTT switch is closed. It is very compact; the actual size of the circuit board shown in **fig. 2** is ¾ by 1¾ inch, and the clearance required above the board is only 3/8 inch.*

construction

For most compact assembly all resistors for which numerical values are shown should be installed first, as close to the board as possible. Capacitors fit between and overlap the resistors. Transistors and diodes are installed in a second layer, with leads extending down to the board between the other components.

With all components in place except C2, C3, R2 and R3, the burst duration should be checked by observing the voltage at the collector of Q2 as the PTT

*Printed-circuit boards are available from the author for $2.50, postpaid, in the United States and Canada.

switch is closed. Adjust R1 if necessary. The oscillator frequency adjustment must be made experimentally using a counter or other standard, as the capacitors, diodes and resistors all have 10% tolerance and the allowable margin of error in most repeater tone decoders is on the order of 0.5%. Select C2 and R2 to give the desired high tone (2000 Hz in the unit shown here); then select R3 to give the low note. Installation of C3 is usually unnecessary.

The circuit has been tested in a variety of equipment with the WB8CQR single-tone decoder and keys the repeater with less than 2-kHz deviation on the transmitted signal. Deviation can be set at whatever level is desired by changing resistor values in the output voltage divider. Frequency is comparatively stable for a power supply voltage range between 12.5 and 15 volts. There is some drift with temperature change; if it is excessive, try new resistors and capacitors in the oscillator. I have found a few that were much worse than average and resulted in unsatisfactory performance of the unit in which they were installed.

The same oscillator circuit was used to make a miniature tone generator that could be completely contained in the mobile microphone case. The circuit is shown in **fig. 3**. Power for the oscillator is drawn from a 350-μF electrolytic capacitor charged from the PTT circuit. It had only one fault; the tone tailed off in frequency as the capacitor discharged, and the signal swept from 2000 Hz to below 1800 Hz before the oscillator cut off. This circuit is also sensitive to lead lengths in the capacitor network. C1 must be selected in its working location. If you want a universal repeater keyer, this will do it! If you value the opinion of your friends, however, I recommend the version shown in **fig. 1**.

reference

1. John Bliss and David Zinder, "Four-Layer and Current-Limiter Diodes Reduce Circuit Cost and Complexity," Motorola Applications Note AN-221.

ham radio

cw break-in circuit

Fast break-in
is a must
for traffic nets
and contests —
here's a circuit using
solid-state switching
for quiet operation

W. Mike Mitchell, W8SYK, 2564 Glenwood Avenue, Toledo, Ohio 43610

Several simple break-in circuits for CW have been tried at my station with varying degrees of success. Some seemed to work fairly well, but key clicks and thumps were difficult to eliminate. Mechanical relays for switching increased the room noise level considerably. When the break-in system is too noisy, one tends to send faster or shorten character spacing to hold the relays closed, thus reducing noise. This, of course, defeats the purpose of break-in, which is to allow signals to be heard between letters while sending. Other circuits I have not yet tried seemed far too complicated for simple break-in.

preliminary steps

Before attempting to use any break-in system, the receiver and transmitter should be tested to determine if they will perform properly under fast switching conditions. In full break-in, the exciter and final-amplifier plate voltages are on and the tubes biased to cut-off or beyond. This condition could cause diode noise in the receiver and should be corrected.* The receiver should be tested for its willingness to cooperate with the break-in system by connecting a variable voltage, 0-75 volts, to the avc line. With bias connected key the transmitter. If a clean signal is heard without key clicks or thumps and the gain can be adjusted to the desired level, full break-in circuitry can be added with no difficulty.

break-in circuit

A separate receiving antenna is used at my station. In the circuit shown in **fig. 1** a switch, SW1, is used to change modes. The circuit is designed to be used with grid-block keying, and the −75 V is obtained from the transmitter bias supply. A separate supply could be used, however.

*Although this problem can be caused by tube-type rectifiers in the transmitter high-voltage supply (due to contact potential, leakage paths, etc), a common cause of receiver noise under the conditions stated by the author is improper bias and neutralization of the final amplifier tubes. **editor.**

When the four-pole, three-position switch is in the break-in position, SW1D connects the receiver to the receiving antenna, and the transmitting antenna input is grounded at this point through SW1C. Capacitors C3, C4 and diode D2 form a solid-state switch, which is quite effective. This circuit is an improvement over simply shorting the antenna to ground and is more effective than a spdt relay.

SW1B connects the key or electronic keyer to the base of Q1, an npn silicon transistor. With -75 V connected to the emitter and the base resistor, R1, returned to ground through the key, Q1 ates with the transmitting antenna, but the solid-state switch is still in the circuit.

construction

The entire circuit is built in a 2 x 3 x 5-inch minibox. Phonograph jacks and plugs are used for all connections. Shielded leads are used. The transistor I used is a Motorola RV video amplifier type M4843. Television receivers, especially color sets, use transistors with rather high voltage ratings. Some horizontal sweep power transistors operate with peak voltages as high as 800 volts. In this circuit any good quality npn transistor of the required voltage rating may be used,

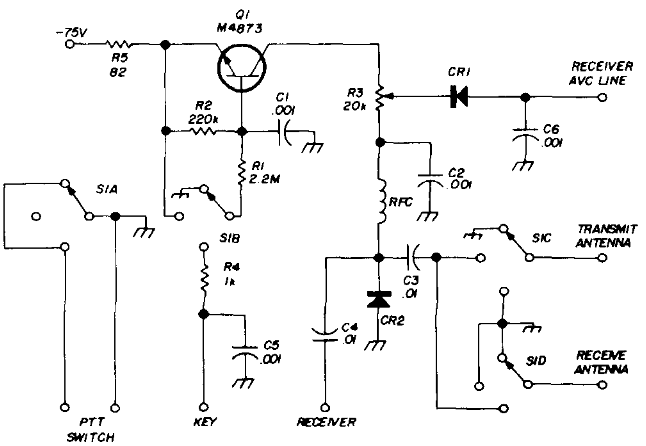


fig. 1. CW break-in circuit using solid-state switch for stations with separate transmitting and receiving antennas. Design is for grid-block keying systems.

conducts heavily, and the -75 V appears at the collector and at the top of R3. Since R3 is connected in series with D2, D2 also conducts heavily, grounding the antenna input to the receiver. A variable bias voltage of 0.6 to -75 V is now available at the slider arm of R3 and is connected to the receiver avc line through D1. D1 prevents shorting the avc line during key-up conditions.

SW1A turns the transmitter B+ on in both break-in and normal transmit positions. In the transmit position, Q1 conducts and the receiver may be used for monitoring but will remain off until the switch is returned to receive or break-in. In the receive position, the receiver oper- but it would be a good idea to check for leakage before closing the box. No voltage should be present on the collector with the key open in the receive or break-in switch position.

I've been using the circuit for a few months and have been pleased with the results. Received signals can be heard between letters at reasonable code speeds. I use the circuit with an unmodified 75A4 receiver on fast avc. The receiving antenna consists of about 25 feet of wire and works quite well except for signals below S4 or S5. A better receiving antenna will be installed soon, which should improve circuit performance.

ham radio

low-pass filters for 10 and 15 meters

Data for building two low-pass filters with better harmonic attenuation than conventional designs

John Schultz, W2EEY, 1829 Cornelia Street, Brooklyn, New York 11227

Low-pass filters have been designed and built for many years according to the conventional formulas found in various handbooks. Such formulas are based on so-called image-reflection design, and a filter built according to these formulas consists of one to three constant-k center sections and two m-derived terminating half sections. The filter is usually designed for use with a 52- or 72-ohm coaxial line. The attenuation characteristics of such a filter are valid only if the filter is used with the type of line for which it is designed and if that line operates near unity swr. In recent years, filter design has improved because of an interest on the part of military and other communications-equipment designers to achieve superior filter performance at minimum cost.

This article presents construction data on low-pass filters for 10 and 15 meters which have been designed according to latest available techniques. Either filter may be built from readily available parts for any power to 2 kW PEP.

The advantage of filters designed according to modern techniques is the superior harmonic attenuation obtained using fewer components. For example, the filters described here use only 3 coils; yet the harmonic attenuation is as good or better than that of filters using 5-6 coils. Using fewer coils may not sound like an advantage in theory, but it means a great deal in practice. Unlike capacitors, coils in a low-pass filter must either be shielded or oriented to prevent mutual coupling, which degrades filter performance.

Building a really effective low-pass filter that gives a *true* 50-70 dB harmonic attenuation, using conventional design techniques, often presents a mechanical problem because of the shielding required between filter elements. Modern filters, on the other hand, are not only easier to build to achieve the same performance level but are less critical as to construction techniques. The latter assertion can't be proved from theory, but it certainly seems to be the case as far as I've been able to observe when building various filters.

design characteristics

The filter design is shown in **fig. 1**. It's intended for insertion in a coaxial transmission line of 52-72 ohms (design optimized for 52 ohms), either between an exciter and a linear amplifier or between a linear amplifier and antenna. The three-section design uses a combination of parallel- and series-resonant circuits. The design can't be reduced to only two coils, because all circuit elements are interdependent. Built as shown, however, the filter yields outstanding harmonic attenuation without involved construction details.

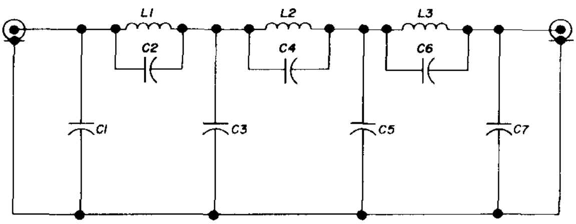


fig. 1. General arrangement of filter. Refer to table 1 for constants.

The filter design has a cut-off frequency up to which the filter will pass radio frequencies with minimum attenuation. Beyond the cut-off frequency, the attenuation increases rapidly with frequency until it reaches the first peak of maximum attenuation. In the specific designs shown later, this latter frequency is from 1.5 to 2 times that of the cut-off frequency. At this first attenuation peak, the attenuation is theoretically at least 70-90 dB as compared to the level below the cut-off frequency. The attenuation at all higher frequencies is at least 70 dB, with a number of peaks providing even higher attenuation.

practical considerations

One can design filters that achieve theoretically even greater harmonic attenuation. However, the practical realization of levels greater than 70-90 dB with simple construction materials and techniques is illusory. The practical limit for filter elements seems to be about 120 dB, and this has been achieved only in designs using the most elaborate and expensive construction techniques. A paper design may achieve *almost an infinite* harmonic attenuation level, and, indeed, this is one of the dangers of conventional filter design where it appears that one could add constant-k sections almost endlessly. In short, the design shown in **fig. 1** represents the practical limit for a filter that will work well.

15-meter model

The first filter to be described is for use with transmitters operating at 21 MHz or below. Component values are shown in **table 1**. All may be achieved with readily available capacitor values. The 15-meter filter attenuation begins about 22-23 MHz and reaches its first peak (about 60 dB) at 40-42 MHz (**fig. 2**), which provides good harmonic attenuation in the i-f range of most TV sets. This feature is, in fact, the reason for developing a 15-meter filter. A low-pass filter that begins cutoff above 21 MHz provides excellent attenuation at TV intermediate frequencies as well as at the beginning of the vhf TV channels. Another consideration is that, as the sunspot count decreases in the coming years, there will be less activity on 10 meters.

Many cases of TVI can be eliminated by this means where TV i-f interference has been a problem. In a few instances, even problems with nearby CB installations can be avoided with such a filter since its attenuation at frequencies above the 21-MHz band will be effective for both reception as well as transmission.

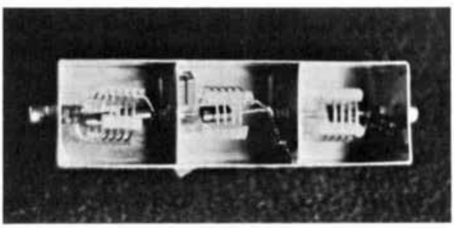
10-meter model

The second filter has a cut-off frequency of about 30 MHz. An attempt was made to design a filter that offers significant protection at TV-receiver i-fs using filter elements within reasonable tolerances. Circuit values for this filter are also shown in **table 1**. The first maximum attenuation peak occurs about 60 MHz. However, the slope after the cut-off frequency is quite steep, and significant attenuation begins at 40 MHz. Again, the filter was designed for available capacitor values.

capacitors

Mica capacitors should be used. The physically smallest 500-vdcw mica is inexpensive and may be used for filters operating at the 300-watt PEP output level (15 meters) and at 100-150 watts for 10 meters.

These capacitors therefore, are suitable for a filter between a 100-watt (nominal)



Typical filter using brass sheet stock. This design was intended for use between an exciter and a linear amplifier. Receptacles are rf-type phono connectors.

output exciter and a high-power linear. Such a filter is often overlooked in TVI problems because of the expense of a commercial filter for both the exciter-final link and the final-antenna link. However, a filter between exciter and final is useful in attenuating harmonic radiation, which causes TVI, because the exciter will have some harmonic output.

Larger mica capacitors may be used for filters for any desired power level. Molded mica capacitors rated at 1500 volts dc working are useful in filters operating to 1-kW PEP *output*. Type CM-15 mica capacitors, rated at 2500 or

table 1. Practical component values. Capacitor values are based on commercially available parts. Try not to substitute.

component C in pF L in μH	15-meter filter (22 MHz cutoff)	10-meter filter (30 MHz cutoff)
C1	68	50
C2	7	5
C3	200	100 & 39 parallel
C4	27	20
C5	180	100 & 33 parallel
C6	22	15
C7	57	47
L1	.41	.30
L2	.45	.33
L3	.35	.26

5000 vdcw, may be used with even the most efficient 2-kW PEP linear.

construction

Filter construction is easy since only three coils are used, which should be mutually shielded. The coils can be made from Air-Dux or B&W stock, or wound from tinned copper wire. The small sizes of coil stock are fine for transmitter *output* powers up to 500 watts PEP. Coils for higher power should be wound with no. 10 or 12 tinned copper wire. The capacitor values in **table 1** should be adhered to.

The photo shows a filter using low-voltage mica capacitors. Brass sheet stock forms an enclosure 5½ inches long by 2 inches square. Equally spaced dividers separate filter sections, and simple feed-through insulators are used between sections.

