INTEGRATED-CIRCUIT COMMUNICATIONS RECEIVER FOR 80 METERS

JULY 1971

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July, 1971

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Radio signals from a spacecraft on the other side of the sun have been used to prove, once again, the correctness of Einstein's General Theory of Relativity. This theory, which is an extension of the well known equations that relate mass and energy, is a geometrical theory of gravity, and is of tremendous importance to understanding the universe.

According to the General Theory of Relativity, electromagnetic waves near massive bodies, such as the sun, travel more slowly than they do in free space. Until recently, there have been three methods of testing this theory, all proposed by Einstein. One test involves the slowly-rotating elliptical orbit of Mercury, the planet nearest the sun. Einstein's equations predict the slight rotation of the orbit much more closely than the older gravitational theory of Sir Isaac Newton.

A second test predicts a slight change in the color of the light from the sun and the stars. The stars' intense gravitational fields cause the light they produce to shift toward the red end of the spectrum, as seen from the earth. Although this effect has been observed, it has not been measured accurately because the shift is very slight and difficult to measure.

A third test considers the apparent bending of starlight as it passes through the gravitational field of the sun. However, this can only be measured during a total eclipse of the sun so distant stars can be observed optically. When this rare alignment of the stars took place in 1919 Einstein's predictions were verified within the accuracy of the measuring equipment.

A chance for a fourth test of the General Theory of Relativity occurred recently when the Mariner 6 spacecraft passed near the sun. This is the same craft which flew by Mars in 1969 and measured surface temperatures and atmospheric composition, and sent back television pictures of the planet's surface. Since Mariner 6 passed very close to the sun's intense gravitational field, according to Einstein's equations the radio signals from the spacecraft would be slowed slightly.

To measure this signal delay radio signals were transmitted from earth to a repeater on board the Mariner 6 which returned the signals to earth. The normal round-trip time for the signals, not counting any gravitational affects, is estimated at 45 minutes. According to the General Theory of Relativity the radio signals would be slowed by 200 microseconds as they traveled through the sun's gravitational field.

Information recently released by the Jet Propulsion Laboratory in Pasadena, California indicates that the Mariner 6 radio signals exhibited a maximum relativistic signal delay of about 204 microseconds, within two per cent of that predicted by Einstein's Theory. If the sixteenth-century theory of Isaac Newton were correct there would have been no time delay at all.

Jim Fisk, W1DTY
editor
DESCRIPTION:
Top Band Systems introduces the TBS-2000, a completely new concept linear amplifier with built-in transformerless 220VAC power supply. Top Band Systems' exclusive transformerless, grounded-grid, zero-biased design makes for a highly efficient, lightweight linear amplifier. Weighing but ten pounds, the TBS-2000 is an ideal companion for any transmitter or transceiver on six bands — 160 through 10 meters, including MARS. The TBS-2000 can be operated off a 110-125VAC source by simply plugging-in the accessory TBS-110 solid-state module. The TBS-2000 can also be operated mobile with the addition of the TBS-12 plug-in inverter. One knob, broad band tuning allows you to “set and forget” while operating across the band.

SPECIFICATIONS:
Band Coverage: 160, 80, 40, 20, 15, and 10 meters
Input Power: 1600 PEP on SSB, 1000 watts on CW
Driving Power: 80-150 watts
Output Impedance: 50 ohms nominally
Tube Complement: six RCA 31LQ6
Plate Current Meter: 0-2 amperes, 5% move.
Relative Output Indicator: indicator light
Relay: built-in antenna change over relay
Power Supply Regulation: 3% key-up to key down
Power Supply Filter Capacity: total of 550 mfd
Input Voltage: 220-240VAC, 50/60 HZ standard 110-125VAC input with accessory TBS-110 module — 11-14VDC input with accessory TBS-12 inverter
Power Cord: a generous ten foot power cord is provided
Polarity: cord may be plugged into wall without regard to polarity
Color: light gray cabinet with dark gray panel insert
Dimensions: cabinet is 11.25” wide, 5.75” high, 8.75” deep
Weight: net 10 lbs (4.6Kg); shipping weight 13 lbs (6 Kg)
Price: TBS-2000 $199.00; TBS-110 $39.00; TBS-12 TBA

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integrated-circuit communications receiver for 80 meters

A high-performance integrated-circuit ssb receiver featuring half-microvolt sensitivity, crystal-filter selectivity 100-dB agc range and low-drift vfo

Integrated circuits are being used more and more in the design and construction of amateur radio equipment. The idea for this receiver was originally conceived after reading K7WQR's excellent article on the Motorola MC1596G balanced modulator. In the receiver described here the MC1596G is used as a double-balanced mixer.

The first receiver I built around the MC1596G is shown in block form in fig. 1. This original prototype had no front end, i-f amplifier or agc circuits. However, with the high conversion gain provided by the MC1596G signals on 80 meters were copied with little effort.

The second design, shown in fig. 2, added an RCA 40673 zener-protected dual-gate mosfet rf amplifier stage ahead of the MC1596G mixer. However, manual control of rf and audio gain was still required to listen comfortably to signals on 80 meters. (The front panel has an rf gain control which is not used in the final design; this was used in the second prototype.)

An agc system for a receiver with no i-f stages presented a real problem. I was stuck until I discovered the Plessey SL-600 series of integrated circuits. One of these ICs, the SL621, is designed specifically for gain control circuitry; another, the SL610, is designed for rf amplifier applications. With the discovery

*Gain of the MC1596G is typically 24 dB when impedances are properly matched.
of these vital links, the receiver design finalized into the form shown in fig. 3.

As can be seen from the schematic and photographs, modular construction was used throughout the receiver. This speeds construction time, allows bench testing of all modules before deciding on final mechanical design, and allows for circuit changes without upsetting the physical layout.

**rf amplifier**

The Plessey SL610C is a low-noise, low-distortion rf voltage amplifier with integral supply-line decoupling and provisions for agc. It has a 50-dB agc range with maximum signal handling capability of 250 mV rms.

The rf amplifier stage was built on single-sided copper-clad printed-circuit board. Generous quantities of Teflon push-through terminals keep construction simple and leads short and direct. Miniature RG-174/U coaxial cable is used in the rf amplifier and to connect the modules together throughout the receiver. Expensive coaxial connectors are eliminated by running the coax through rubber grommets in the chassis.

The rf amplifier, as well as the other individual circuit modules, is housed in a small minibox; power-supply voltage is fed in through a 0.001-μF feedthrough capacitor. With this construction technique no oscillations were experienced; gain is approximately 18 dB.

**mixer and filter**

Except for the addition of ssb input
and output transformers, the balanced mixer configuration is the same as that described by K7WQR. The Miller transformers have low loss, provide sharp tuning and appear to match the crystal filter very well. The 24-pF capacitors across the transformer windings provide increased gain. These transformers eliminate the complex problem of matching the input and output impedance of the crystal filter. Incorrect impedance matching severely distorts the passband of the filter; homebrewing these transformers is much too difficult for the average experimenter.

The 90-dB dynamic range of the
L1, L2  Cambion LS3-5 with 4-turn link or 25 turns no. 22 enameled on Amidon T50-6 toroid form with 3-turn no. 22 link.

L3  14 turns no. 28, 5/8" diameter, slug tuned.

MC1596G integrated circuit makes the device relatively insensitive to input levels. This fact, coupled with the 3-μV sensitivity and high conversion gain, makes the MC1596G the logical choice for the balanced mixer stage.

The only adjustments in the mixer/filter module are T1, T2 and the 50k null-adjustment pot. Transformers T1 and T2 are tuned for maximum signal. The null-adjustment pot is set for maximum 9-MHz signal at pin D of T2. These
adjustments are quite simple as they are rather well defined.

vfo

The vfo is basically the same as the circuit presented in the 1969 edition of The Radio Amateur's Handbook. This vfo is extremely stable and the output waveform is clean and symmetrical. A bandpass filter is not required on the output because the high common-mode rejection of the IC balanced mixer (typically 85 dB) eliminates any unwanted sidebands present in the vfo signal.

With this circuit vfo drift over a period of several hours was on the order of a few cycles per second. This far exceeds the requirements for this receiver. I have used this circuit several times, and the purchase cost of the 3N128 mosfet is well worth its performance and stability. How-
ever, to obtain good stability it is important to use a good quality double-bearing air-variable capacitor along with rigid mechanical design.