Brass sheet has several advantages. The material is easy to work. The sides of the enclosure as well as the dividers can be soldered. The cover can also be completely solder-sealed. Such shielding efforts really help, particularly when trying to combat TVI in the uhf ranges where the screwdriver assembly of conventional filters allows rf leakage.

results

The attenuation characteristics of the filters I built are shown in **fig. 2**. The 15-meter filter slope reaches an attenuation peak at the TV i-f range. The equipment I used to check the filter was of good laboratory quality, which the average amateur doesn't have. Nonetheless, the instrumentation wasn't capable of making *accurate* attenuation measurements in the vhf range beyond -60 to -70 dB. The curves of **fig. 2**, therefore, are conservative.

A careful sweep of the vhf range disclosed no frequency where filter attenuation fell below -60 to -70 dB. This result included the effects of the phono-type connectors used in the filter construction. The attenuation of the filter in the pass-band region varied between .1 and about .25 dB but never exceeded the latter value. When inserted in a matched 52-ohm transmission line, the filter produced a worstcase swr of 1.1.

conclusion

I claim no credit for the original design of the filter. That belongs to a number of scientists. The purpose of this article is to present two selected and truly practical low-pass filters that satisfy requirements for any 80-10 meter amateur installation.

A point that should again be emphasized is that the filters *must* include all the sections to be effective. You can't eliminate any section without completely changing the filter's attenuation characteristic.

ham radio

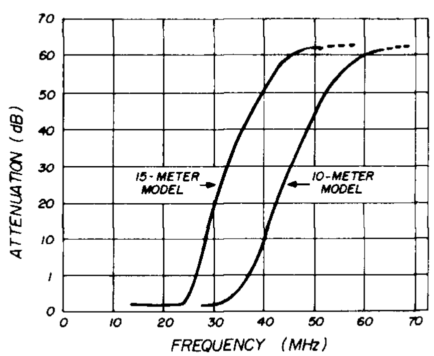


fig. 2. Measured results of filter attenuation characteristics.

threshold-gate/limiter for cw reception

Solid-state diodes in a simple and effective circuit to reduce filter ringing

John J. Duda, W2ELV, 6 Tuscarora Avenue, Geneseo, New York 14454

A disadvantage of audio filters and Q multipliers is their ringing effect on received CW signals. This ringing is caused by the shaping effect introduced in the audio signal by the filter or Q multiplier, namely, rounding and lengthening, respectively, of the signal leading and trailing edge. A method of reducing this distortion is to introduce a later distortion that sharpens and shortens the signal.

threshold gating

A characteristic of solid-state diodes, i. e., their ability of not conducting in the forward direction until a critical voltage is reached, can be used to decrease ringing and background noise as well. **Fig. 1** shows how a pair of diodes can be used to counteract ringing by providing a threshold-gating effect. The circuit has two additional features – it eliminates background noise below threshold level and provides single-signal reception of all signals with audio images falling below threshold. Further sharpening can be accomplished with a second set of diodes having a higher knee voltage, which operate as limiters. The effect of the combina-

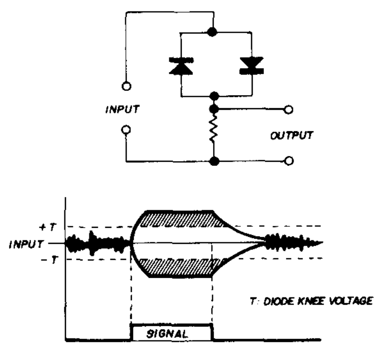


fig. 1. Threshold-gating. Input waveform represents ringing effect of high-Q filtering; shaded parts represent output of threshold-gating circuit. Note elimination of background noise and reduction of ringing.

tion is shown in **fig. 2** and can be described as a window-effect. The limiting diodes also prevent blasting by loud signals and, as shown in **fig. 2,** materially reduce the effects of signal fading.

A criticism of the threshold-gating/limiting circuit is that it severely distorts any audio tone passing through its intensity window. This is a valid criticism, and such distortion occurs when the circuit is used without prior high-Q filtering – the tone sounds raspy or scratchy. However, with the introduction of high-Q filtering the tone changes to a rather pleasant sound. Best results were observed when both Q multiplier and audio filter were used. It can be readily demonstrated that high-Q filtering and threshold-gating/limiting are effective in combination.

practical circuit

A practical circuit appears in **fig. 3.** Diodes may be selected from commercially available devices. In this case, I found that the emitter-base junction of a 2N414 made a good threshold diode, while the 1N54A performed well as a limiter. A switch was included so that the threshold-gating/limiting effect could be disabled for receiver tuning and when a signal quickly drops below threshold. A foot switch was convenient for this function. Note that the receiver output is not properly terminated. The problem here is the possibility of abnormally high voltages in the receiver output circuit causing damage to components. However, the limiting diodes reduce this possibility by clamping the output when high-level signals are received. The circuit has been used with vacuum-tube receivers without adverse effect. Although low-impedance earphones are indicated, high-impedance earphones may be used. These may be substituted directly, but it's preferable to use a matching transformer such as a vacuum-tube audio output transformer.

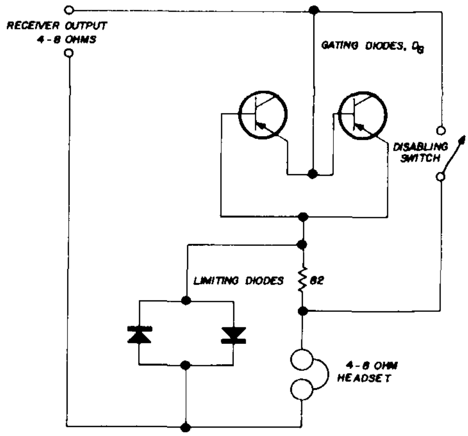


fig. 3. Intensity window practical circuit. Emitter-base junction of a 2N414 is used for the gating diode and 1N54A as limiting diode.

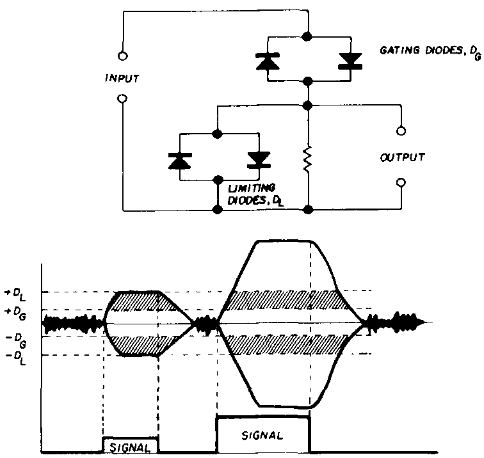


fig. 2. The intensity window. The combination of threshold-gating and signal limiting restrict output (shaded region) to components falling between the knee voltages of the two sets of diodes. Note further sharpening of input signal and reduction of fading effects.

With high-Q filtering, the circuit provides the unique experience of being able to tune across a CW band and hear signals of approximately equal amplitude and tone drop in and out of a noiseless background. All signals tend to sound alike in terms of keying characteristics, as the combination of high-Q filtering and threshold-gating/limiting tends to eliminate individual differences. Most signals seem to be improved by the process. The circuit can be built into the cord of a headset.

ham radio

Are 144 channel possible in an FM 2

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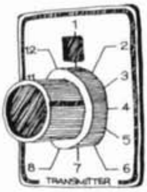

*Swan adds another dimension to 2 meter FM operation. Now with Swan's new independent switching for transmit and receive tuning (shown at right), combined with capacity for 12 receive and 12 transmit crystals, the FM 1210-A provides the capability for 144 channel combinations. With this wide selection of channels, crowded frequencies and unwanted QRM are virtually eliminated.

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The power of the FM 1210-A is rated at 10 watts output which, with the proper antenna, provides you with reliable communications. The output transistor is protected against damage from an improper load by an automatic protection circuit.

Each crystal has its own trimmer capacitor for exact frequency adjustment. In addition, the FM-1210-A is the ONLY 2 meter transceiver to provide a crystal oven for superior stability on those cold mornings.

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10 Watts, 12 Channels . . . Your best value! Features automatic protection of the output transistor, and individual trimmers on each transmit and receive crystal. Its compact size makes it easy to install under the dash of your automobile, or use it with its attachable AC power supply in your ham shack. Everything you need is included at one low price: microphone, built-in speaker, AC and DC operation, and our quick disconnect mobile mounting bracket.

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FM-2X SPECIFICATIONS

General

- Frequency coverage 144-148 mc.
- Number of channels: 12.
- Crystals installed for 3 channels as follows: Channel 1: transmit and receive 146.94 mc; Channel 2: transmit 146.34, receive 146.94 mc; Channel 3: transmit 146.34, receive 146.76 mc.
- Modulation: frequency modulation (phase type).
- Transmitter control: push to talk on microphone.
- Power source: AC 117 volts 50-60 cycles, DC 13.5 volts ±10%.
- Dimensions: 8¼" x 7" x 3".
- Weight: 8¼ lbs.
- Furnished with unit: dynamic microphone, antenna connector plug, spare fuses and lamps, AC power supply, DC power cord with fuse holder.

Transmitter

- Fully solid state.
- RF power output 10 watts nominal.
- Frequency deviation adjustable to ±15 kc; factory adjusted to approximately 5 kc.
- Frequency stability: ±.001%.
- Spurious radiation: —60 db below carrier.
- Frequency multiplication: 12 times.

Receiver

- Circuitry: crystal controlled double conversion superheterodyne.
- Input impedance: 50 to 75 ohms.
- Intermediate frequencies: 10.7 mc and 455 kc.
- Sensitivity: 0.5 uv for 20 db quieting, 0.5 uv for 12 db SINAD.
- Intermodulation: more than 50 db down.
- Audio output: 1 watt to internal speaker.

More Details? CHECK—OFF Page 94

combinations* meter transceiver?

FM 1210-A SPECIFICATIONS

- Frequency coverage 144-148 mc.
- Number of channels: 144 (12 rcv, 12 xmt, independent switching).
- 8 crystals are included as follows: TRANSMIT: 146.22, 146.34, 146.76, 146.94. RECEIVE: 146.28, 146.88, 146.76, 146.94.
- Modulation: frequency modulation (phase type).
- Transmitter control: push to talk on microphone.
- Power source: AC 117 volts 50-60 cycles, DC 13.5 volts ±10%.
- Dimensions: 8¼" x 7" x 3".
- Weight: 8¼ lbs.
- Furnished with unit: dynamic microphone, antenna connector plug, spare fuses and lamps, AC power supply, DC power cord, and mobile mounting bracket.

Transmitter

- Fully solid state, no tubes.
- RF output power: 10 watts nominal.
- Frequency deviation: phase type, factory adjusted to 5 kHz.
- Frequency stability: ±.001%, −30° to +50°C, oven controlled.
- Spurious & harmonic radiation: −60 db minimum.
- Frequency multiplication: 12.

Receiver

- Type: superheterodyne, dual conversion 16.9 mHz and 455 kHz IF.
- Input impedance: 50 to 75 ohms.
- Sensitivity: 0.5 uv for 20 db quieting. 0.25 mv for 12 db SINAD.
- Intermodulation: greater than 55 db.
- Audio output: 2 watts at less than 10% distortion.
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More Details? CHECK—OFF Page 94

rf bypassing at vhf

Suggestions for choosing the correct bypass capacitor in vhf circuits on PC boards

James P. Weir, WB6BHI, 5002 Barstow Street, San Diego, California 92117

If you're planning to build equipment for use at vhf, the following suggestions will be helpful in selecting values of small capacitors for rf bypassing.

Above the self-resonant frequency of a capacitor an inductive component appears that can degrade the effectiveness of the capacitor as an rf-bypassing element. At frequencies near 100 MHz the problem is compounded when equipment is built on PC boards.

capacitor frequency characteristics

The inductive reactance that predominates in a capacitor above its self-resonant frequency is often ignored by many amateurs. To them, a capacitor provides ac coupling, ac bypassing, and dc blocking. Many also believe that the larger the capacitor, the better it will bypass high frequencies. The fallacy in these assumptions will become apparent in the following discussion.

Consider **fig. 1.** At A is a "perfect" capacitor. It has zero lead length, zero electrode dimensions, and a lossless dieletric. However, when plates are added to the "perfect" capacitor, and leads are added to the plates, a certain amount of inductance is introduced, as shown in B. The inductance in the wire leads is approximately 20 nH (0.02 μH) per inch of lead length.

Now suppose the capacitor of **fig. 1B** is used in a bypass circuit on a PC board; 1/16-inch PC-board foil has an inductance of 20 nH per inch. If we try to bypass the emitter of a 100-MHz transistor amplifier with a large-value capacitor having ½-inch leads, and the PC-board foil between bypass capacitor and emitter lead is ½ inch, a total of 1½ inches of lead length will exist between the transistor emitter and ground. At 20 nH per inch, this results in 30 nH between emitter and ground. At 100 MHz, the inductive reactance of this combination is of the order of 20 ohms.

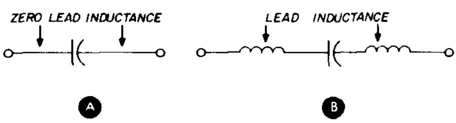


fig. 1. A "perfect" capacitor has no inductance. When leads are added, their inductance degrades the capacitor's effectiveness as a bypass element at vhf.

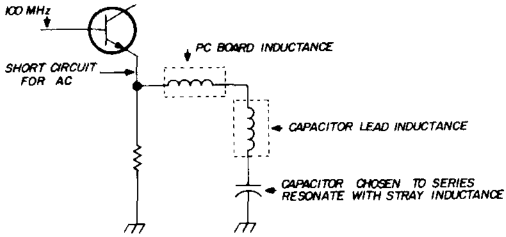


fig. 2. Effect of added inductance to a vhf-bypass circuit by PC-board foil and capacitor leads.

reactance considerations

The idea is to choose a capacitor that is series resonant at the desired bypass frequency. For instance, in the above example, a 68-pF capacitor with ½-inch leads and ½ inch of PC-board foil will series resonate at 100 MHz. The circuit will have minimum impedance at this frequency, and maximum current will flow. Thus the circuit will provide an effective by-pass for unwanted rf energy to ground. (See **fig. 2.**)

In summary, at frequencies above a capacitor's self-resonant frequency inductive reactance predominates, and the capacitor doesn't function efficiently as a bypass element. Below its self-resonant frequency, *capacitive reactance predominates* and the capacitor looks capacitive to the circuit. This relationship is shown in **fig. 3.**

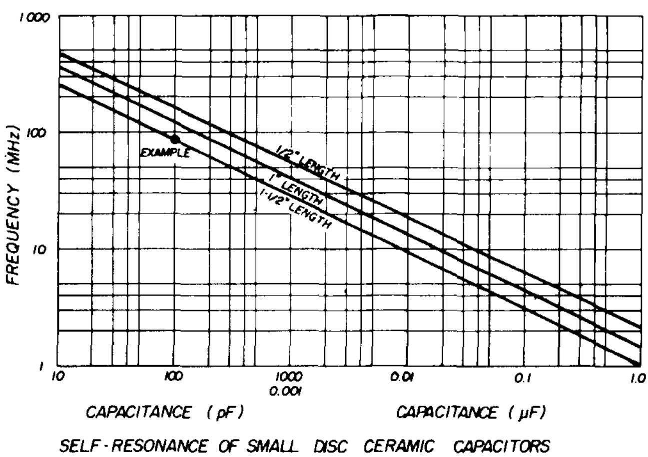


fig. 4. Aid for choosing disc capacitors in bypass circuits at vhf. All lead lengths between active elements and ground should be as short as possible.

graphical aid

Fig. 4 shows experimental results measured with small disc capacitors and a grid-dip oscillator to find resonant frequencies of various capacitor values.

To use the graph in designing a bypass circuit, first ensure that the lead length between the point to be bypassed and ground is as short as possible. Then choose a capacitor value that self-resonates at the frequency to be bypassed.

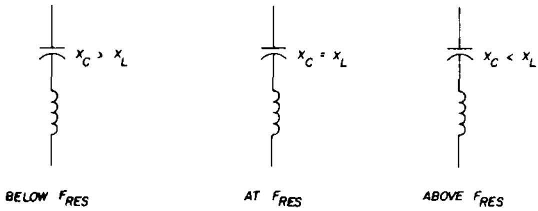
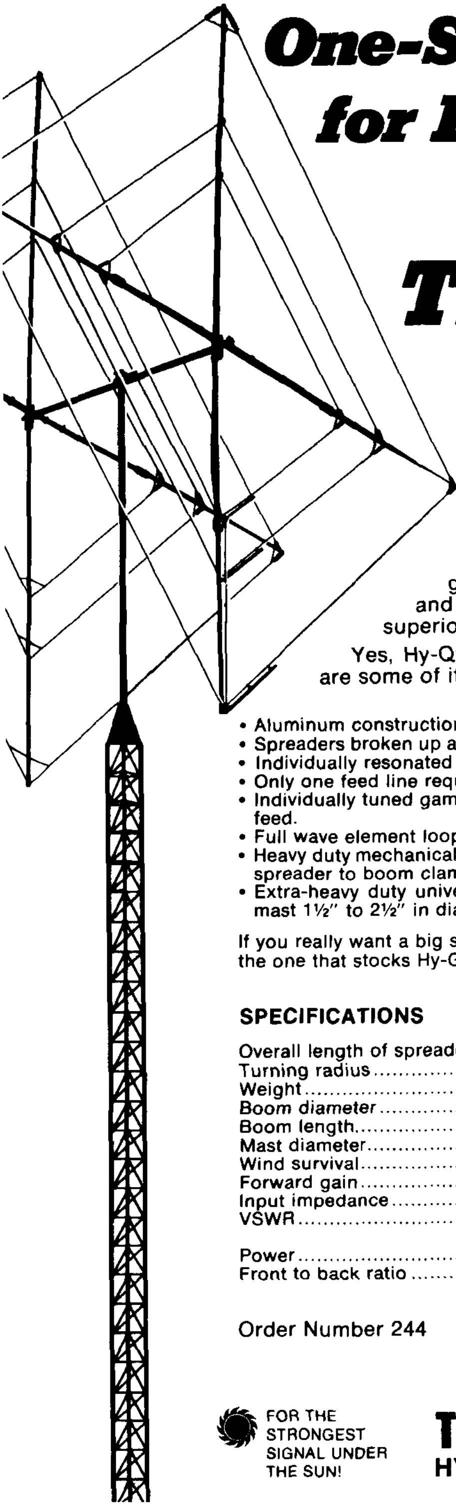


fig. 3. The behavior of capacitive reactance in a capacitor in terms of its self-resonant frequency.

In short (no pun intended), choose your bypass capacitor with care or you might as well not have a bypass at all.

ham radio



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SPECIFICATIONS

Overall length of spreaders	305"
Turning radius	13' 6"
Weight	42 lbs.
Boom diameter	2"
Boom length	8"
Mast diameter	1¼" to 2½"
Wind survival	100 MPH
Forward gain	8.5 db
Input impedance	52 ohms
VSWR	1.2:1 or better at resonance on all bands.
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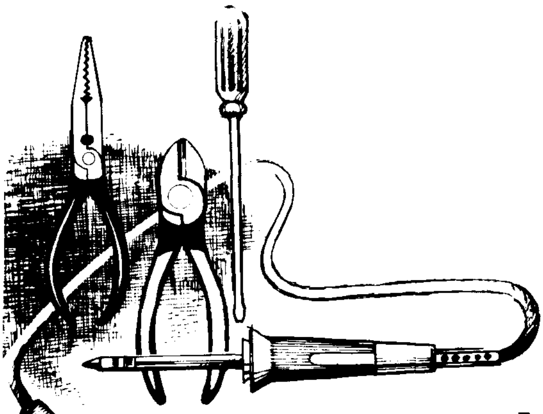


circuits and techniques

ed noll, W3FQJ

amateur applications for wwv-wwvh

WWV (Fort Collins, Colorado)[1], and WWVH (Kauai, Hawaii) transmit frequency and time signals plus other data that provide a variety of helpful services in the modern ham shack, from setting the station clock to measuring modulation. Many frequencies provide calibration points for receivers, frequency meters and calibrators. Standard audio tones permit calibration of audio sources used for testing ssb and f-m transmitters. One-second time-marking signals are transmitted continuously by both stations.

WWV broadcasts on carrier frequencies of 2.5, 5, 10, 15, and 25 MHz. WWVH transmits on the same carrier frequencies with the exception of 25 MHz. These standard signals, available day and night, are heard in most parts of the earth. The stability is exceptional, and frequencies are held stable to better than two parts in 10^{11}. In fact, deviations at WWV are normally less than one part in 10^{12} from day to day. Propagation variables such as Doppler effect, when they occur, usually result in a greater fluctuation in the carrier frequencies. This is a result of the path and not the standard.

signal makeup

In addition to serving as a carrier frequency standard, the modulation data carried by the WWV-WWVH transmissions is substantial. The broadcast format is shown in **fig. 1**. Transmissions from both stations are identical except for a few minor variations that will be mentioned.

The sequence and content for most minutes of each hour are depicted in **fig. 2**. At 00-second of each minute there is a 0.8-second long 1000-hertz tone on WWV and 1200-hertz tone on WWVH. Just prior there is a voice announcement of Greenwich mean time (gmt). Following the time pulse there are continuous second ticks that continue until the voice announcement that comes before the next time tone. The tone frequency is either 500 or 600 hertz, alternating between these frequencies each minute. The 29th second tick (pulse) is omitted.

The time announcement period extends between 45 and 60 seconds. At WWV the first half of this period is silent except for second ticks. The gmt time announcement is made in a male voice during the second half of this period. The positions switch for WWVH; the announcement comes first in a female voice and the silent period comes second. In those areas where both signals are re-

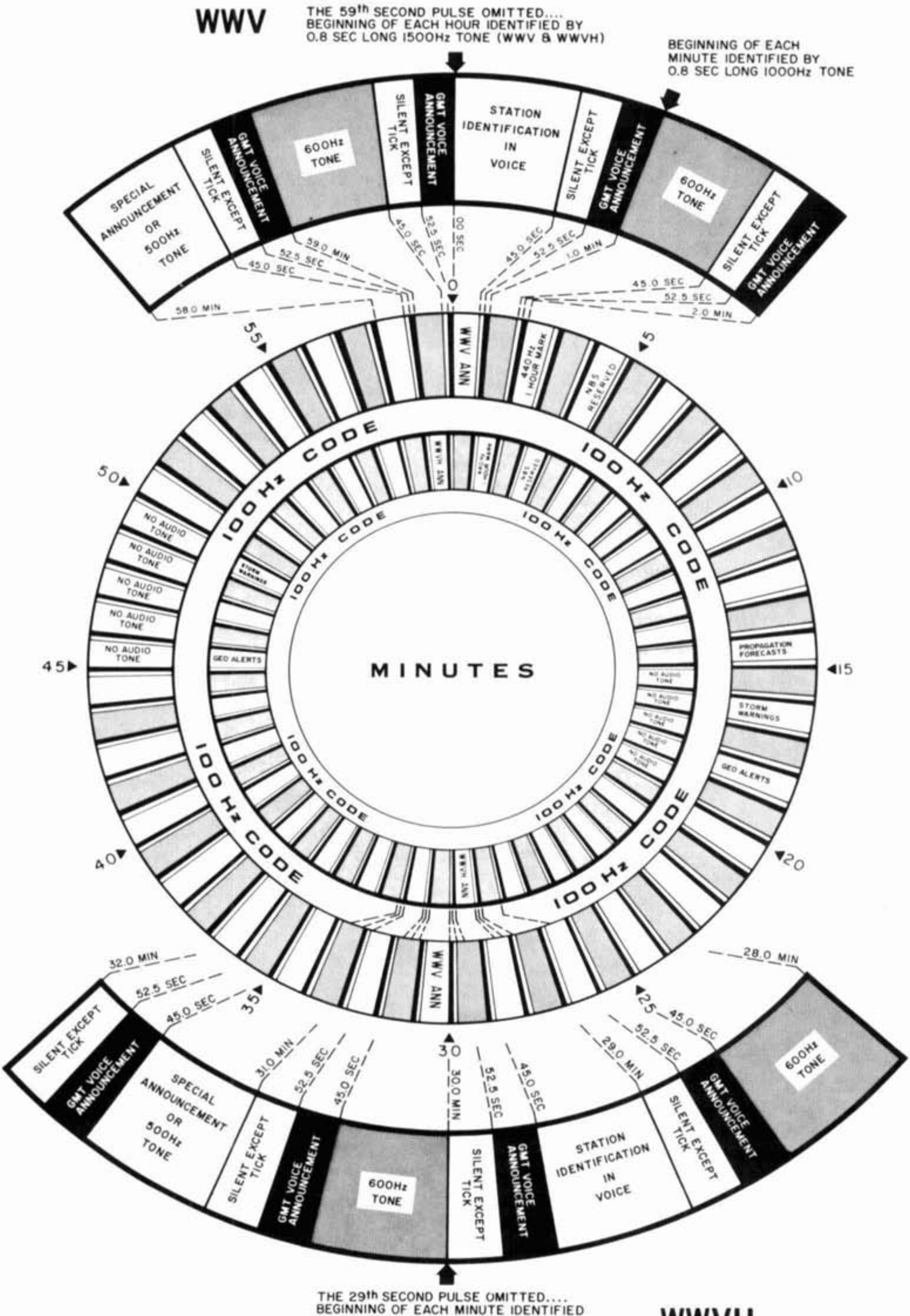


fig. 1. WWV and WWVH broadcast format.

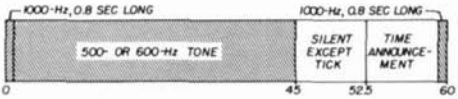


fig. 2. Typical content of a transmission minute from WWV. WWVH is similar except for 0.8-second segments.

ceived you hear the WWVH announcement first followed by the WWV announcement. The first minute of *each hour* begins with a 0.8-second, 1500-hertz tone on both stations.

Tone signals as displayed on an oscilloscope screen for 500 and 600 hertz frequncies are shown in **fig. 3.** This signal was demodulated in Pennsylvania from the 15-MHz carrier. Just above the 20-meter band this carrier is a good indicator of the transcontinental path quality on 20 and often for 15. When the WWVH signal is very audible in the background it indicates a path is open to the Pacific.

The stations identify on the hour and half hour. One station makes its announcement during the minute before the hour or half hour while the other station identifies itself during the minute after the hour or half hour.

Certain minutes of each hour are set aside for other emission sequences. As shown in **fig. 1,** no audio tone is transmitted between the 45th and 50th minute of each hour for WWV, and between the 15th and 20th minute for WWVH.

WWV gives propagation forecasts during the 14th minute of each hour, storm warnings during 49th minute.

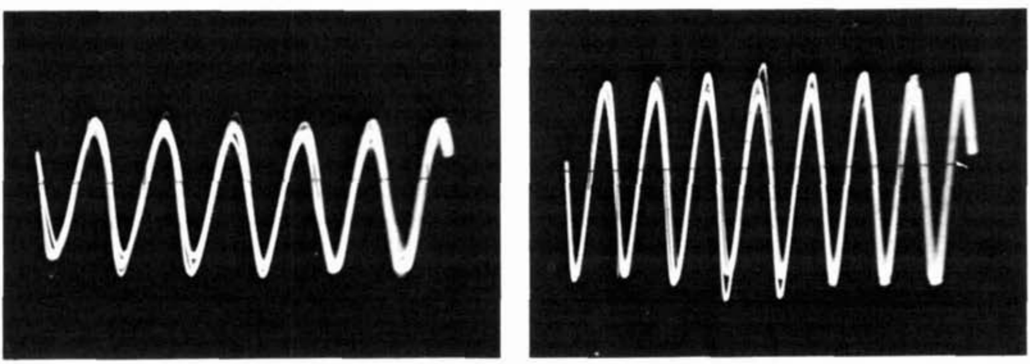
A 440-hertz tone is transmitted for minute. At WWVH the geophysical alerts are given during the 45th minute and storm warnings during 49th minute.

At 440-hertz tone is transmitted for approximately 45 seconds beginning one minute after the hour at WWVH and two minutes after the hour at WWV. This is a standard musical tone of note A above middle C. In addition, the tone can be used as hourly markers for various types of chart recorders and automated devices.

Special National Bureau of Standards transmissions are allocated a spot three minutes after the hour on WWVH and four minutes after the hour on WWV.

The makeup of the seconds-tick signal is shown in **fig. 4**. It occupies a time slot of 0.005 seconds and occurs once each second (one hertz repetition rate). The WWV pulse consists of five sine waves of 1000 hertz; the WWVH pulse, 6 cycles of 1200 hertz.