**product detector**

The product detector circuit is essentially the same as that described by K7WQR. High-level signal performance and sensitivity is excellent; conversion gain is high, typically 24 dB. In fact, performance of this circuit is so good, VE3GFN has discarded his hot-carrier diode product detector\(^4\) and replaced it with this one.

**audio**

The audio system uses another IC, the General Electric PA237. Although this IC should be used with a power supply of 24 volts for its rated output power of 2 watts, with a 12-volt power supply it

*July 1971*
drives adequately a pair of Armaco P-500 stereo headphones. A less expensive audio system would probably result from using a consumer-rated audio-power IC such as the Motorola MFC9010.

**agc**

The agc system is built around the SL621C agc generator manufactured by Plessey Microelectronics.* This IC is designed to be used with the SL610C rf amplifier in ssb applications. As with other advanced agc systems, this integrated circuit generates the agc voltage directly from the detected audio waveform, provides a “hold” period to maintain the agc level during speech pauses and is immune to noise interference. When the SL621 agc generator is used in conjunction with the SL610 rf amplifier, audio level is maintained within 4 dB for a 110-dB range of receiver input signal. In my receiver the audio level holds within 4 dB for rf input signals up to 150 mV rms.

If you consider using the SL621C I recommend that you read the excellent article by W3TN0. The input to the SL621C must be held to approximately 10 mV rms. In the circuit in fig. 3 I have used W3TN0’s method of accomplishing

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*Plessey integrated circuits are available from Plessey Electronics Corporation, 170 Finn Court, Farmingdale, Long Island, New York 11735. The SL610C rf amplifier and SL612C i-f amplifier are $5.65 each; the SL621C agc generator is $8.30.

The following semiconductors are available from Circuit Specialists Company, Box 3047, Scottsdale, Arizona 87257. MC1496 ($3.90), T9558/HEP802 ($1.59), 2N3904/HEP736 ($1.28), 2N2219 ($1.38), 2N3054/HEP703 ($2.75), PA237 ($4.30), 3N128 ($1.74), 12-volt 20222 zener (.70), 6-volt 20215 zener (.70) and 1N4148 (.40). Please add 25c for shipping.
An emitter-coupled clipper to prevent the input capacitor from charging, and a resistive voltage divider to keep the audio signal at the 10 mV level required by the IC.

**power supply**

The two voltage requirements of 6 and 12 volts are derived from series-type voltage regulation (fig. 3). This method is quite good if a large amount of filtering is included in the circuit. However, for better regulation and less ripple you should consider one of the integrated-circuit voltage regulators that are available.

**performance**

The sensitivity of the complete communications receiver is 0.5 μV for 10-dB signal-plus-noise-to-noise ratio; this was measured with a Boonton type 65B signal generator. No cross modulation was detected for input levels up to 100 mV rms. Frequency readout (with the Eddystone 898* dial) is to 1 kHz; frequency error over the 500-kHz tuning range is 18 kHz.

**conclusions**

I plan to use other versions of this basic design in future homebrew receivers. One possible approach is to feed the antenna directly into the first mixer and use AGC in the i-f section as in the W7ZOI design. The Plessey SL612 integrated-circuit i-f amplifier is compatible with the SL621C AGC generator and looks like an ideal choice. I am presently working on an all-band converter using the MC1596G balanced-mixer IC that will use this receiver as a tunable i-f from 3.5 to 4.0 MHz.

I would like to thank M. Goldstein, VE3GCF, and A. Martin for the photographs; I would also like to thank J. Riach, VE3DSR, for his constructive criticism.

**references**

6. Plessey Microelectronic SL600 specification sheets.

*The spinner-type main-tuning knob shown in the photographs is not standard; it was machined by VE3ELP.*
This two-meter FM transmitter is suitable for operation through the FM repeater stations which are located on a great many mountain tops. With an auto-battery power supply of 12 to 14 volts carrier output measures from 2 to 3 watts. A 24-volt supply to the final 2N3632 power stage will provide 7 to 8 watts of FM output. The 2N3632 transistors are not the most desirable type, but surplus devices were less expensive than the newer types which were available a year or so ago. Some 2N3632 transistors run wild and burn out easily when used with a power supply greater than 15 volts.

Phase modulation, converted to FM, is much easier to handle than A-M with transistor systems, and carrier output is about twice as high as that for A-M. The collector supply with amplitude modulation has to be reduced greatly with most power transistors to operate within the maximum allowable peak voltages. SSB has the same problems. These modulation systems require power transistors with good linearity and peak voltage ratings more than four times the value of dc.
supply.\(^1\) Phase or frequency modulation requires that the peak voltage under load conditions be less than twice the dc supply value. This permits supply voltages two times higher and results in 2 to 4 times as much rf carrier output.

In an overall system with a good fm receiver (not slope detection) fm can compete with ssb in effectiveness; it may even surpass ssb for difficult paths on 144 MHz. Also, ignition and some power noises are suppressed much better by fm receivers since the limiters in an fm receiver which remove a-m also knock off noise pulses at the carrier level. This cannot be done in an a-m or ssb receiver without some pretty sophisticated if noise blankers.

This transmitter has been in intermittent service for over a year with a repeater which is behind a small mountain range. It is not line of sight, and the “knife-edge” diffraction effects are very poor in the direction of my station. The previous 1-watt fm transmitter wouldn’t do the job even with a 10-dB gain antenna. This transmitter usually does the job.

phase modulator

The phase modulator uses a pair of varactor diodes — rectifiers normally used for small power supplies. The 1N645 rectifier has some variable capacitance effect with variations of audio voltage when the diodes are reverse biased with a few volts. Nearly any small power rectifier with very high back resistance will work in this circuit. Some types have much higher resting capacitance and require a smaller shunt capacitance and resonant at 4.6 MHz.

The 1N645s in series work with a slug-tuned coil (from an older type broadcast receiver) since the total shunt capacitance is only a few picofarads. The untuned crystal oscillator is lightly loaded through a 2-pF capacitor. The crystal can be zeroed in on a desired frequency if it is slightly off by means of a variable capacitor from one side of the crystal to ground.

The phase modulator LC circuit should be used to drive a high input impedance class-A amplifier through a 1- or 2-pF capacitor. Actually, it can be used to drive a frequency doubler without too much distortion if the rf output requirements are moderate. In the circuit shown in fig. 1 frequency doublers are used throughout; in the first few doublers the power requirements can be met with small surplus transistors of the 2N706 or 2N708 class. The 2N5188 power transistor can be made to work up to 148 MHz but it will not put out much over 250 or 500 milliwatts since a 12-volt power supply is near its maximum rating. The 2N5188 is in the half-dollar price range from RCA distributors.

This type of frequency-doubler drive circuit has proven to be much superior to inductive-coupled circuits. The capacitance dividers step the tuned-circuit impedance down to 50 ohms or so to work into the base of the next stage. The large capacitance across the base acts as a low impedance of a few ohms at the doubled output frequency. Without a low-impedance path from base to emitter the collector-to-base capacitance will feed back enough energy to greatly reduce output power.

This frequency multiplier design saves dc power and transistor heating, and
permits considerable latitude in choosing transistors. For maximum efficiency the transistor should have a cutoff frequency rating of 5 to 10 times the operating frequency. The 2N5188 is operating too close to its cutoff frequency for good efficiency as a two-meter doubler, but some devices work reasonably well as two-meter amplifiers.

The lower-frequency doubler stages are not as critical, so I moved the transistors around for best overall drive to the final amplifier. One 2N5188 worked fairly well in the 144-MHz 2N3553 stage (at 1/10 the cost) with only a 12-volt power supply; the 2N5188 will not work at higher supply voltages. However, this transmitter is normally used with a 12-volt storage battery so the 2N5188 is used most of the time in the 144-MHz stage to save the more expensive 2N3553 for other uses. (The 2N3553 makes a good final amplifier with a 24- or 28-volt supply providing 5 to 7 watts output.) With a 12-volt supply power output is less than 2 watts, somewhat inferior to the

from a standpoint of less parasitic oscillation and transistor burnout than other circuits I've tried in previous transmitters. The little power transistors are real monsters unless the base-to-emitter path is just right. A small rf choke consisting of 5 or 6 turns of wire on a lossy 1/8-inch diameter ferrite rod makes about the best dc path from base to emitter. If the rf driving power is large enough, a 10-ohm carbon-composition or carbon-film resistor can be used for this dc path in place of the ferrite-core rf choke.