WWV and WWVH transmit a complex time code signal continuously. This code is produced at a one pulse per second rate and is carried on a 100 hertz subcarrier. It provides a standardized timing base containing time-of-year information based on universal time in seconds, minutes, hours and day of the year. It provides a standardized time for use when scientific



500 Hz pattern **600 Hz pattern**

fig. 3. WWV tones as received and displayed on oscilloscope screen.

observations are made simultaneously at separate locations. Perhaps it may be a help for radio amateur satellite communications systems. Ten-millisecond resolution is obtainable from these transmissions.

audio calibration

The standard audio tones from WWV are excellent for calibrating sine- and square-wave audio oscillators. Fixed-frequency and switchable solid-state audio generators such as two-tone oscillators and audio generators for checking fm deviation can be constructed and set on precise frequencies using the WWV signal and oscilloscopic Lissajous patterns.

Tunable audio or square wave generators also can be set or checked on a number of frequencies using fundamental, harmonic or sub-harmonic patterns. The demodulated WWV signal is applied to the vertical input of the oscilloscope as shown in **fig. 5**. From **table 1** note the variety of frequencies that can be measured using the harmonics and subharmonics of the two standard tones. When necessary other components can be derived from the 440 hertz tone, although it is only transmitted for one 45-second interval each hour.

It would be no problem to construct a switchable tone generator with certain key frequencies that could check the audio filters of CW, sideband, fm and a-m equipment. Several subharmonic and

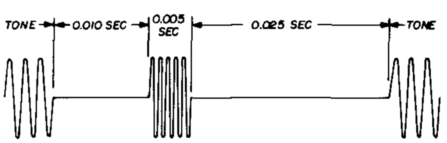


fig. 4. Makeup of second time pulses.

harmonic characteristic patterns are given in **fig. 6**. These were photographed at night while receiving the 10 MHz WWV signal.

stable audio oscillators

P. C. Lipoma[2] uses a Motorola

table 1. Checkpoints for calibration using WWV tones.

500 Hz WWV	600 Hz WWV	440 Hz WWV	Ratio
100	120	88	1-0.2
125	150	110	1-0.25
166+	200	146+	1-0.33
250	300	220	1-0.5
500	600	440	1-1
1000	1200	880	2-1
1500	1800	1320	3-1
2000	2400	1760	4-1
2500	3000	2200	5-1
3000	3600	2640	6-1

MC1454 integrated circuit in a Wein-bridge oscillator circuit, **fig. 7**. Frequency of operation is determined by the R1C1 and R2C2 time constants. Usually C1 and C2 are of equal value while the ratio of R1 and R2 is 2/1 to compensate for input and shunting impedances. Typically the capacitor value for 1000-hertz operation

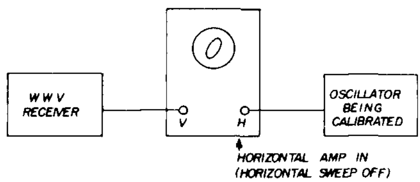


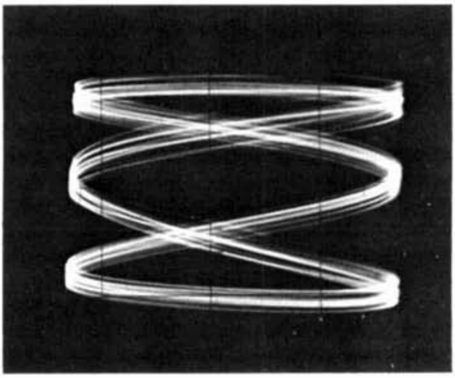
fig. 5. Setup for Lissajous calibration.

is 0.033 μF. To halve the frequency you would double the capacitor value; to double the frequency, halve the capacitor value. Resistor R2 could be made variable to permit precise frequency setting using the WWV standard tones. For example, a two-to-one Lissajous would set the oscillator precisely on 1000 hertz using the 500 hertz incoming standard.

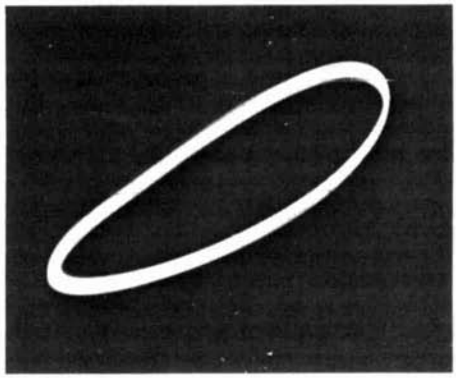
Two such oscillators would give you an excellent two-tone source. An oscillator with switchable capacitors would be good for checking audio filters.

radio-frequency calibration

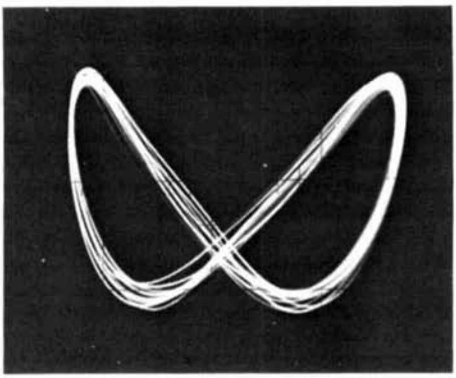
Radio-frequency calibration can also be made by applying the signal source along with the WWV signal to the receiver



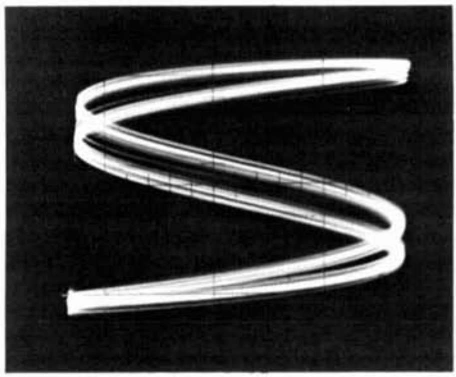
Ratio 1 to 0.33



Ratio 1 to 1



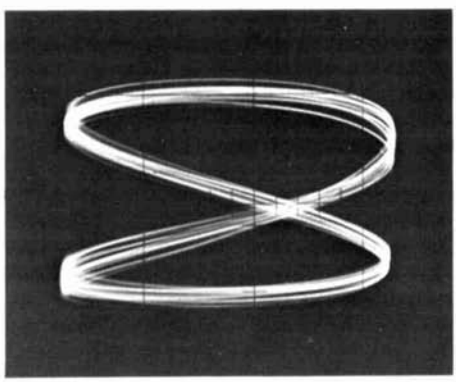
Ration 2 to 1



Ratio 3 to 1

fig. 6. Typical Lissajous patterns taken while receiving WWV. The test setup used is shown in figure 5.

input, **fig. 8**. You can calibrate by ear or make a more precise check by using an oscilloscope connected to the receiver i-f system. The pattern swells on each side of zero-beat of the rf oscillator under calibration, **fig. 9**. You obtain a similar pattern when checking a 5-MHz or 7.5 MHz source as you bring its harmonic output to beat with the 15-MHz WWV signal. In fact, it is easy to calibrate a 100-kHz harmonic oscillator such as those used in the usual crystal calibrator with the same procedure. A good calibration time exists during the 45-50 minute no-tone time interval of WWV-WWVH transmissions.



Ratio 1 to 0.5

propagation forecasts

WWV transmits propagation forecasts during the 14th minute of each hour. The telecommunications center of the Depart-

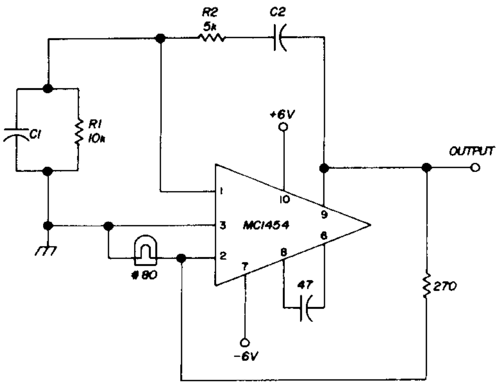


fig. 7. Integrated-circuit Wein-bridge audio oscillator. Making R2 variable would allow precise frequency adjustment using WWV as a standard.

ment of Commerce issues these forecasts daily at 0100, 0700, 1300 and 1900 gmt. Presently each forecast is broadcast unchanged on WWV until the next regular forecast is issued. They give an estimate of the radio quality expected on high-frequency radiocommunications circuits across the North Atlantic path. They apply to typical propagation paths such as Washington-Paris, New York-London and Washinton-Reykjavik. However, they are a good guide to propagation conditions for amateur band paths between eastern U. S. A. and Europe.

The forecast statement consists of a letter and a number. The letter is a state of current radio quality over the North

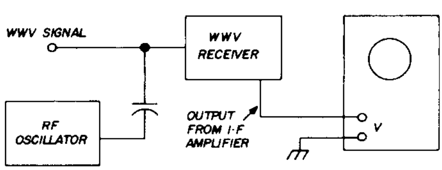


fig. 8. Setup for calibrating an rf oscillator with WWV signal.

Atlantic path at the time of issue. It is expressed in one of three grades:

N Normal or quiet
U Unsettled
W Disturbed

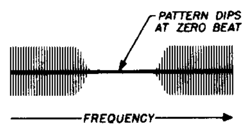
The number in the forecast states the expected value of radio propagation quality on a scale of 1 to 9:

1. Useless
2. Very poor
3. Poor
4. Poor to Fair
5. Fair
6. Fair to good
7. Good
8. Very good
9. Excellent

geophysical alerts

Solar and geophysical information is broadcast on WWV 18 minutes after the hour and on WWVH at 40 minutes after the hour. Information is changed daily after 0400 gmt. However, outstanding events are added to the next hourly announcement as soon as they are identified. The information transmitted concerns solar activity, flux and flaring, proton events and flares and conditions of the geomagnetic field. For example the solar flux is announced and a forecast

fig. 9. Comparative oscilloscope patterns showing zero-beat.

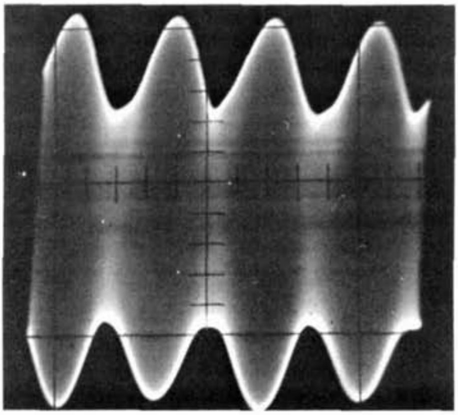


made whether solar activity is to be very low, low, moderate, high or very high. A geomagnetic field broadcast will state whether the field is to be quiet, unsettled or active and when a geomagnetic storm is to be expected.

Radio propagation conditions are affected by many factors including solar and geophysical events, and the weather. Hams who delve into the complex subject of propagation forecasting can tie their results in with the various types of data transmitted by WWV-WWVH. Those of us who keep schedules across the North Atlantic path look forward to those great N9 conditions.

oscilloscopic sideband patterns

Service-type oscilloscopes are available at reasonable cost. Most hams own or have access to such an oscilloscope. Most



Carrier present.

fig. 10. Oscilloscope patterns of a phasing-type sideband generator with single tone modulation.

of these instruments have a frequency response in the vertical amplifier system that extends to 4 MHz and higher.

One of the problems of observing and measuring solid-state units is their relatively low voltage and low power level. The high sensitivity of an oscilloscope with a usable vertical amplifier tends to overcome this observation problem. Observations at 160 meters and even 40 and 80 meters are possible.

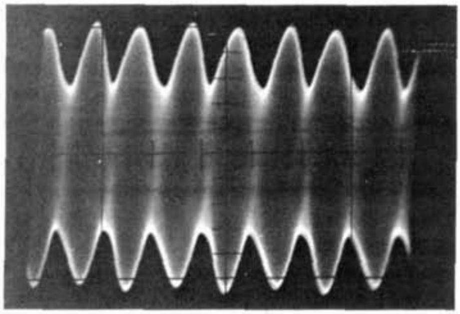
In the early days of sideband operation much equipment was home-built and many hams were well versed in ssb adjustment, measurement and observation techniques. Solid-state science and QRP activities have brought about a renewed interest.

The set of oscilloscopic displays shown in **fig. 10** were photographed from the screen of a service-type oscilloscope. Each of the patterns is labeled and is appropriate for various types of solid-state sideband gear, including a 160-meter phasing-type IC sideband generator to be covered in a future column.

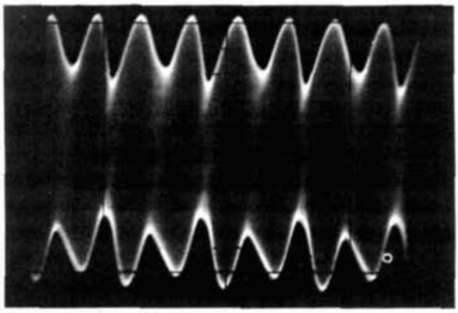
references

1. P. P. Viezbicke, "NBS Frequency and Time Broadcast Services," NBS Bulletin 236, U. S. Department of Commerce.
2. P. C. Lipoma, "$5 Wein-Bridge Oscillator," *Electronic Design*, April 29, 1971, page 65.

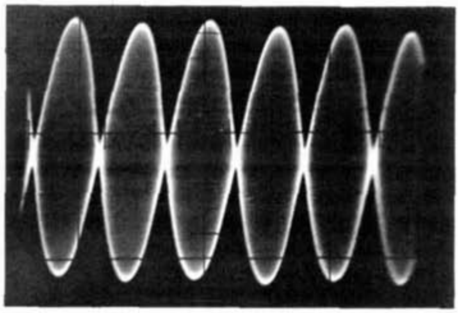
ham radio



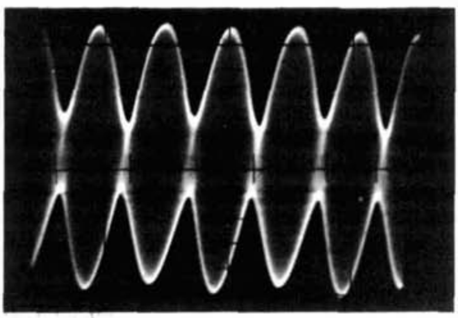
Undesired sideband component.