The more rf and dc power into and out of a transistor, the lower the input and output impedances. You can expect values of 2 to 10 ohms in the output stage. This makes it difficult to match impedances to the driver and the antenna circuits.

As shown, with only one tuned circuit,
harmonic output is high. However, I use a dual-cavity antenna filter on all transmitters and receivers between the antenna coax lead and the coaxial relay. This reduces the harmonic content of all stages needed in this stage. The 2N5183 and 2N3565 transistors used in the other audio stages are low priced high gain bipolar types. A diode speech clipper was added to keep the average modulation level as high as possible. The frequency components above 2000 Hz are reduced by a low-pass filter consisting of a small 1-H choke and a pair of 0.047-μF capacitors. The higher audio frequencies must be attenuated in order to convert from phase to frequency modulation. The phase modulator diodes require only a volt or two of audio in the lower voice frequency range, and a small fraction of a volt at 2500 Hz. The RC values in the last audio stage aid this affect.

audio

The audio system in this transmitter is designed for high-impedance crystal or ceramic microphones. The fet preamplifier (2N4302 or MPF103, etc.) has a high input impedance. Rf feedback in a two-meter transmitter is always a problem so some rf filtering and bypassing is needed in this stage. The 2N5183 and 2N3565 transistors used in the other audio stages are low priced high gain bipolar types. A diode speech clipper was added to keep the average modulation level as high as possible. The frequency components above 2000 Hz are reduced by a low-pass filter consisting of a small 1-H choke and a pair of 0.047-μF capacitors. The higher audio frequencies must be attenuated in order to convert from phase to frequency modulation. The phase modulator diodes require only a volt or two of audio in the lower voice frequency range, and a small fraction of a volt at 2500 Hz. The RC values in the last audio stage aid this affect.

fig. 1. Schematic for the 8-watt two-meter fm transmitter. Small decoupling rf chokes in the 12-volt supply lines are approximately 1/2-μH. The ferrite-core rf chokes in the last two stages consist of 6 turns no. 20 enameled on a 1/8-inch diameter powdered-iron rod from a 455-kHz i-f transformer.

references

crt
intensifier
for RTTY

A simple circuit for intensifying the RTTY monitor scope during receive

Radioteletype is a very interesting facet of amateur radio, and equipment is often designed for the highest degree of automation. When using an oscilloscope as a tuning aid there is no problem of beam brilliance as long as the beam is being deflected by the incoming mark and space signals. The beam can be adjusted, using the intensity control, for proper brilliance with signal. However, a problem arises during RTTY operation when no-signal periods occur—the beam is not moving, and screen brightness becomes very intense. Unfortunately, the high intensity spot will burn the screen if the intensity control is not turned back.

The inconvenience of monitoring beam brilliance and continually making adjustments to save the cathode ray screen led me to look for a system that would accomplish this function automatically.

The desired circuit for controlling cathode-ray-tube bias should OR the mark and space signals so that if either is present the grid bias on the cathode ray tube is lowered, and the signal pattern is displayed.

Two requirements are necessary for controlling cathode-ray-tube bias. First, the bias must not get low enough to cause the electron beam to bloom (get out of focus). The beam focus point changes when the beam current passes a certain point, and this must be avoided. The maximum positive voltage that the control circuit can apply to the grid of the tube must be limited to a maximum that will not cause blooming of the beam.

Second, the control circuit should have some degree of proportional control when the incoming mark and space signals begin to fall below the level at which limiting takes place in the RTTY converter and the display on the cathode ray tube screen begins to shrink. As the display begins to shrink and beam travel speed is reduced, screen brilliance will increase due to the reduced area of illumination. The increase of brilliance with reduced display size points out the desirability of a brightness control that is proportional to display size when signal levels fall below the limiting levels of the RTTY converter.

the circuit

A circuit which will provide brightness control of the cathode ray tube during typical RTTY signal conditions is shown in fig. 1. The intensifier circuit is con

fig. 1. Schematic of the CRT intensifier. Value of CR5 is discussed in text.
connected between the brightness control and the cathode-ray-tube control grid. It is activated by space and mark signals from the oscilloscope's X and Y amplifiers. Loading on the X and Y amplifiers is reduced by the 150k resistors R2 and R3. Coupling to the X and Y channels is provided by C2 and R2 to the X amplifier and C3 and R3 to the Y amplifier.

**operation**

The dc intensification voltage is developed across R and C. The peak intensification voltage is set by the 10-volt zener diode, CR5, and limits this voltage to a safe value which will not cause blooming of the beam during intensification. Selection of the zener diode as well as suggestions for particular applications will be discussed later.

The rectifier circuits from the X and Y oscilloscope channels consist of voltage-doubler circuits. The X circuit is made up by CR1, CR3, and C2, with C1 and R1 common to both the X and Y channels. The Y circuit consists of CR2, CR4 and C3 with C1 and R1. The X and Y signals feed into their respective doubler circuits; the highest signal, mark or space, sets the voltage level until the zener diode begins to conduct and limit the voltage to a peak brightness level. The time constant for the brightness level is determined by C1 and R1. By varying C, the length of time is controlled during which intensification is extended.

**construction**

To determine the required zener voltage for particular scope the following procedure is recommended. A high-impedance voltmeter is connected between the grid number 1 and the cathode of the CRT. (Caution. High voltages are usually involved, so do not change connections or touch the voltmeter while power is applied.)

The first measurement is obtained by applying power to the scope without mark or space input signals. (This should produce a spot.) Reduce intensity until the spot is completely extinguished; then read and record the voltage. The next reading is made with both mark and space signals applied, the CRT showing a cross display. Adjust the brilliance until a pleasing display intensity is obtained; then read the voltmeter and record this reading. To obtain the zener voltage rating subtract the second reading from the first; a quarter-watt zener diode with this voltage rating will provide good results.

The CRT intensifier can be built on a small printed-circuit board or Vector-type perforated board. Or, you may mount the components on two or three terminal strips which have been installed at convenient spots on the scope chassis. Fig. 2 shows a printed-circuit layout which includes mounting holes. This layout is small enough so that no trouble should be experienced in finding a suitable location within your scope. The board can be vertically mounted with L-shaped brackets. If the circuit board is mounted inside the scope give proper consideration to lead length and proximity to other components.
superior
phone patch

Hybrid circuits to interconnect the amateur station and a commercial telephone circuit are not uncommon, both in kit form and assembled. Most such phone patches, however, have a number of disadvantages. These include the necessity of using the telephone handset, which frequently over-drives the transmitter; complex procedures to go from normal operation to patch and return; and unsatisfactory vox operation.

features

The unit described in this article overcomes the problems mentioned above and has additional desirable features. The operator can talk to either party — telephone or radio — together or selectively, using the station microphone and headset or speaker. He is in complete control, with ability to cut off or override either party at any time. Changeover from normal operation to patch and back is simple and fast. Finally, it is possible to record all three parties' conversations and play the recording back to telephone, radio, or local monitor.

A block diagram of the system is shown in fig. 1. Even without the tape recorder connections, which are omitted, it is apparent that each input — transmitter, telephone, and monitor — receives signals from two sources; and some form
of hybrid or other isolation is required to keep the signal originating at one source from feeding back to the other. However, the only place where input and output circuits have common terminals is the simpler circuit at no greater cost. The amplifiers are Motorola MC 1439Gs — internally protected against input overload, latch-up, and output short-circuit; and they’re relatively inexpensive.

Connections for a typical audio amplifier are shown in fig. 2. The model shown is an inverting amplifier, with signal input at the inverting (−) lead and the noninverting (+) lead grounded. It is stabilized by 0.1 μF bypass capacitors at leads 4 and 7 and a compensation network between leads 1 and 8. Values shown are recommended by the manufacturer for unity gain; they work well for all gains and frequencies encountered in the phone patch. This compensation is applied to all seven amplifiers in the patch but is omitted from the schematic (fig. 3) for simplicity.

Gain is determined by the ratio of \( R_F \) to \( R_I \); and a feedback capacitor, \( C_F \), is added to three amplifiers to suppress unwanted high-frequency response.

circuit

In fig. 3, T1 and T2 form the hybrid. I use a pair of UTC transistor/line transformers, type A-22, which have split secondaries with 250 ohms impedance on each half, and 500-ohm center-tapped primaries. The secondaries are cross-connected so that a signal injected into one
primary is balanced out in the other transformer. These transformers work very well, but those wishing to build a similar unit from scratch may want to try a transformer with a higher-impedance primary for T1, and possibly eliminate the two 470-ohm resistors I had to put in series with the amplifier outputs to make them work properly.

T3 is a one-to-one isolation transformer with from 500- to 1000-ohm impedance each side and a third winding that provides a signal for the tape recorder input and VU meter.

The pad between the hybrid and T3 presents a relatively constant impedance to the hybrid, facilitating balancing with the 1k variable resistor. Good balance is essential if vox operation is desired.

amplifier considerations

As mentioned earlier, the power supply and compensation connections to the amplifiers have been omitted from the schematic for clarity. Amplifiers 1, 4, and 6 are simple inverting models, with adjustable gain controlled by varying their feedback resistances. The .001-µF feedback capacitors on amplifiers 1 and 6 suppress an approximately 25-kHz oscillation that appeared when the unit was connected to one of my station receivers; others may not find them necessary.

Amplifier 5 is similar; but instead of adjustable gain, it has an RC network in its feedback circuit to make it an active filter as well as an amplifier. Signal level from the receiver to the phone line is controlled with the gain controls on the receiver.

Tariffs of many Bell System telephone companies, in addition to limiting the strength of the signal that may be transmitted over their lines, require that devices connected to the lines through their voice coupler have minimal output at 2600 Hz and above. The circuit shown has a maximum voltage gain of 10 at approximately 1000 Hz and practically no gain at 400 and 2000 Hz. This narrow bandpass admittedly sacrifices some voice quality, but intelligibility seems to be generally good. The circuit eliminates a lot of heterodynes and other interference and keeps the telephone company happy as well. Those desiring a broader bandpass, while still meeting phone company requirements, might try a two- or three-stage biquadratic filter in place of amplifier 5.

Amplifiers 2 and 3 were originally constructed similarly to the others, but two problems resulted. First, with the microphone and the feedback resistor both connected to the inverting input of amplifier 2, the receiver output to T1 from amplifier 5 fed back around amplifier 2 to the input of amplifier 3 and the transmitter, which defeated the purpose of the hybrid. To correct this, amplifier 2 was connected as a noninverting amplifier, with the microphone input to lead 3 and feedback to lead 2.

Furthermore, the high gain needed in amplifier 2 to amplify the microphone signal to phone-line level makes the shielding of the microphone leads to amplifiers 2 and 3 critical. The circuitry used permits mounting both the input and feedback resistors directly on the circuit boards, minimizing lead length and simplifying shielding.

Amplifier 7 is a meter amplifier. Positions 1 and 2 of the meter switch (S11)
read power-supply voltage; in position 3 the amplifier samples the signal on the phone line, making it possible to monitor the level of the outgoing signal. In position 4, used to balance the patch circuit, the meter shows the signal level at the transmitter input.

**controls**

In addition to the six potentiometers, there are ten toggle switches and the rotary meter switch on the control panel. The PATCH ON/OFF switch, S1, connects the patch to the telephone circuit. Switches S2 through S7 are ON/OFF switches for the six audio amplifiers and determine which patch functions are active. S8, not shown in the circuit diagram, is a tape recorder START/STOP switch, like the pushbutton on some tape recorder microphones. S9 unbalances the hybrid by opening one side to permit tape playback to the transmitter. S10 controls the primary power relay on the remote power supply; a second set of contacts connects the receiver directly to
the monitor output when patch power is off. S11, the meter switch, was described above. A 28-volt pilot lamp is connected between V+ and V-, providing visual indication that both sides of the supply are on.

construction

The unit is built to mount in a station control console. The controls, microphone input, and monitor output are on the front panel. The back panel has a two-contact Jones plug for the telephone line, phono jacks for outputs to transmitter and tape recorder, a single pin jack for the push-to-talk lead to the transmitter, and an octal plug for the remaining connections, including ground.

Amplifiers are mounted on two etched circuit boards, four on one and three on the other. These boards plug into 22-contact mounting strips attached to the bottom frame, which made it easy to remove the boards for experimental component changes during development. A metal strip across one end of the frame holds two transformers; the other, together with the H pad, is on a similar strip across the other end of the frame. Space was left on the frame for two more circuit-board mounts. One will be used to mount a VOX circuit that will control a vhf fm transmitter, and the other will permit installation of the three-unit biquad low-pass filter mentioned earlier if it proves to be desirable. The entire assembly was made from sheet aluminum and do-it-yourself strips and angles using home tools.

operation

For normal operation without a third party on the telephone, the TALK TO RADIO (S3) and MONITOR RECEIVER (S7) circuits are on. To set up a patch, S1 is turned on, the telephone circuit is activated, TALK TO PHONE (S2) and MONITOR PATCH (S6) are turned on, and S3 is turned off to keep the preliminary phone conversation off the air. Telephone contact is established using the station microphone and monitor. S7 may be turned off if signals from the receiver make it difficult to hear the party on the phone.

Contact between the parties is established by turning on the TELEPHONE RCVR (S4) and TELEPHONE XMTR (S5) switches, and proceeds with vox operation unless the telephone party trips the transmitter too often with laughter or interruptions. With S2 and S3 off, the operator can carry on another conversation or monitor another receiver without fear of interrupting the patch, but can monitor and break in if necessary.

I was tempted to title this article "an ideal phone patch" after several contacts, but the patch isn't quite. The ideal patch would have constant level output to telephone and transmitter regardless of input source or signal strength. So far I have been unable to develop or find an agc circuit to accomplish this with operational amplifiers. I'd like to hear from the ham who has.

references

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More Details? CHECK-OFF Page 94
Looking for a laboratory-quality power source for your IC projects? Here's a likely candidate.

After building many solid-state projects, I learned some interesting things about power sourcing, so I decided to build my own power supply. The little dandy shown on these pages is presented with the hope that others will benefit from my experience in this area.

First a "wish list" was made detailing everything the supply had to do to justify the investment of time and material. A axiom is in order at this point: Most semiconductors are destroyed during circuit testing and trouble shooting that expire from intrinsic device failure! The principal cause of such destruction is over-voltage. So, heading the list is:

1. Variable voltage sourcing.
2. High-resolution voltage control with constant-current over the full range, and accurate resetability.
3. A high-resolution voltmeter, with 1% accuracy over the complete range.
5. Regulation better than .01 percent.
6. Ripple less than 50 mV.
7. A signalling method to identify which voltage range is being metered (a paramount requirement — a try at idiot-proofing!).
8. Sufficient reserve current to power the most ambitious solid-state projects.
9. Small size and the capability of operating continuously at full load.

The schematic of fig. 1 shows the circuit.
The Motorola MC1569R regulator IC was chosen because it satisfied the largest part of the regulation demands in one package. The MC1569R has a large power-handling capability, with a through-put current of 500 mA. Thus it was necessary to drive the low-beta series-pass transistor, Q1, to full saturation. The MC1569R will tolerate 36 volts input with safety. The circuit includes a voltage-control network consisting of a simple arrangement with a fixed 6.8k biasing resistor in combination with a 50k, 10-turn pot. This allows the output to be varied between 3.4 and 28 volts.

Still another attractive feature is the current-limiting ability, achieved by an external biasing transistor, Q2. Perhaps the most important feature is that the regulator won’t oscillate (a plague affecting all high-gain op amp devices).

Two versions of this IC are available: the MC1469R with a rating of 35 volts maximum input; and the MC1569R, which has a maximum rating of 40 volts. If you choose a maximum of 34 volts to pin 3, the MC1469R will be more satisfactory.

The letter “R” denotes a TO66 package—do not use the “G” package (TO5 can) in this application, as its output is limited to 200 mA.

Underchassis view. The large 3300-uF, 45-Vdc electrolytic capacitor dominates the scene—essential for eliminating input transients to the regulator.

The variable-voltage control resistance (R1 in fig. 1) is determined by 
\[ R1 = (2V_0 - 7) \text{ k ohms} \]
However, the nearest standard 10-turn pot is 50k, thus limiting the highest voltage to about 28 volts (minus the saturation voltage of the regulator transistor). Do not add any fixed resistance in series with this pot (R1), as it will increase the minimum voltage far above the useful range of RTL devices; i. e., 3.6 volts.