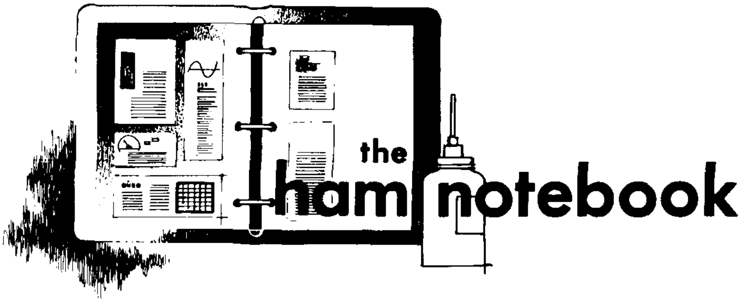
Carrier and undesired sideband.



Output of balanced modulator shows limited topping.



Output of balanced modulator with carrier feedthrough.



audio filter mod

The circuit in **fig. 1.** is a simple modification of W4NVK's audio filter* that provides variable selectivity with little loss in gain. The 5- to 25-ohm carbon resistor in series with the 88-mH inductor lowers the effective Q of the circuit and broadens frequency response. By adding a rotary switch and several different resistance values you can provide several steps of selectivity. For my purposes one resistor was selected for intermediate bandwidth; a shorting switch removes the resistor from the circuit for sharp selectivity.

Fred Redburn, K6HIU

plug-in toroids

When developing a circuit, you often wish to get it working as soon as possible on one band, with the provision of experimenting on other bands when time permits. A permanent installation is usually out of the question. One simple way to circumvent this problem is to apply a variation of the old plug-in coil technique – use a screw-in toroid.

Two basic parts are the screw-in terminal strip with as many terminals as the tank circuit requires, and a circuit board large enough to accommodate the toroid and its associated capacitors. The leading edge of the board is drilled and filed to accept the terminal strip; the toroid and capacitances are mounted; copper strips are etched to make the connections at the terminal-strip mounting screws. I have used this idea in my direct-conversion receiver and I can easily extend the receiver's coverage with a new screw-in toroid.

It is difficult to approximate the mechanical stability of this setup in touchy oscillator circuits – the thing is as solid as the chassis. With sturdy construction this technique offers better matching in multiband rf finals and drivers. Optimum matching and loading is impossible on different bands by the usual method of tapping down on coils or shorting out sections. The leads associated with the rf tanks in transistor stages must be kept short and as low-loss as possible. You can plug in the optimally tuned circuit for each band without the losses and leads associated with band-

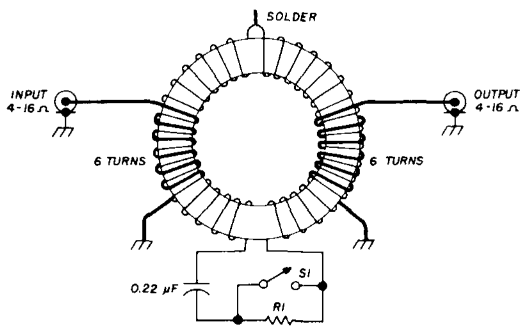


fig. 1. Selectivity of simple audio filter is changed by adding ½-watt resistor, R1, in series with inductor. Value of R1 is 5 to 20 ohms, depending on desired selectivity. Selectivity is broad with S1 open, sharp with S1 closed.

*E. Dusina, W4NVK, "The Simplest Audio Filter," *ham radio,* October, 1970, page 44.

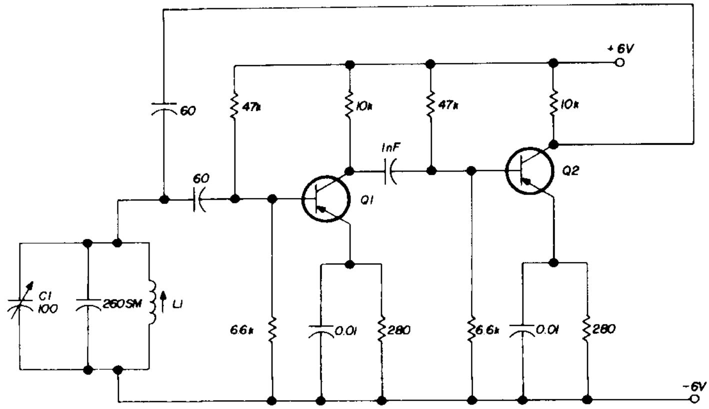


fig. 2. Franklin oscillator using pnp transistors. Use a stable, double-bearing variable capacitor at C1. L1 is 25 turns no. 30, closewound on 3/8-inch iron-core form.

switches and multiband design compromises. On some popular matching systems such as the double-pi section it is easy to lose efficiency by using conventional turns-shorting techniques. With plug-in toroids you get maximum efficiency on each band — this particularly important to the QRP enthusiast.

Adrian Weiss, K8EEG

franklin oscillator

Although known for many years, the Franklin oscillator circuit is seldom found in amateur-built gear. Yet it offers one of the most stable and at the same time most fool-proof circuits available. Nothing about it is critical. It is almost impossible to foul it up to the extent that it won't work! There is no tap on an inductor to juggle for proper feedback. There is no capacitance-dividing network to complicate computation of L/C ratios.

Usually, when you see the Franklin oscillator circuit, it is used with high-impedance active devices, vacuum tubes or field-effect transistors. It will work, though, with bipolar transistors by revising the size of the two capacitors that serve as both feedback devices and isolators. (When used with vacuum tubes or fets, these capacitors are very small, about 2 pF, and therefore serve to isolate the tuned circuit from the possible variations of internal capacitance in the tubes or fets.) With low-impedance active devices, such as bipolar transistors, these capacitors must be increased to around 60 pF to maintain proper feedback. This larger capacitance does not seem to have any deteriorating affect upon frequency stability.

The Franklin circuit, as you'll recognize from the diagram, is closely related to the multivibrator. In fact, that's what it is, with the addition of a tuned circuit to encourage oscillation on a single frequency and with reasonably good waveform. It will oscillate quite readily if you use *hot* rf transistors; don't try to use transistors not designated for rf. If you feed the circuit with regulated dc frequency stability is quite remarkable.

The fourth harmonic of an eighty-meter oscillator, beat against the carrier of a Voice of America propaganda broadcasting station a little above 15 MHz, retained the same audio beat note for hours at a time!

There's little to be said about construction technique, other than the components involved in the Franklin circuit lend themselves to an orderly array on a perforated board; the physical layout is almost exactly like the schematic diagram. Other than one lead, which runs the full length from back to front, there are no cross-overs. A printed circuit devotee should be able to defeat that cross-over by a long end run!

As with any high-stability low-power oscillator it is best to extract the excitation voltage through an emitter-follower or source-follower stage to avoid disturbing external influences. The buffer stage can be attached to the collector of either transistor. Use as small a coupling capacitor as possible to reduce loading effects.

Carl Drumeller, W5JJ

paralleling power transistors

Theoretically speaking, whenever the power requirements of a particular design cannot be satisfied by a single transistor, several transistors can simply be paralleled to meet the power specifications. In practice, however, this is not always true. **Fig. 3** will help explain this.

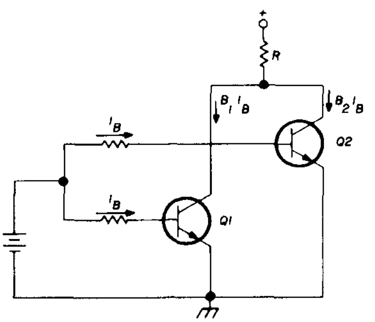


fig. 3. Parallel power transistors Q1 and Q2 share the current through resistor R.

Assume that two transistors, Q1 and Q2, are parallel connected to carry the current through load resistor R. If both devices receive the same base drive I_b, the collector current through each transistor will be determined by its own current gain (B). For many transistor types, the current gain of a given device can differ by as much as a factor of 10 from another device of the same type and still meet the manufacturer's specifications. If, for example, Q1 has a current gain five times as large as the B of Q2, then Q1 will conduct five times as much collector current as Q2 if both receive the same base current. Obviously, a condition of this sort could lead to the eventual destruction of both devices.

In addition to variations in current gains, variations in base-emitter voltages also affect the current conducted by selected devices. As shown by **fig. 4**, V_{be} partially determines the base current received by a transistor, and this current produces the collector current. Differences in base emitter voltages (V_{be}) between paralleled devices, therefore, will

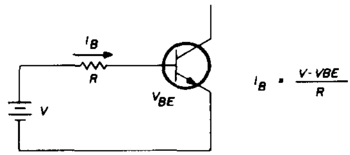


fig. 4. Base current is determined by supply voltage V, emitter-base voltage Vbe and resistance R.

affect the load currents carried by the individual devices.

Identical transistors can be paralleled without an unequal sharing of load currents. Identical devices can be purchased, but they are usually quite expensive in relation to the common garden variety devices. Transistors found on the same integrated circuit chip, incidently, are many times almost perfectly matched and can be easily paralleled.

The adverse effects induced by differences in both current gains and base-emitter voltages in paralleled transistors can be minimized by addition of negative feedback to each individual circuit. This is most easily accomplished by simply placing a resistor in each emitter circuit – the larger the resistor, the smaller the current imbalances in the devices. A point will be reached quickly where further increases in the size of the emitter resistors will not appreciably decrease the current imbalance in randomly selected devices.

Fig. 5 is included as an aid in selecting the proper value of resistance. According to Smith,[1] this curve is based on statistical data obtained from randomly selected silicon npn transistors. Bear in mind that the curve is approximate and should be used only as a guideline.

As an example, consider that two parallel transistors are to share a 20 ampere load current equally (10 amperes apiece) and that each has an emitter resistance of 0.25 ohms. From **fig. 5** (curve A), it can be seen that a current imbalance of 10% is possible. Since 10% of 10 amperes is 1 ampere, one of the transistors could conceivably conduct 11 (10 + 1) amps. Without the resistors, an imbalance of 35% is possible, and one of the devices could see 13.5 (10 + 3.5) amperes.

If more than two transistors must be placed in parallel, curve B should be employed.

James E. McAlister, WA5EKA

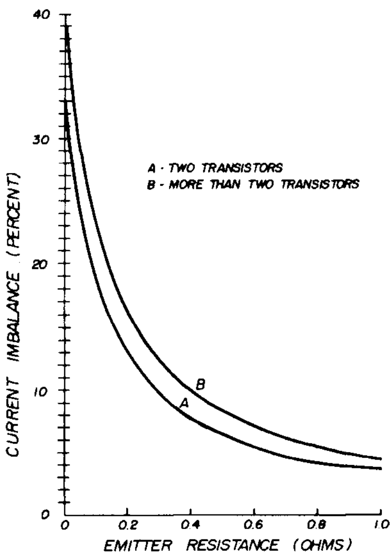
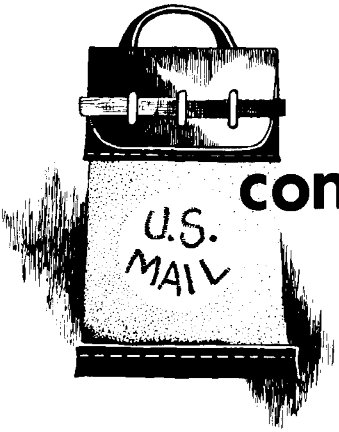


fig. 5. Graph for determining value of emitter resistor when placing power transistors in parallel.

reference

1. Robert S. Smith, "Selecting Current Sharing Resistors for NPN Silicon Power Transistors," *EDN Magazine*, March 15, 1969.



comments

army loop antenna

Dear HR:

The Army loop antenna mentioned in the September, 1971 issue (page 59) and the method of tuning it seems rather lossy and not very rugged mechanically. This is especially true since a good solid capacitor is already built into the antenna.

When coaxial cable is used for loop antenna construction the capacitance between the inner and outer conductors can be used to advantage both mechanically and electrically. A balanced loop such as the one described could be constructed leaving the inner conductor floating and sealed at the feedpoint. Prune-tune as required from the center equally in both directions. Since an unbalanced coaxial feed does not do too much for a balanced antenna it might be just as well to use one side of the coax loop for one feedpoint and the other side for the other, and do all of the prune-tuning at the base where it is handy.

There is one limitation to this type of loop construction: the inductance and capacitance of the coaxial cable used, i. e. the diameter of the loop and the type of the cable. For a quick check I took a 38-foot section of ½-inch semiflexible line (25 pF per foot) which ran in a single-turn loop and grid-dipped it at about 10.5 MHz. A 7-MHz loop antenna with the inner and outer conductors of the same length are a practical size and could be used on 75 meters with a plug-in series capacitor.

Since short loops have quite low radiation resistance, the resistance of all conductors and connections must be kept to a minimum. Coaxial-cable construction should minimize (or eliminate) the need for additional tuning units that are lossy, bulky and do not stand the weather very well. Vinyl-covered coaxial cable is well protected from corrosion and the weather, and the ends can be sealed and painted with corona reducing material; rf power-handling depends upon the size of the cable. There are a number of easy-to-form semiflexible cables from which to choose.

This type of coaxial cable also makes a good solid weatherproof gamma rod capacitor for feeding parasitic beams because it eliminates the corroding slide rod and variable capacitor. Prune-tuning the coaxial-cable gamma matching system may take a little longer but is well worth the effort when it comes to durability. I used such a gamma match on a recently built full-size loop antenna (one wavelength long) to good advantage; the winter snow and icing are rough down here!

Wayne W. Cooper, K4ZZV
Miami Shores, Florida

1296 preamplifier

Dear HR:

In WA2VTR's "Low-Noise 1296-MHz Preamplifier" article in the June, 1971 issue of *ham radio* the author referred to Hewlett-Packard 5082-2800 hot-carrier diodes as mixers at these frequencies. This device is a good high-level mixer, but the HP 5082-2835 is a much better low-noise uhf mixer.* They are low cost, too.

Leonard J. Petraitis, W9IKW
Regional Sales Manager
Hewlett Packard
Skokie, Illinois 60076

infrared communications

Dear HR:

In "Gallium Arsenide LED Experiments" in the June, 1970 issue W4KAE describes some equipment for using infrared light-emitting diodes and photodetectors for communications. I've experimented since about 1969 with LEDs but the big problem has been building lens systems which are rigid enough to stand up under continuous use, yet allow easy adjustment. This is the hardest part if you don't have a fully equipped machine shop. I recently came across a piece of equipment which, though designed for something completely different, can easily be converted for communications. A photoelectric cell system designed for burglar alarms, and made by the Alarm Device Manufacturing Company, 165 Eileen Way, Syosset, Long Island, New York 11791.

One version of this series of burglar alarm equipment is the model 1312 *Small Laser Photoelectric System* which actually uses a LED pulsed at several kHz, and a silicon photodiode detector. It comes in two units, one with the LED and the other with the detector. In

*In addition, the HP 5082-2835 has a typical capacitance of 0.75 pF as compared to 2.0 pF for the 5082-2800. Therefore, it is less apt to operate as a varactor. **editor** burglar alarms it has a guaranteed range of 800 feet (assuming no fog or rain), but most units can be used for quite a bit more. Both units are complete with mounting hardware, optics, an easily adjustable swivel arrangement and case, and are designed for installation by inexperienced installers. To convert it to communications it is only necessary to modulate the pulsing circuit to produce pulse frequency modulation and detect the fm in the output.

For serious experimenters the price of $125 may make the system of some interest, but it is hard to get, since the manufacturer sells only to burglar alarm installation companies. If your local alarm installer refuses to sell you one, or if he wants too much of a markup, I can get a limited number at the above price, including shipping.

Peter A. Stark, K2OAW
Mount Kisco, New York

RTTY afc

Dear HR:

While reading the article, "Automatic Frequency Control for RTTY" in the September, 1971 issue, I came across one point that should be clarified for the benefit of your readers. In the article W5NPD states that in most RTTY signals 2975 Hz is used as the mark tone and that this tone is present for a larger percentage of the time. It should be noted that the standard mark tone has been 2125 Hz for years; most, if not all, AFSK systems use 2125 Hz for mark. Many builders have omitted a normal/reverse switch and straight wired the unit in the normal 2125-Hz position.

To use 2975 Hz as the mark tone the operator should listen in the upper sideband (bfo low) position with the normal/reverse switch on the converter in the reverse position. For those who use their converter in the normal (bfo high, lower sideband) position, it is feasible to build the afc using 2125 Hz as the standard for the discriminator tuned circuits.

Tony King, WA4UPE
College Park, Georgia

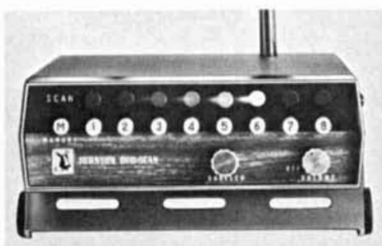
new products

ham wattmeter

Designed especially for the amateur radio market, three new rf wattmeters are now available from Bird Electronic Corporation. Two models will cover the frequency range from 1.8 through 30 MHz and the third covers from 50 to 150 MHz. The Model 4350 measures forward and reflected power in two ranges: 200 w and 2000 w, while the Model 4351 has ranges of 200 w and 1000 w. The Model 4352 has ranges of 40 w and 400 w covering the two vhf bands of six meters and two meters.

The new line of wattmeters are designated Ham-Mate,* and use the well known Thruline construction, made famous in the industrial field by the Bird Model 43. The new wattmeters emphasize dependable rf power measurement. Special attention is given to the directivity of the Ham-Mate, which is the ability to differentiate between rf power flowing in opposite directions in a transmission line. The new Ham-Mate has a minimum of 20-dB directivity which assures meaningful reflected power and vswr measurement. All three models sell for $79. More information is available by using *check-off* on page 94, or by writing to Bird Electronic Corporation, 30303 Aurora Road, Cleveland, Ohio 44139.

scanning receiver



A new fm monitor receiver which covers both low- and high-band vhf channels has been introduced by the E. F. Johnson Company. Called the Duo-Scan* monitor receiver, it features dual-conversion circuitry and a double ceramic filter. The two ceramic filters result in sharp selectivity characteristics and an adjacent channel rejection of 60 dB. Another feature of the new Duo-Scan is an integrated-circuit limiting system. This IC limiting produces a symmetrically *hard*

*Ham-Mate and Thruline are registered trademarks of the Bird Electronic Corporation.

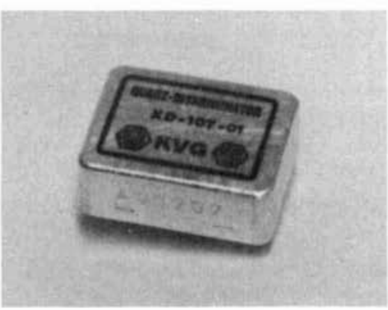
More Details? CHECK—OFF Page 94

pattern that effectively eliminates noise. The receiver's all solid-state circuitry has a sensitivity of 0.4 μV for 12 dB SINAD.

The Duo-Scan receiver has eight channels which can be any low- and high-band combination. If just one low-band frequency is to be monitored, for instance, the remaining seven channels can all be used for high-band monitoring. This allows you to monitor all the local 2-meter repeaters and the activity on 52-525 MHz. Programming channels for high- or low-band is done with simple jumper plugs, requiring no rewiring or tuneup adjustments. Each channel has a lock-out pushbutton to permit bypassing of that channel if desired. The monitor can also be used in the manual mode with the pushbuttons used to lock in channels.

A built-in power supply allows both 12-Vdc mobile operation and 117-Vac base-station operation. Other features include noise-operated squelch, channel selector indicator lights and external speaker jack. Suggested price for the receiver is $169.95. Complete details are available from local E. F. Johnson dealers, by writing directly to the E. F. Johnson Company, Waseca, Minnesota 56093, or by using *check-off* on page 94.

crystal discriminators

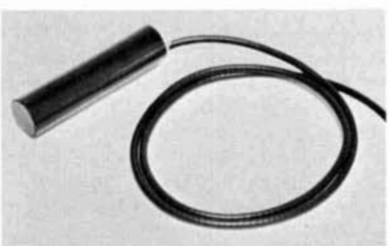


Spectrum International has added five new crystal discriminators to their line of crystal products manufactured by KVG in West Germany. The new models, XD 9-01, XD 9-02 and XD 9-03 are designed for RTTY, afc and lab measurements with a 9-MHz center frequency, the model XD 107-01 for narrow-band fm and the model XD 107-02 for wide-band fm. Both fm versions have a center frequency of 10.7 MHz.

Crystal discriminators make simple and effective demodulators for fm and RTTY receivers. The receiver i-f output is fed into the discriminator input, and audio output results without the tedious alignment and power requirements of ratio detectors and LC discriminators. Input and output transformers are included in the hermetically sealed crystal discriminator package. Compatible with tube or solid-state equipment, these miniaturized discriminators are designed for replacement in high-density conventional equipment along with new miniaturized designs.

The line of five filters include models with deviation between 5 and 50 kHz. All models have standardized input terminations of 500 ohms and outputs of 100 kilohms. Models are priced at $14.95 and $16.95. Complete technical specifications are available from Spectrum International, Box 87, Topsfield, Massachusetts 01983 or use *check-off* on page 94.

sniff-it rf detector



The Dycomm Sniff-It turns any vtvm or vom into a versatile rf detector. The model DS-1 Sniff-It indicates the presence of rf from the lowest intermediate frequencies up to uhf at power levels ranging from one milliwatt to 250 watts. A typical reading with the Sniff-It connected to a Simpson 260 vom on the 50-μA range would be 5 to 10 μA when placed near a 1-mW 450-MHz oscillator.

Uses for the Sniff-It include troubleshooting receivers (by indicating the presence of signals near the rf and i-f stages and output from the local oscillator), aligning converters, peaking crystal oscillators and QRP projects and balancing push-pull amplifier stages (by placing the Sniff-It next to each stage and adjusting until equal readings are obtained). When tvi proofing the station, the Sniff-It detects rf leaks around the transmitter cabinets, feedthrough to cables, coax shield breaks leaking rf, local oscillators pumping out too much rf and unneutralized rf stages.

The Sniff-It can also be used in adjusting antennas. You can run the Sniff-It along a ¼-wave whip and check for nulls. If the null is at the end of the antenna you know you have the right length. If the null comes before the tip of the antenna you know that the antenna is too long. Similarly, antenna feedlines and 5/8-wave-length verticals can be adjusted by checking for nulls and comparing your findings to the theoretical figures found in any good antenna handbook.

By choosing the current range on the vom, the Sniff-It detects a wide range of power levels. A vtvm can be used to show relative voltage drops across a load resistor.

The Sniff-It is available for $5 from Dycomm, 948 Avenue E, Riviera Beach, Florida 33404. More information is available by using *check-off* on page 94.

fm transceiver with frequency synthesized receiver

Clegg's nwe FM-27 is a completely solid-state mobile transceiver using a *Crystiplexer* tuner. The *Crystiplexer* is a new synthesizing system that allows any channel in the range of 146-147 MHz to

More Details? CHECK—OFF Page 94

JUGE

More Details? CHECK—OFF Page 94

be monitored with crystal precision — but without the need for additional crystals. To monitor any specific frequency within this band the operator merely sets the two receiver controls to numbers corresponding to the desired frequency. To monitor 146.94, for example, the operator sets the first control to 9, and the second to 4.

Receiver selectivity is rated at 70-dB adjacent-channel attenuation. Sensitivity is rated at better than 0.35 μV for 20-dB quieting.

The transmitter portion of the new transceiver is 10-channel solid-state unit with 20-25 watts rf output. The entire transceiver weighs less than three pounds and is packaged in a rugged anti-theft case with a special locking-clamp mounting. Two crystal-controlled transmit channels and a push-to-talk microphone are included at the sales price of $449.95.

Further information is available through *check-off* on page 94 or by writing to Clegg Division, International Signal and Control Corporation, Box 388, R. D. 3, Lititz, Pennsylvania 17543.

tube and transistor substitution guide

Tab books has brought out the updated 3rd edition of their handy servicing substitution guide. The 256-page "1972 Popular Tube/Transistor Substitution Guide" is designed to fit in a tube caddy and lists 99% of the tubes and transistors which normally need replacing in home-entertainment equipment. Moreover, only readily-available and comparably-priced substitutes are listed — no need to search through lists of tubes and transistors rarely used.

This brand-new volume contains 8 sections — four devoted to tubes and four to transistors. Section 1 provides a cross-reference of popular American receiving tubes, listing substitutes which have similar or superior characteristics and which require no mechanical changes or circuit modifications. For convenience, the *best* substitute is listed separately from others that may be used. Section 2 lists substitutes for popular tube types found in commercial and industrial equipment. Again, the most appropriate substitute is identified. Section 3 provides a cross-reference of popular foreign/American tube types, and Section 4 illustrates base diagrams for all tubes.

Section 5 contains a complete listing of popular American transistors and the most readily-available, popularly-priced substitutes. Section 6 lists American substitutes for the most often encountered foreign transistors. Section 7 lists general-purpose replacements, offered by leading manufacturers. Section 8 illustrates base diagrams keyed to the original type listings.

The vinyl-covered version of the book costs $4.95 and the paperback is $2.95 from Tab Books, Blue Ridge Summit, Pennsylvania 17214. More information is available by using *check-off* on page 94.

audio ics

Radio amateurs and experimenters may benefit from two new audio integrated circuits introduced by Motorola. The two new ICs, while designed for such consumer product applications as televisions, radios and portable phonographs, should also work well in many amateur receiver and experimental designs.

The MFC9020 is rated at two watts output and is housed in a plastic package with two heat dissipating tabs. The MFC6070 is the one-watt version and is supplied in a smaller case. Printed-circuit board layouts which can be used interchangeably with either device, are shown on the respective data sheets. The boards are designed for speaker return to either ground or to the positive supply. Input impedance is in the order of a megohm, and only 200 mV input is required for full output. Total harmonic distortion averages about 1% at rated output.

For further information, please contact the Technical Information Center, Motorola Inc., Semiconductor Products Division, Box 20924, Phoenix, Arizona 85036 or use *check-off* on page 94.

More Details? CHECK—OFF Page 94

reference data for radio engineers

Whether you are in amateur radio, commercial radio or electronics, the new fifth edition of "Reference Data for Radio Engineers" is an invaluable tool. This new compilation of approximately 1150 pages and 1350 illustrations plus a comprehensive index and cross-index was made by an extremely qualified group of practicing engineers, professors, and industry and government experts under the direction of the staff of the International Telephone and Telegraph Corporation.

The book is skillfully written, greatly enlarged and meticulously revised and edited. Approximately 50% of the text is new material, including seven subject areas not covered by the fourth edition. In addition to the basic phases of electronics, there is new material on microminiature electronics, space communications, navigation aids, quantum electronics and many other topics.

In 1942, the British subsidiary of ITT, Standard Telephones and Cables Limited, saw the need for a complete, reliable reference source for the radio and electronics engineer. Thus, the first edition of this reference was developed as a 60 page brochure. Because of the enthusiastic reception of information compiled under one cover, the brochure has grown into a book-length volume.

Its usefulness, however, is not restricted to the practicing radio and electronics engineer for whom it was originally prepared. *Reference Data for Radio Engineers* has been accepted for classroom use in over 200 leading colleges and universities in the United States.

The text is generously supplemented with literally hundreds of charts, nomographs, diagrams, tables, circuit information, illustrations and an inexhaustible index and cross-index. 1150 pages, hard bound. Published by Howard W. Sams & Company. $20.00 postpaid from Comtec Books, Post Office Box 592, Amherst, New Hampshire 03031.

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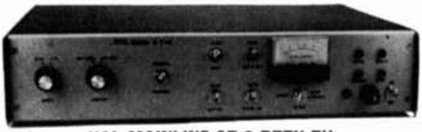

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Complete parts kit, excluding keyboard, for the W4UX CW code-typer. All circuitry on one 3 x 6" G10 glass PC board. Plug-in IC sockets. Optional contest ID available, $35.00. Watch for announcement of the new **HAL** code-typers, both Morse and RTTY.