Circuit description

Starting with the input to the series-pass regulator transistor (a Motorola 2N3771), the powering of all systems is done from 36 volts at the collector of this transistor. The output, or emitter, has an Ohmite 1.0-ohm pot (part no. 0101) in series with the load and a current-sensing transistor connected across this pot. This pot is set to sense 2 amperes. You’ll note that an IR drop across this resistor upsets the \( V_{be} \) drop of the transistor (a 2N2219), causing the collector of this transistor to pull current from pin 4 of the MC1569R. This, in turn, drops the voltage output of the regulator, thereby biasing the 2N3771 base voltage down so that excessive current cannot be drawn—a Rube Goldberg action, but still a simple and effective means of device protection. A few words later about setting this potentiometer.

Meter and lamp switching

In the 3.4- to 10-volt range, the green lamp is lit and the 0- to 10-volt scale of the meter is the relevant range. When the multiturn pot is rotated upwards, approaching 9.5 volts, zener D1 and its related voltage-offsetting diodes begin to conduct current via two paths. One is through D3 and D4 to ground; the other and lower offset path is through D2 and the Darlington pair transistors (Q4,Q5). At the point where the zener abruptly avalanches, the sum of all voltage drops through the second or lower offset path is

*Symbols used in this article are: \( V_o \) = output voltage; \( V_Z \) = avalanche (zener) voltage; \( V_F \) = forward voltage. editor
equal to 10 volts. This network divides off excess current on each scale when the voltage is set near its upper range. Due to variations in beta of the 2N2219 (Darlington), the base biasing trimmer resistor may require adjusting.

A 25k trim pot in this circuit sets the proper toggle sensing of this network. When the 10-volt level actuates the Darlington-pair relay driver, the activated relay switches lamps from green to amber, and the metering shifts from 0-10 to 10-20 volts (full scale). This is accomplished by switching the negative side of the meter from ground to the cathode of the zener, so as to read the product of $I^2R$ across the zener loading resistor on the 10-20 volt scale.

One may question the accuracy of such reading in view of the nonlinearity of most zeners. However, by using a 1-watt, 2% zener packaged in a metal can, the $V_Z$ will remain stable provided the current is held within the maximum dissipation of the device. By not heating the zener, we avoid the effects of impedance change in the device. Meter comparison checks with a Simpson 270 showed no difference in scale accuracy.

As the voltage-control pot is again elevated, the next-level voltage shift energizes the second relay, disabling the

---

**fig. 1.** Schematic of IC regulator power supply that provides variable voltage sourcing from 3.4 - 28 Vdc at 2 amps. Relays areAdvance/Hart 67DP-G-4CS, 24 Vdc, 700 ohms. Q1 is installed in a Motorola MS10 heat sink; the IC is installed in a Therrmalloy 61688 heat sink.
first sensing stage to conserve current. The indicator lamp shifts from amber to red, and the metering shifts from 10-20 volts to 20-30 volts (full scale), with readings taken across the second zener loading resistor. (Incidentally, this could continue ad infinitum.)

The meter has a 200-microampere movement at 5k Ω/volt. A fixed 10k series resistor plus a 50k trimpot sets the full scale to 10 volts. It reads all scales with this one setting — set and forget.

**fine sensing control**

You will note another trimpot in the base lead of the second Darlington switch. Again, variations in betas plus minute differences in $V_F$ levels of the diodes dictate a fine tuning of the sensing network. Once this pot is set and the network shifts at 20 volts, the pot needs no further attention.

There will be some residual hysteresis when the voltage passes through switching levels. This is desirable, as it elim-
inates ambiguity in meter setting when voltages are set near the threshold of level change. The hysteresis is about 150 millivolts; but with regulation better than this figure, there will be no "hunting" when the supply is loaded and unloaded in fast sequence, such as with a pulsed load.

**heat dissipation**

The 2N3771 is used as a variable, electronically controlled rheostat, which in this application must dissipate considerable power in the form of heat. Let's consider a worst-case situation to show how much power we must sink off as heat.

The input voltage to the 2N3771 is 36 volts from the rectifier-filter stage. The voltage control is set for 4 volts and we intend to use 2 amps from the supply. Therefore, we must drop 34 volts through the transistor, while it must pass 2 amperes or a total of 68 watts at 75°C. However, we're operating at 50% of the rated power load (150 watts at 25°C); but this is still a lot of heat to be cooked away — (try holding a 75 watt lamp bulb!).

One of the cardinal rules of transistor design is: "To prevent thermal damage, the heat extracted from the device must equal or exceed the heat generated." Therefore, an adequate heat sink for this transistor must be used, or else the safe operating area will be exceeded and the device will be instantly destroyed, even though it is running at 1/2 its rated power. In this application, a Motorola MS10 heat sink is used. Remember, it's the product of voltage drop and current that equals power-dissipation requirements!

This supply has been run on a heat test for 24 hours at 1/2 load without failure, although the cabinet was quite warm. A reading with a precision thermometer indicated nearly 75°C (167°F) at the edge of the sink — still safely within tolerance. Most tabletop projects don't require this amount of current, but it's nice to know you have a supply with a substantial reserve of power, just in case.

**adjustment**

To set the current limiting pot, first set the control, wired as a rheostat, at the 25% point or roughly 1/4 ohm. Then connect a 25-ohm, 100 watt adjustable bleeder resistor, set to 20 ohms, across the output terminals of the supply. With the voltage control set for 25 volts, slowly reset the bleeder to 13 ohms. Then increase the rheostat resistance to a point where the supply automatically switches to a lower voltage range, indicating current limiting.

Now reduce this control resistance until the voltage returns to 25 volts (at 13 ohms bleed) and quickly disconnect the load while watching the voltmeter. If the voltage shifts up or down, carefully fine-tune the current-limiting control while momentarily touching the load to the supply. Then when the full load-no-load voltage remains constant, this sensing control is in balance. Reduce the disconnected bleeder resistance to 10 ohms and attach the bleeder to the terminals as a check for supply shutdown, which should occur instantly. Lock the control shaft, and the supply is ready to operate.

I installed this control inside the cabinet, so that it can't be disturbed; it can, however, be mounted with the shaft extended and a knob installed for variable...
current-limiting control from the front panel. Calibration and marking would be a simple task.

One last word about the MC1569R regulator. A small TO66 heat sink is necessary to keep the temperature within bounds. A Thermalloy 61688 is suggested for this application.

construction notes

The supply was built in a 5 x 6 x 8-inch LMB aluminum box, with the circuit board mounted on the left side. There's nothing exotic about the assembly of the supply or wiring of relays and circuit-board devices. Number 22 teflon-covered wire (surplus) was used for these components. The high-current leads from the bridge rectifier to the pass transistor, then to the output binding posts, were no. 14 teflon-coated wire.

The output binding posts are spaced on 3/4-inch centers to accept Pomona-type ganged plugs. Three terminals are used, with the green post internally connected to the chassis, as both positive and negative leads are ungrounded.

conclusion

This supply has been a pleasure to use and has been indispensable in the construction of IC device projects — I’m sure it will be the same for you.

Those interested in further information in this application of ICs will find the material in the references very helpful. All are available upon written request from Technical Information Center, Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036. References 2 and 3 are contained in Motorola’s “The Microelectronics Data Book,” second edition, December 1969.

references

conversion from fast-scan to slow-scan television

Scan conversion offers an easy way to get on SSTV — here are some ideas for sampling circuits and a multimode camera.

Slow-scan television (SSTV) has been called one of the new and exciting frontiers of amateur radio, and rightly so. The number of experimentally inclined amateurs regularly transmitting and receiving good-quality still pictures with standard SSTV equipment is steadily increasing. Listen on 14.23, 7.22, or 3.845 MHz, especially late in the evening, and at International SSTV net time (2 p.m. EST) on 14.23 MHz to verify this for yourself.

First, however, you’ll need an SSTV monitor. Many construction articles on monitors have been published. One of the most recent describes an oscilloscope adapter for decoding SSTV signals.

What is needed to attract more amateur TV enthusiasts into the realm of SSTV — for example, those now active on fast-scan ATV in the 450-MHz band — is an easy way to use homemade or manufactured vidicon cameras on SSTV.

For about a year we have been developing a simplified approach to scan conversion in addition to perfecting solid-state monitors. Don Miller, W9NTP, Ted Cohen, W4UMF; and others have pioneered with sampler cameras that convert fast-scan (FS) or standard TV signals to slow-scan (SS) standards (see reference 2).