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HAL DEVICES

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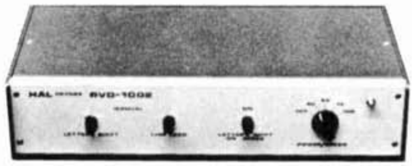

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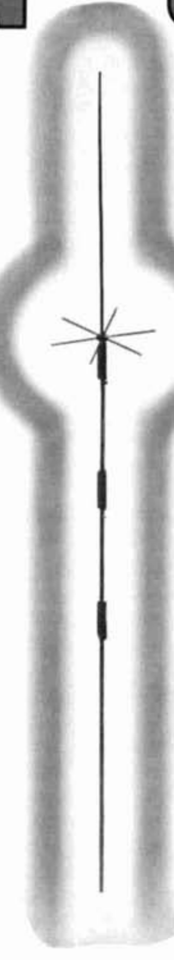

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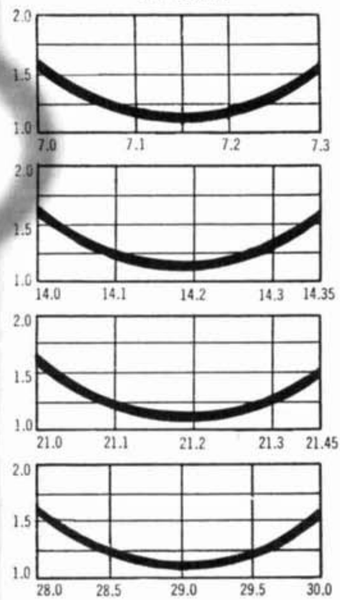

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SEVENTH ARKANSAS QSO PARTY. RULES: 2200 GMT Saturday, January 22 to 0400 GMT Monday, January 24. Arkansas stations score 1 point per contact and mulitply by the number of states, provinces, and countries worked. Outside stations score 5 points for each Arkansas station worked and multiply the total by the number of counties in Arkansas worked. Stations may be worked once on each band and each mode. Suggested frequencies (plus or minus 5) will be: C.W. 3560, 7060, 14,060, 21,060, 28,060; S.S.B.: 3960, 7260, 14,300, 21,360, 28,560; Novice: 3735, 7175, 21,110. Arkansas stations send QSO number, RS(T) and county. All others send QSO number, RS(T) and state, province or country. Logs and scores must be postmarked no later than February 21 and sent to the North Arkansas Amateur Radio Society, Inc., c/o Don Banta, WA5ZKE, Rt. 1, Green Forest Ark. 72638.

EXCLUSIVELY HAM TELETYPE — 19th year, **RTTY Journal**, articles, news, DX, VHF, classified ads. Sample 30¢. $3.00 per year. Box 837, Royal Oak, Michigan 48068.

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WANTED: HEATHKIT TUNNEL DIPPER must be in excellent condition. State price. For sale Ameco TX-62 with matching VFO. Both for $125. KG6ASC/5 3504 26th St., Lubbock, TX 79410.

WANTED: JULY, 1969 issue of Ham Radio Magazine. E. Alves, 275 So. Marengo Ave. #30, Pasadena, California 91106.

THE WHEATON COMMUNITY Radio Amateurs (WCRA) will hold the tenth annual Mid-Winter Swap and Shop on Sunday, February 20, 1972 at the DuPage County Fair Grounds, Wheaton, Illinois. Hours — 8.00 a.m. to 5:00 p.m. $1.00 Advance/ $1.50 donation at the door. Send SASE for advanced tickets P. O. Box QSL, Wheaton, Illinois 60187. Refreshments and unlimited parking. Bring your own tables. Free coffee and doughnuts 9:00 to 9:30 a.m. Hams, CBers, electronic hobbyists, friends and commercial exhibitors are cordially invited. Write W.C.R.A., L. O. Shaw, W9OKI, P. O. Box QSL, Wheaton Illinois (60187) for information.

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

TOROIDS 44 and 88 mhy. Unpotted, 5 for $1.50 ppd. W. Weinschenker, Box 353, Irwin, Pa. 15642.

KIT BUILDERS — All American Sports Amplifier (featured Sept. 1971 Popular Mechanics) now available with step by step instructions. Fantastic new (patent pending) amplified filter concept doubles normal TV viewing range. Free data sheet. CADCO SYSTEMS, Box 18904, Oklahoma City, Oklahoma 73118.

B.A.R.T.G. SPRING RTTY CONTEST. 0200 GMT Saturday, March 25th until 0200 GMT Monday, March 27, 1972. Not more than 36 hours of operation is permitted. Times spent listening count as operating time. The 12 hour non-operating period can be taken at any time, but off-periods may not be less than two hours. Times on and off the air must be on the Log and Score sheets. The Contest is also open to SWL RTTYers. 3.5, 7, 14. 21 and 28 Mhz. Amateur Bands. Stations may not be contacted more than once on any one Band. ARRL Countries List. except KL7, KH6 and VO to be considered as separate Countries. Messages exchanged will consist of: (A) Time GMT. (B) Message Number and RST. All two-way RTTY contacts within one's own Country will earn **TWO** points. All two-way RTTY contacts outside one's own Country will earn **TEN** points. All Stations will receive a bonus of **200** points per Country worked including their own. **NOTE** any one Country may be counted again if worked on another Band but Continents are counted once only. Two way exchange points times total Countries worked plus total Country points times number of Continents worked gives total score. Use one log for each Band. Logs to contain Band, Time GMT, Message and RST Numbers sent and received and exchange *points claimed.* ***ALL logs must be received by May 31, 1972 to qualify.*** Send to: Ted Double, G8CDW, B.A.R.T.G. Contest Manager, 89 Linden Gardens, Enfield, Middlesex, England.

ATTENTION DEALERS — stock All American Sports Amplifier long range TV receiving kits, featured September 1971 Popular Electronics. Write Dealer Divison, CADCO SYSTEMS, Box 18904, Oklahoma City, Oklahoma 73118.

QSLS. SECOND TO NONE. *Same day service.* Samples 25¢. Ray, K7HLR, Box 331, Clearfield, Utah 84015.

TV & RADIO TUBES 36¢. FREE catalog. Cornell, 4219 N. University, San Diego, California 92105.

NEW ELECTRONIC PARTS. Buy-Sell. Free Flyer. large catalog $1.00 deposit. Bigelow Electronics, Dept. HR, Bluffton, Ohio 45817.

HEATH SB-100 with AC supply, absolutely mint condition $300. Hallicrafters HT-32 transmitter FB $180. Both shipped prepaid. Cline, WB6LXI/7, Box 6127, Salt Lake City, Utah 84106.

FOR SALE: COLLINS STATION, 75S-3B, 32S-3, 516-F2, *all cables, manuals. Excellent condition.* $1000 FOB. Certified check of Money Order. Al Schnurle, St. Anthony, Idaho 83445.

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FAIRCHILD — PHILCO — RCA
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NEW LOW PRICES
RTL or TTL LOGIC

UL 900 Buffer	80¢	10/5.50
UL 914 Gate	80¢	10/5.50
UL 923 JK Flip-flop	$1.50	10/8.50
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MC 890P Dual JK Flip-flop	$2.00	10/18.95

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MC 780P Decade	$3.00
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MC 9760P Decade	5.00

ONE EACH OF 3 ABOVE $10.50

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7400 Quad 2 Input NAND Gate	65¢	10/5.95
7404 Hex Inverter	65¢	10/5.95
7441A Decimal Decoder/Driver	$3.50	10/29.95
NEW!! 7447 7 Segment Decoder/Driver	$3.10 each	10/$27.95
7473 Dual JK Flip-flop	$1.30	10/10.95
7475 Quad Latch	$2.10	10/19.95
7490 Decade Counter	$2.40	10/19.95
709 Op Amp	$1.75	10/16.50
741 Op Amp	$2.70	10/25.00
CA 3035 Linear Amplifier	$2.25	10/21.95

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14 Pin Dual Inline socket terminals 25¢ 10/2.25

16 Pin Dual Inline socket terminals 30¢ 10/2.75

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NEW NATIONAL Long Life Nixie tubes NL 940S 0-9 with two decimal points $4.50 ea. 10/42.95

SOCKET for NL 940S .... 50¢ each

100 KC CRYSTAL NEW $3.95

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Miniature read switch glass enclosure ¾" long. .... .35 ea. 10/$3.00

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$5.00 minimum order.
Please add sufficient postage.

COOLING FAN BLOWER 4 pole 110V 60 cyc motor with 4 bladed nylon fan. Very quiet, about 50 CFM 2¼"W x 3"H x 2¼"D. Sh. wt. 3 lbs. .... $2.25 each

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1000 PIV DIODES 1 Amp Epoxy .... 10/$2.95

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ARN-30 108-135 mc tunable receivers. High frequency version of the famous command receivers. Listen to local airport frequency or convert to 2 meters. Like New with schematic and operating instructions. 12 lbs. $14.95

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Western Union facsimile machines, send and receive pictures and memos. Works on 115 v 60 cycles. Shipped with auto-start, auto-phase pos-to-pos, conversion instructions. 20 lbs. $19.95

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Telfax paper for above facsimile.
2¢ each 1000 for $12.95

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Teletype model 14 printer pulled from service from Western Union. Units are in good condition. 75 lb. shipping weight. While they last .... $29.95 ea.

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BACK WITH AN EVEN BETTER SUPPLY

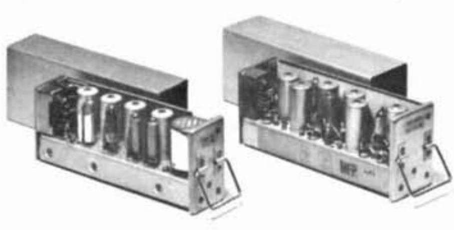
R & R has the Motorola Plug In's we sold out of last year and more.

We now have the popular LOW BAND 25-50 MC equipment. Unit comes with these plug-ins:

- 1st IF & 2nd Mixer
- RF & 1st Mixer
- Oscillator-Doubler unit-Amplifier
- 2nd IF & Discriminator
- Audio Squelch
- Filter Unit

SCHEMATIC Diagrams for all units supplied

COMPLETE SET $9.95



More Details? CHECK—OFF Page 94

SB-301 AM CW Filters 6M Convertor $260, SB-401 $265, DX-60A $55, HG-10 $25, Unassembled SB-110A Hp-23A power $320, AR-15 stereo $320. Built by engineer with experience. Accessories included. WB4LYZ, 133 Laird, Nashville, TN 37205.

NEWSPAPER OF AMATEUR RADIO. Free sample copy. Worldradio, 2509 Donner, Sacramento, CA 95818.

ORIGINAL EZ-IN DOUBLE HOLDERS display 20 cards in plastic, 3 for $1.00, 10 for $3.00 prepaid. Guaranteed. Patented. Free sample to dealers. Tepabco, John K4NMT, Box 198R, Gallatin, Tenn. 37066.

VHF NOISE BLANKER — See Westcom ad in Dec. '70 and Mar. '71 Ham Radio.

TONE ENCODERS AND DECODERS — New line of solid state encoders and decoders compatible with any sub-audible continuous tone system. Small in size, usable from 67-250 Hz, $8.95 to $14.95. Send for literature. Communications Specialists, Box 153, Brea, Calif. 92621.

AUTOMATIC MORSE CODE Copying Machine. Featured in Ham Radio Magazine November 1971. Copy up to 120 wpm without knowing Morse code. Simply hook to your receiver's audio and read printout. Send $14.95 for detailed construction plans. VMG Electronics, 2138H West Sunnyside Phoenix, Arizona 85029.

ASK HARRY FIRST Ameco, Clegg, Cushcraft, Galaxy, Hallicrafters, Hy-Gain, Mosely, Regency, Sonar, Simpson, Ten Tec, others. Good trades accepted. S.A.S.E. Name literature wanted. Harry's Amateur Radio Supply, 3528 Gaskin Rd. (Belgium) Baldwinsville, N. Y. 13027. 10AM-9PM. Closed Sunday. 315-635-7452.

SELL DRAKE T4X, R4A, AC-3, PS and speaker, all mint condition. First check for $675 takes it. Motorola P33BAC 2M Handie-Talkie, rechargeable .34, .94 XMIT and .76, .94 RCV crystals. Good condition, $125. Jack Hill, WA8R1Y, 902 Locust Lane, Albion, Michigan.

75S-2 with xtal pack for 3.4 to 30 MHz. Also 410 to 460 MHz P.A. 4x150G in cavity. Best offers. J. A. Koehler, VE5FP, 2 Sullivan St., Saskatoon, Sask.

QSL'S — BROWNIE W3CJI — 3111B Lehigh, Allentown, Pa. 18103. Samples 10¢. Cut catalogue 25¢.

FOR SALE. HEATHKIT PHONE PATCH HD-15 WIRED $20. Write G. Suprenant, Betty Jean Drive, Monson, Mass. 01057.

HOOSIER ELECTRONICS Your ham headquarters in the heart of the Midwest where only the finest amateur equipment is sold. Authorized dealers for Drake, Hy-Gain, Regency, Ten-Tec, Galaxy, Electro-Voice, and Shure. All equipment new and fully guaranteed. Write today for our low quote and try our personal friendly Hoosier service. Hoosier Electronics, Dept. G, R. R. 25, Box 403, Terre Haute, Indiana 47802.

SET ASIDE THE WEEKEND OF JANUARY 22 & 23, 1972 for the 23rd annual DX Conference at the Del Webb Towne House in Fresno, California. The Southern California DX Club, hosts for this year's affair, invite all hams who are interested in DX to attend, beginners as well as big guns. An outstanding group of speakers: OH2BH, SM5SB, K2IXP, WA6FSC. In addition the DX Forum, 2 hour cocktail party, the famous steak dinner, and the big DX breakfast on Sunday. The new Signal/One Corp. of Gardena, Calif. has donated a Signal/One CX7A as the pre-registration prize. Send pre-registration fee of $14.50 to Hollander, WB6UDC, 13531 Malena Dr., Tustin Calif. 92680. Checks payable to the Southern California DX Club and include SASE if you wish receipt. You will receive your ticket at the Conference registration desk. Deadline for pre-registration is January 7, 1972; after that the registration fee will be $16.00.

HT-37 SSB transmitter. Needs some alignment and tubes but is now on the air. Asking $159.00. Xclnt appearance. Bob, W0AGP, 11042 Spring, Omaha Nebraska 68144.

SELLING OUT WAREHOUSE full teletype, facsimile, electronic equipment and parts-bargains galore. No list. Goodman, 5826 South Western Avenue, Chicago, Illinois 60636.

BARRY

PAYS CASH for your unused equipment, tubes, components, semi-conductors, etc. Send your list today for a fast cash offer.
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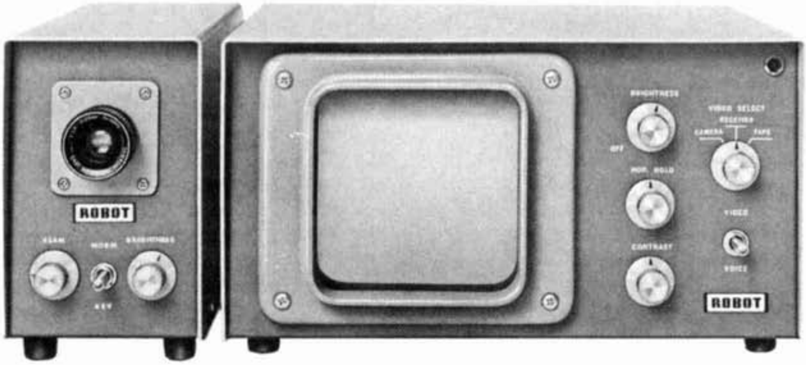

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FREE: With purchase of monitor only — 5 min. demo tape. Gets you on the air for only $495.00.