W3EFG has built a multimode camera that includes a sampler board. It has performed well on the air and was first shown and demonstrated at the 1978 Dayton Hamvention. W3YZC started with a homebrew fast-scan vidicon camera and built a separate scan converter with power supply. This unit used the camera video output to derive SSTV signals.

Modifications for SSTV

The circuits described in this article to obtain SSTV signals can be easily adapted to almost any tube or transistor vidicon camera without destroying the capability of the camera for use elsewhere. The only change necessary in the camera is the addition of simple transistor circuitry to provide a switchable 15- or 60-Hz frame rate from the vidicon camera. This consists of adding a 4:1 unijunction-transistor countdown circuit to convert the 60-Hz pulse to 15 Hz and the addition of a larger value vertical-sweep capacitor. The circuit includes 3 transistors, a few resistors and capacitors, and a miniature DPDT toggle switch.

*Co-author W3YZC joined the silent keys in January. Al's passing is a great loss to all who knew him.
mounted on the back of the camera.

The composite video signal is used "as is" – the horizontal (15,750 Hz) and vertical (15 Hz) sync signals are stripped in the scan-conversion circuit. For slow scan, the modified FS camera must be tilted 90 degrees and operated on its left side, so that what was originally the top of the picture will be to the viewer's right. It's not necessary to reverse the vertical yoke connections because of the polarities used in producing the sliding pulse from the 15,750- and 1/8-Hz ramps (see reference 2).
features

The scan converter design uses a minimum of components. Proven, debugged circuitry results in a scan converter that delivers a high-quality SSTV picture with excellent resolution and contrast. The converter is easy to build and adjust. The accompanying photos, taken with the circuitry described here, pretty well speak for themselves.

The following paragraphs described the basic scan converter circuits and give some ideas for packaging. We have also included a brief description of the multimode vidicon camera built by W3EFG, which includes design innovations from circuits by W3YZC and from the articles on homebrew cameras.3, 4

The multimode camera was the result of an attempt to build a densely packaged, universal camera later used on ATV, SSTV and that could be adapted for experimentation on VHF and UHF with pseudo-random narrow-band TV having motion capability.5

converter functional description

The functions of the scan converter are depicted in fig. 1, which shows interconnections for a standard vidicon camera. The 4:1 countdown from 60 to 15 Hz and the sweep-circuit modification will vary somewhat from camera to

---

Fig. 2. Schematic of the slow-scan converter. Voltages and waveforms are shown for initial setup.
camera. However, circuit details associated with a typical modification may be deduced from the vertical-sweep circuit of the multimode camera described later (see fig. 7).

The block diagram shows the various set-up and operational potentiometers as well as typical waveforms and voltage levels. If positive-going horizontal and vertical sync pulses are available in the camera, sync stripper Q1 may be eliminated. This was done in W3EFG’s camera, since the FS board was directly beneath the SS converter and fm modulator board.

scan circuit

The scan converter schematic is shown in fig. 2. Composite standard video is fed to both the sync stripper, Q1, and to the video preamp and equalizer, Q13. The 15,750-Hz pulses initiate a linear 15,750-Hz sawtooth voltage that is added to a 1/8-Hz linear sawtooth voltage from an 8-second vertical oscillator, Q12. Note that Q12 is a free-running oscillator, which is synchronized with the start of the SSTV horizontal line by the network

W3YZC’s homebrew FS vidicon camera.
composed of 1N914 diode, R34, and C6.

The two ramps are added across R14 of the Schmitt trigger, which causes the circuit to fire over the range of approxi-
mately 0.8 to 1.1 volt. This produces a sliding pulse at the collector of Q7 that is differentiated by C12 and R42 to give a 0.5-μs pulse (approximately). The 0.5-μs pulse opens gate Q16, which samples the video through Q15 to holding capacitor C13. The charge on C13, which is the sstv sampled video, is coupled by a Darling-
ton-pair buffer, Q17, Q18, to the modu-
lator.

The value of holding capacitor C13 was optimized to produce the best sstv picture. Emitter followers Q17, Q18 provide a high-impedance source to the collector of Q15.

A common-base-connected video pre-
amp, Q13, drives the sample-and-hold circuit. The incoming standard FS video is fed through an equalizing network,

shading showed up as a bright or dark area on the left or right side of the sstv picture.

The video pot, R40, adjusts the bias of Q13 and controls both gain and the sync clipping level. The gain of Q13 is approxi-
mately equal to the ratio of R39 to R36 and may be adjusted if required.

device selection

Special mention should be made about the characteristics of the sampling-gate transistor, Q15. Considerable investiga-
tion preceded the selection of the opti-
mum device to produce the best resolution consistent with good gating action.

A transistor with poor gating charac-
teristics will produce a leak-through pat-
tern on the sstv monitor, resulting in streaks as the picture is painted across the tube. Best operation was obtained from a high-speed germanium switching tran-
sistor—the 2N1141. The 2N1141 has been around for quite awhile and is still listed in the catalogs. A lower-frequency 2N1142 was tried, but it produced slight-
ly degraded performance.

All transistors shown in the schematics have worked well. Countless other npn and pnp devices with similar or related characteristics are available and may be used in these circuits. For example, the inexpensive epoxy transistors have been used in most circuits and work fine. The
2N3906 will probably replace the 2N2904, and the 2N3904 will likely work in place of the 2N1613 or the 2N697. We suggest that if you wish to use junk-box transistors, stick with the silicon types, with the exception of the 2N1141 for Q15.

**power supply**

The sampling system is totally intolerant of 60- or 120-Hz hum in the video. Even a few hundredths of a volt ripple will show up as vertical bright bars, slight undulations, or wavy kinks on the horizontal sweep in the sstv picture. For this reason it’s essential that the power supply be well filtered, with less than 0.01-volt ripple or better. The circuit of fig. 4 is recommended for the scan converter and modulator.

In some vidicon cameras, stray magnetic fields may occur at a 15-Hz frame rate. Thus it may be necessary to disconnect the primary of a self-contained power transformer. Filament and vidicon voltages can then be supplied from an external supply placed at least three feet from the camera. Only operating experience will reveal this requirement.

*See Motorola’s “Semiconductor Data Book,” 5th edition, October 1970, for recommended replacements and substitutions for these devices.*

**slow-scan modulator**

An sstv fm modulator similar to that used by most slow scanners is shown in fig. 3. Its setup on frequency is straightforward and has been previously described. Voltagess and input waveforms are shown in fig. 1. It is desirable to first apply 10 volts to T. P. 1 and set the 2300-Hz white frequency, then ground T. P. 1 for the 1200-Hz sync frequency from the multivibrator. This should be
repeated several times. T. P. 2 (filtered by R59 and C17) is a good point to connect an oscilloscope for monitoring black and white level in the scene being televised. Using the lens iris and video pot R40, adjustments should be optimized to prevent white clipping and to obtain proper black-level excursion.

Following the multivibrator, Q24 provides drive to the 2.5-k Hz low-pass filter. L1 and L2 are 88 mH toroids, tuned by the capacitor values shown. The odd values should be obtained by combining standard-value mylar or mica capacitors.

The filter may be mounted on a small board that can be tucked into an available space, along with the power supply. Note that sstv output is at a low impedance and at a fairly high level (approximately 0.5 volt across 3 ohms), which is compatible with 3-8 ohm outputs from receivers and recorders. The sstv output is taken from a phono jack insulated from the case with fiber washers.

set up procedures

It is convenient to view the FS video on a fstm video monitor when setting up the start of the sampling pulse and the point on the horizontal ramp where the pulse ends and returns to start a new sstv frame. Since Q13 tends to isolate feedthrough of this pulse to the video input, C4 should be jumpered to the video input, for initial setup. The differentiated spike will then be clearly visible on a regular monitor as a thin, bright vertical line. Its width is indicative of the sampling-pulse width, and its excursion from the viewer's right on the screen to the viewer's left indicates that portion of the FS picture being sampled.
A 1:1 aspect ratio is used in SSTV, so a narrow portion to the left and right of the FS picture will be lost. Since there is some interaction in adjustments, a careful procedure must be followed to center the sampling range while watching the FS monitor. (Two small pieces of black tape on the monitor screen will help.)

The horizontal-ramp pot, R2, will affect the beginning of the sampling pulse. The sampling speed, and hence the limit or end of a frame is determined by the vertical-ramp pot, R26. Resistor R10 sets a dc level of 1.8 volts, which may be adjusted to shift the sampling-position range of R2 and R26.

A vernier range of adjustments is possible for R2 and R26; however, the final setting of both controls is quite critical. Screwdriver-adjusted potentio-
meters with locking nuts are recommended. The voltages and waveforms shown in fig. 2 are provided as a guide. These are approximately equivalent to those obtained by the authors. Patience during adjustment and optimization of values may be required.

**packaging**

The converter shown in the photo is contained in a 10 x 5 x 3-inch minibox which provides ample room for two small power transformers and associated switches, pots, and connectors.

The vector-board chassis could be adapted to a printed-circuit board. Perhaps some enterprising slow-scan enthusiast with PC-board layout facilities will tackle this job and make such boards available. This would certainly give sstv

**fig. 9. Suggested power supply for FS or SS camera. T1, Lafayette 33E34059; T2, Lafayette 99E62663.**
activity a further boost with more sampler cameras on the air.

Scan converter board wiring is not critical as to lead lengths, interconnections, or placement of wires and components. Standard construction techniques were used. Push-through vector board pins were used for tie points. Resistors and capacitors were wired point-to-point to the transistor sockets. Several straight buswire runs on pins for the 12 V and ground leads were used. Because of the high frequency components in the narrow sampling-pulse circuitry, single-point ground returns for Q6, Q7, Q16, and Q15 are recommended. Also a short run of 75-ohm mini-coax from the back panel video connector to the video input is essential, plus a short length of coax across the board to C1 of the sync stripper transistor, Q1. These coax cables should be grounded at only one point on the board to prevent ground currents in the FS video.

fast-scan camera

The circuit details shown in figs. 5 through 10 are provided with a minimum of explanation for those ambitious slow-scanners who may wish to duplicate a

Solid-state sstv monitor using a 5FP7 tube. The photos of the ID chart and the authors were made from W3EFG's camera and this unit.
typical homebrew multimode camera. These circuits, which are used in W3EFG's camera, are generally straightforward and can be modified to drive vidicon focus—deflection-coil yoke assemblies having different impedances.

With the exception of the video board and vidicon yoke in the 3 x 2½ x 8-inch camera head, all circuitry in figs. 6 through 8 are on a vector board measuring 4½/8 x 3½/16 x 3/32 inches. This FS board is mounted in the 5 x 7 x 3-inch minibox beneath the SS converter board. Switching is shown in fig. 10 for the various operating modes.

A suggested power supply for the entire camera is shown in fig. 9. Only the portion of the supply associated with the 24-volt transformer need be built if only the scan-converter board is constructed. However, the supply can be built to supply total power to an existing camera if hum problems develop, as mentioned earlier.

**vertical sweep**

Attention is called to fig. 7, which shows the vertical-sweep circuit. To make the 15 to 60 Hz frame-frequency modification to an existing camera, as mentioned earlier and shown in fig. 1, parts of the circuit in fig. 5 can be used. We suggest that the components associated with Q9, Q10, Q11 be put on a small vector board, with the indicated switching circuit (see fig. 11). This board may then be placed in any available space within, or external to, an existing camera. Careful study of the particular camera circuit will show the correct tie-in points.
This modification should work equally well with random interface and 2:1 interlaced cameras. *

conclusion

These fast-scan camera circuits are third- and fourth-generation versions used by the authors. All are proven circuits and produce excellent FS and SS pictures.

This article is intended to provide active slow-scanners and atvers an optimum means of producing high-quality, live sstv pictures. You may wonder if "holding still" for eight seconds is difficult. Our experience shows this is no problem. Since we're scan-converting or sampling a fast-scan camera, there is no latent change pattern on the target, such as may occur with the open-shuttered vidicons usually employed in the SS mode.

Other advantages of the sampling approach include the ability, in real time, to focus the vidicon optically and electrically. Second-order benefits include automatic light compensation via automatic target circuitry.

We would like to thank all sstv amateurs contacted for their continued interest in our activities and for their encouragement. In particular, thanks are due W9NTP and W4UMF for their inspiration and pioneering efforts to promote the sampling technique, which appears to be a much-needed break-through for sstv amateurs.

references

*A G. E. 4TE23 camera was so modified with excellent results.

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july 1971
six-meter antenna coupler

This 500-watt antenna coupler for 50 MHz matches both balanced and unbalanced feedlines and uses commercially-available hardware.

Current six-meter transceiver and transverter designs follow the general supposition that the operator will be using 50-ohm coaxial cable and an antenna system of like impedance. Output tank circuits are usually pi-networks designed to match a 40- to 60-ohm load and allow little deviation beyond these limits. On the other hand, the amateur buys 50-ohm coax, assembles a 50-ohm antenna to the manufacturer’s specifications, and assumes the load presented to the output of the transceiver is 50 ohms. In most cases it is not unless careful attention is given to swr measurements, antenna match adjustments, antenna location and a host of other variables.

To compound the problem amateurs begin loading the system with goodies such as swr bridges, monitor scopes and the like which do nothing to improve transmission line flatness, and in most cases add to the mismatched condition by adding impedance “bumps” to which the transceiver has difficulty accommodating. The end result is a transceiver which is difficult to tune and erratic to operate.

In these situations the often maligned and usually misunderstood antenna coupler can be used to its best advantage. Many hams who lack experience with couplers have the mistaken idea that they are a panacea solution to antenna problems. However, an antenna coupler will not compensate for a misadjusted antenna or one in need of repair; nor will it compensate for final-tank-circuit inefficiencies.

It will provide the transmitter with a constant load impedance irrespective of antenna variations. In addition, it will assist in receiving by attenuating spurious signals through the introduction of another tuned circuit in the input.

construction

Many articles have been written on antenna couplers. Unfortunately, these designs often require the builder to fabricate coaxial cavities and various plastic...
spacers and other hardware to incorporate an SWR bridge into the coupler. The coupler described here takes the lazy man’s approach and uses commercially-made hardware throughout; it requires an absolute minimum of fabrication.

The coupler consists of a conventional input/output circuit of a 2-turn input coil tuned with a 100-pF variable to ground. The input coil surrounds the output coil and is inductively coupled; the output inductor consists of 7 turns of no. 10 copper wire tuned by a 7-35 pF butterfly variable to ground. The output inductor is tapped for 300-ohm balanced output at 2½ turns from each end.

**swr bridge**

An SWR bridge is included to provide a self-contained functional unit. The heart of the bridge consists of a coaxial cavity line and RF pickoff elements from a Heathkit SWR bridge. The coaxial-section components were purchased from Heath for less than $2 and eliminated the need for sheet-metal bending, parts fabrication and chasing all over for plastic, brass rod and the like. The meter is a Radio Shack Micronta, 0-1 mA, catalog no. 22-018. The meter face was removed, and the original numbers and lettering were
erased with a coarse typewriter eraser. The scale was relabeled to correspond with swr. Lettering was done with rub-on letters. The meter face was then sprayed with clear acrylic. A full-scale drawing of the meter face is shown in fig. 1.

**assembly**

Drilling templates are shown in figs. 2 and 3. The chassis should be drilled and all holes deburred. Burnish all exterior surfaces with 00 or 0 grade steel wool. Wipe all surfaces to be painted with a degreasing solvent or white vinegar to remove surface dirt and oils. The unit in the photograph was built for K1ZFE and was painted flat black and Dove Gray to match his equipment. Krylon spray colors were used; excellent results were obtained by applying several light coats with plenty of drying time in between. After painting, each cabinet half was baked in an oven for one hour at 200° to assure complete drying. Black transfer lettering was added to the front panel and Dymo labels on the rear.

Mechanical assembly should begin with the swr coaxial section and SO-239 input connector. The section must be shortened by one inch to fit this cabinet. The output end of the coax section center conductor is mounted to a 6-32 ceramic standoff insulator. Then add the terminal strips, terminating resistors, rectifier diodes and .001 bypass capacitors; assemble the switch, sensitivity pot and all interconnecting wiring. Wiring from the rectifier diodes to the switch should use shielded wire.

The two front-panel air-variable capacitors and the terminal tie point on the left side (bottom) of the chassis should be assembled to the cabinet next.