SWAN 250 6 meter SSB transceiver, excellent condition with new 117XC power supply/speaker $325
LAFAYETTE 460 6 meter transmitter/receiver, excellent condition with built-in speaker $95
P&H 6-150 TRANSVERTER, 5 watts of 20 meter drive gets 150 watts pep out on 6 meters, good condition $95
PEARCE-SIMPSON GLADDING 25, 2 meter transceiver, brand new with AC/DC power supply, FM $299
LAFAYETTE HA-144 2 meter portable transceiver in like new condition, with leather case $95
DYCOMM BLOCK BOOSTER 2 meter FM mobile amplifier provides 50 watts out for 10 watts in $89.95
DYCOMM "10-0" 2 meter mobile amplifier puts out 100 watts when driven by 10 watts of FM $185
DYCOMM "BRICK" or TR-22 BOOSTER, one of the most popular your 1-2W HT can push out 20-25W $69.95
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DRAKE TR-4 TRANSCEIVER covers 80-10 meters, excellent condition, with AC-4/MS-4 power supply $535
HAMMARLUND HQ-215 solid state 80-10 meter receiver, uses same mixing as Collins "S" line. In excellent condition for only $295
HALLICRAFTER S-108 general coverage receiver with ham bandspread, very good condition $89.95
HAMMARLUND HQ-100 general coverage receiver with ham bandspread, good condition $95.00
HAMMARLUND HQ-170/CLOCK, a ham band only receiver giving superior performance on 6-160 meters $165
EIMAC 3-500Z $37.00
EIMAC 8874 ..... $38.00
EIMAC 8877 ..... $200.00
Above tubes Eimac Factory Warranty.
RCA AN/SRR-11 VLF Receiver (14 to 600 KHz) $175.00
21 foot guy rope ½" Sisal with U bolt at $2.95
JENNINGS UCSXF - 2300 vacuum variable (100 to 2300 pf at 10kv ..... write

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ITC OIL FILLED PLATE TRANSFORMER 6636 VCT @ 500 ma continuous duty. 110/220 primary. 120 lbs. $85
JO-BLOCK avalanche silicon rectifier, 12,000 piv @ 1 amp. Insulated so that chassis mounting is practical $9.95
SURGE SUPPRESSOR CE-PS220C protects silicon diodes from transients coming in on the power line. For 2 KW avg. power and a 220 VAC line $35
CE-PS120A similar to above but 110VAC @ 1 KW $10
TRANSMATCH PARTS . . . WE CAN SUPPLY THE PARTS NEEDED FOR BUILDING A HIGH POWER TRANSMATCH SUCH AS THE ONES DESCRIBED IN QST (JULY '70, OCT. '71, etc.)
CERAMIC SOCKET for 3-500Z, 4-400A, etc. $2.50
CAPACITOR, 1000 mfd. @ 400 VDC $2.50
JENNINGS UXC-500, 25-500pf @ 15KV DC r/e $120
UTC TYPE CG-310 TRANSFORMER, puts out 4000 VDC @ 1 amp on a continuous duty basis. Reg. net. $1080 ..... $350
WE STOCK AIR-DUX COILS ..... WRITE
CORNELL-DUBILIER "HAM-M" ROTATOR. New/complete $99.95
GONSET COMMUNICATOR IV (3341) 2 meter transmitter/receiver with matching GONSET VFO, excellent $195
HALLICRAFTERS SX-122 general coverage receiver in very good condition, .54-34MHz + ham bandspread $295
YAESU FLdx400 TRANSMITTER 80 to 10 meter transmitter with built-in power supply, mint condition $295
SONA LABS "SCAN-O-MATIC" 2 meter 10 channel receiver with scanning and channel lock-out $139.95
CRYSTALS for the above receiver ..... $5.00 ea.
COLLINS MP-1 mobile 12 VDC power supply, designed for the 32S series and KWM-2 but will work with most other modern 200 watt pep transceivers or transmitters $125
AMECO TX-62 TRANSMITTER covers both 6 and 2 meters on AM and CW. Included in this special package price is the matching AMECO 621 VFO, both in like new condition for only $165
ELECTRO INSTRUMENT DIGITAL VOLTMETER, good $125
DX ENGINEERING RF SPEECH PROCESSOR, an RF type speech clipper designed for the KWM-2 or 32S series. Contains an integral mechanical filter for splatter suppression. Specify model 32S or KWM2 ..... $79.50
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TMC-GPR90 RXD w/TMC GSB-1 Both mint $495

BARRY 512 Broadway NY, NY 10012
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More Details? CHECK—OFF Page 94

See you at SAROC, Las Vegas, January 6-9, 1972.

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

METERS AND T.E. REPAIRED or calibrated. Write Hortons Repair Center, 1132 Connway, Heath, Ohio 43055.

AMATEUR SALES AND SERVICE before you buy it anywhere give us a chance to quote you a price. Alpha 70, Clegg, Regency, Robyn and Mosley are just a few of the leading names we sell. Write or call today. Amateur Sales and Service, 1115 Norris St., Raleigh, N. C. 27604. Tel. 1-919-833-2412.

THE SECOND ANNUAL WORLDWIDE VHF ACTIVITY starts at 1900 GMT March 11, 1972 ends at 0300 GMT March 13, 1972. For a valid contact, exchange call and state. Any band above 40 Mhz is acceptable. Foreign stations should exchange their province and call or country and call, as applicable. Scoring: one point per contact times number of states/provinces/countries worked. A station may be worked once each band for contact and multiplier credit. A recognition certificate will be awarded every station that has met one of the following requirements: 50 contacts below two meters OR 25 contacts on the two meter band or 10 contacts on any amateur band higher in frequency than two meters. An endorsement will be added to the certificate(s) of the top station in each call area or country. Certificates will be awarded for each band where a station has met the minimum qualifications for a recognition certificate. Logs should show time, date, freq. band, state and call for each contact. No mode restrictions. Postmark logs by April 15, 1972 and mail to WA3NUL, Itchycoo Park VHF ARS, Box 1062, Hagerstown, Maryland 21740.

FOR SALE: Best reasonable offer. 1 Clegg 22'er — Never used. 1 NCX-3, NCX-A, factory realigned. 1 Hammarlund 170-C, realigned. L. L. Baumgartner, Croton Falls, N. Y. 10519.

DON AND BOB NEW GUARANTEED GOODIES. Ham-M 99.00; TR44 59.95; Mosley CL33 114.00; Hy-Gain TH6DXX 139.00; 400 rotor 148.00; quote Drake, Hy-Gain, Mosley, Tri-Ex 2M transceivers. DA64B 1200W. Dummy load 15.00; Ray 6LO6 3.50; #14 antenna wire 1.95/C; speaker wire 24GA/7STD 1.50/C; industrial surplus, used ham list. MOT MC1709CG Opamp (709) 50¢; MOT HEP 170 2.5A/1000PIV epoxy diode 39¢; used: Hammarlund HX50 125.00; HQ170AC 175.00; Hallicrafters HT41 150.00; SX115 250.00; Clairex 604 photocell 1.00; ¼" copper ribbon 10¢/ft; KY65 code identifier 5.95; 1N3210 200V/15A 1.50; Callbook Spring/Summer Foreign 3.95; Electronic books, stock. Tempo, Kenwood dealer. Discontinued tubes, write. Prices collect. Mastercharge, BankAmericard. Warranty guaranteed. Madison Electronics, 1508 McKinney, Houston, Texas 77002. (713) 224-2668.

THE LAKE COUNTY AMATEUR RADIO CLUB, INC., announces its Annual Banquet to be held at 6:30 p.m., February 12, at the Scherwood Club, 600 E. Joliet St., Schererville, Indiana. Join us with wife or girl friend and enjoy good food (all you can eat), entertainment, speeches, awards, and fellowship. The Scherwood Club is less than a mile from the junction of U.S. Routes 30 and 41. And to help people unfamiliar with the area to get to the club, we have printed a map on the back of each ticket. Tickets are $5.00, each from Herbert S. Brier, W9EGQ, 385 Johnson St., Gary, Indiana 46402, and from other club members. No tickets will be sold at the door.

GROUNDED GRID FILAMENT CHOKES. 30 Amps $5.00. Plate chokes 90 μhys, 800Ma $3.00. PPUSA48 William Deane, 8831 Sovereign Rd., San Diego, California 92123.

HEATH APACHE AND SB-10, full Heath modifications installed, push to talk. All manuals, $75. Bob Worsley, K1ONZ, 16 Revere Drive, Bloomfield, Ct. 06002.

AUDIO FILTERS: Knock down that background noise. KOJO SSB, AM, and CW filters do the job. Write for free brochure and see how serious DX boys hear them. KOJO, Box 7774, 741 E. Highland Ave., Phoenix, Arizona 85011.

More Details? CHECK—OFF Page 94

POTOMAC AREA VHF SOCIETY challenges any other club to attain a better average score during the January 1972 VHF Sweepstakes. To accept this challenge, any club secretary or individual member must submit (postmarked not later than January 7, 1972) a list of the calls of the members of his club, and (postmarked not later than February 15, 1972) a list of the calls of the stations, operated entirely by club members, which participated. Mail to K3LNZ as per Callbook address. Club average scores will be calculated from the results in QST by the following formula: Club aggregate score divided by number of members multiplied by percentage of members participating. A club must have at least six members, and must have been in existence on January 1, 1971. At least 50% of the members must have been in the club on July 1, 1971. Challenger's decision is final as to any highly-unusual lists of members and/or calls. A multi-op station counts as only one member participating. If at least five clubs respond to this challenge, it will be repeated next year. Let's get something going where club size doesn't decide who carries home the bacon!

WANTED: I.F. PLUG-IN unit complete, for Collins R391/URR. K1GVA, 61 Warwick, Portland, Maine 04102.

NOVICE CRYSTALS — free flyer. Nat Stinnette Electronics, Umatilla, Florida 32784.

7289 (3CX100A5) ceramic replacement for 2C39 $3 ea., $30 doz. Please allow for postage. Ed Howell, W4SOD, Folly Beach, S. C. 29439.

OSCILLOSCOPES FOR SALE: AN/USM-140D (HP-170B), DC-22mhz, Dual Trace, $450.00; AN/USM-105A (HP-160A), DC-14mhz, Dual Trace, $375.00; AN/USM-32, 10-4.2mhz, $95.00. All reconditioned and calibrated. James Walter, 2697 Nickel Street, San Pablo, California 94806.

WWV, CW, RTTY tone to logic decoder. Educational Includes eight epoxy PC boards, plans, hardware. $4. Hornung, K6BHF, 1630 Bowling Lane, San Jose, California 95118.

STOLEN: GE MASTR Personal Portable Model PR-36-RFS-55, Serial #1041218, 4 freq. Can be positively identified by modifications and markings. Reward for information leading to recovery. Contact Rochester, N. Y. Police Detective Division or M. S. Stoller, K2AOQ, 373 Park Ave., Rochester, NY 14607. Phone 716-244-2839.

URGENTLY NEEDED. Schematic for Browning Labs Scope OL23A. F. S. McCullough, W4WWH, Rt. A2, Box 236, Dunnellon, Florida 32630.

ROCHESTER, N. Y. is again Hamfest, VHF meet and flea market headquarters for the largest event in the northeast, May 13th. Write WNY Hamfest, Box 1388, Rochester, N. Y. 14603.

TELETYPE #28 LRXB4 reperforator-transmitter "as is" $100; checked out $175. Includes two 3 speed gearshifts. Alltronics-Howard Co., Box 19, Boston, Mass. 02101. 617-742-0048.

WANTED: R389, R390, R390A, R391, R220, Racal and 51S1 receivers. SWRC. P. O. Box 10048, Kansas City, Missouri 64111.

WORLD QSL BUREAU — See ad page 91.

21st ANNUAL DAYTON HAMVENTION will be held on April 22, 1972 at Wampler's Dayton Hara Arena. Technical sessions, Exhibits, Hidden transmitter hunt, Flea market and special program for the XYL. For information write Dayton Hamvention, Dept. H, Box 44, Dayton, OH 45401.

2-METER FM INOUE IC-20, Brand new. 10 watt, solid state, 12 channel, Xtaled, w/accessories, $220.00, Bob Brunkow, 15112 S.E. 44th Bellevue, Washington 98006.

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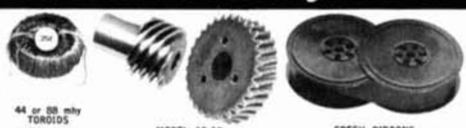

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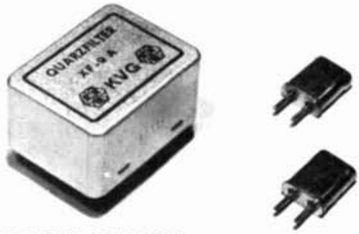

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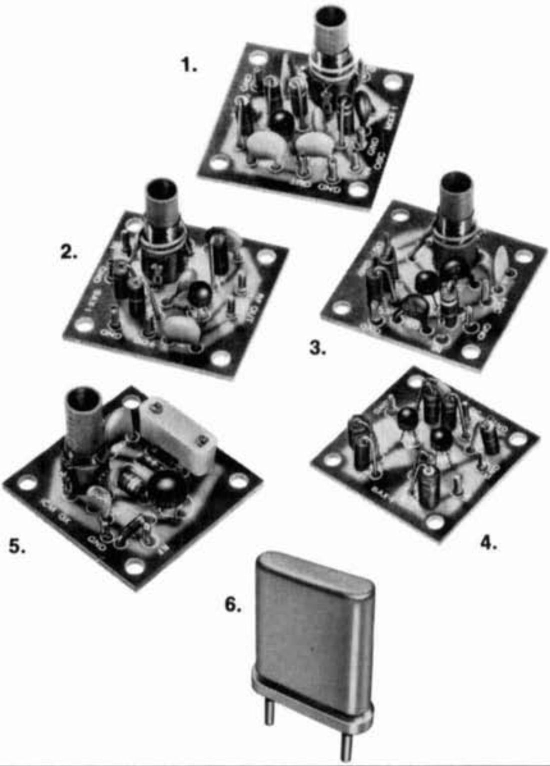

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