**fig. 2. Rear-panel layout for the coupler.**

Tie the ground lugs of each air variable together and to the center ground terminal of the tiepoint; use no. 14 copper wire. L2 is connected to the butterfly capacitor by two copper sleeves made by enlarging the diameter of a ⅛-inch long piece of 3/16-inch copper tubing. Use a 100- or 150-watt soldering iron for soldering.

**table 1. Parts list for 6-meter antenna coupler.**

<table>
<thead>
<tr>
<th>qty</th>
<th>description</th>
<th>cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chassis Box (LMB 564 N)</td>
<td>$2.95</td>
</tr>
<tr>
<td>1</td>
<td>Meter (Radio Shack 22-018)</td>
<td>2.95</td>
</tr>
<tr>
<td>1</td>
<td>Butterfly variable (E. F. Johnson 167-22)</td>
<td>3.45</td>
</tr>
<tr>
<td>1</td>
<td>Hammerlund variable (HF-100)</td>
<td>2.65</td>
</tr>
<tr>
<td>1</td>
<td>Coaxial section (Heath 40-100)</td>
<td>.20</td>
</tr>
<tr>
<td>1</td>
<td>Rf driver element (Heath 40-98)</td>
<td>.55</td>
</tr>
<tr>
<td>2</td>
<td>Rf pickup element (Heath 40-99)</td>
<td>.20</td>
</tr>
<tr>
<td>3</td>
<td>Plastic spacer (Heath 255-12)</td>
<td>.30</td>
</tr>
<tr>
<td>3</td>
<td>2-lug terminal strip (Heath 431-14)</td>
<td>.30</td>
</tr>
<tr>
<td>2</td>
<td>SO-239 coax connectors</td>
<td>1.70</td>
</tr>
<tr>
<td>1</td>
<td>50k pot (Heath 10-11)</td>
<td>.50</td>
</tr>
<tr>
<td>1</td>
<td>2-position rotary switch (Heath 63-177)</td>
<td>.85</td>
</tr>
<tr>
<td>2</td>
<td>1N191 Diodes</td>
<td>.60</td>
</tr>
<tr>
<td>2</td>
<td>.001 disc capacitors</td>
<td>.40</td>
</tr>
<tr>
<td>2</td>
<td>150 Ω ohm resistors, ½ watt</td>
<td>.20</td>
</tr>
<tr>
<td>1</td>
<td>Ceramic standoff</td>
<td>.45</td>
</tr>
<tr>
<td>3</td>
<td>Binding posts (Superior)</td>
<td>.90</td>
</tr>
</tbody>
</table>
Be sure to slide L1 over L2 prior to completing the assembly of L2 to the butterfly. Bend the legs of L1 to fit the spacing of the two ungrounded tie points and make sure that the spacing of L1 around L2 is even. Connect the output of the coaxial line to one end of L1; connect the other end of L1 to the stator of the 100-pF variable.

Assemble the 5-way binding posts to the chassis and the output coaxial connector to its mounting hole. Connect the upper two binding posts to the taps on L2 with a short piece of 300-ohm transmission line (preferably foam filled). Connect the output coax connector to the 5-way binding post nearest the center of the chassis. The lower binding post nearest the outside edge of the chassis should be connected to ground. Assemble the meter to the cabinet and wire it to the 50k pot. All interconnecting wiring in the L1/L2, C1/C2 section is done with no. 14 wire.

test and operation

If the coupler is to be used from one coaxial cable to another, install a jumper wire between the grounded binding post and the one directly above it. This must be done to use the coupler for coax-to-coax transfer. Connect the coupler between the transmitter and the antenna or a 50-ohm non-reactive dummy load such as the Heath-kit cantenna. Tune the transmitter for low power output. Set the swr bridge switch to forward and adjust the sensitivity pot for full meter deflection. Reset the switch to reverse and adjust C1 and C2 for minimum reflected power. It should be possible to adjust the reflected power to zero.

When the coupler is adjusted for minimum reflected power the transmitter can be tuned for full output power. It is possible to move 100 kHz either side of the tuned frequency before the coupler must be re-adjusted. Once the antenna coupler is set for minimum reflected power, leave it alone - tune the transmitter final to obtain maximum output, not the coupler.

conclusion

This unit will handle up to 500 watts without problem. Insertion loss has been measured at 1 to 2 percent. However, the improved efficiency provided by the coupler more than compensates for the low insertion loss. For those amateurs who already have an swr bridge, the coupler section could be built into a smaller cabinet and used with the existing bridge. Tuning procedures would be the same. Just be sure to install the swr bridge between transmitter output and the coupler input.

Inside view of antenna coupler shows mounting of L1 and L2.
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Presented in this article is a solid-state vox unit designed as a companion to my 9-MHz ssb generator described in an earlier issue of *ham radio*. I had three objectives in this design:

1. Operation with all normal settings of the ssb generator audio-gain control and with all settings of the hang-time control.

2. Operation in the cw mode, with a minimum of components, and with fast pick-up time to avoid lost characters.


circuit description

The circuit that fulfills these requirements appears in fig. 1. The function switch is shown in the ssb vox position. The vox input from the generator feeds the base of Q1 through CR1. Note that a positive input is required. To provide this, the ssb generator should be modified as shown in fig. 2. The 47k resistor is connected to ground to quickly discharge the vox filter capacitor.

With no vox input, Q1 has no drive; consequently Q2 and Q3 are turned off. When a positive input arrives from the generator, Q1 turns on Q2, which in turn drives Q3 into saturation, causing relays K1 and K2 to operate. One contact of K1 grounds the transmitter keyline and opens the mute line to the receiver. The second contact may be used to close relays in a linear amplifier when the vox relays close. The hang time is primarily determined by the C3, R4 time constant. The value of R4 was selected so that several times more current would flow through it as into the base of Q2. This minimizes the effect of Q2's base current on the hang time and consequently minimizes temperature effects on the hang time due to transistor gain variations.

The network of CR2, CR3 and R6 insures proper operation of the vox circuit at very short hang time settings. Without these components, C3 must charge and discharge through a major portion of R4's resistance. This means that if the hang-time control is set for a half second as an example, several dots or dashes of a letter must be sent before the vox relays will hold in. With the network shown, C3 charges rapidly to nearly the emitter voltage of Q2 through R6 and CR3 upon closing the key. Upon releasing the key, Q2 receives base drive through CR2, thus avoiding the high attenuation.
path through R4. The quick-charge network also helps prevent relay chattering with short hang-time settings in the ssb vox mode. At the maximum hang-time setting, CR2 is shorted out and CR3 is back-biased with the key down, so neither affects circuit operation. CR3 is also back-biased when the key is released regardless of the hang-time setting and megohm, and so should not disturb the bias circuits of most transmitters. The voltage at my key is -35 volts. For higher keyline voltages, increase the size of R3, and reduce it for lower voltages.

**cathode keying**

You may have a cathode-keyed transmitter with which you may wish to use

---

**fig. 1. Vox schematic. Fast cw break-in is also featured.**

thus has no effect on the discharge curve of the hang-time network.

The 1k resistor in series with the base of Q3 limits the base current to safe values, in this case about 8 mA maximum. The diode across the relay coils clips the large voltage spike created when Q3 turns off in a short time period, such as during break-in operation.

In the cw vox position of the function switch, the keyline is connected to the key jack. Resistors R1, R2 and R3 form a summing network between the positive vox supply and the negative keyline voltage. R2 is adjusted so that the voltage at the base of Q1 is zero. The resistance presented to the keyline is close to a this circuit. In that case, Q1 may be changed to a pnp transistor and components added to the transmitter as shown in fig. 3. The voltage of the zener diode must be larger than the vox circuit supply voltage and must also be large enough to completely cut off the final tubes. The values of R1, R2, and R3 must be large enough to hold Q1 base current to a safe value. Values as shown in fig. 1 are satisfactory. R2 is adjusted so that Q1 base voltage just equals the emitter voltage. Note that the vox input now comes into the base of Q2. This means that a lower-impedance source of this vox voltage is desirable for rapid charging of the hang-time network. The R-ZD1 combina-
tion could be replaced by a voltage divider if regulated voltage is available in the transmitter.

**break-in**

Break-in operation in the cw vox position is possible by turning the hang-time control to minimum. The two relays (if they are capable) will now follow the key. For break-in operation up to several hundred watts, the vacuum relay shown is recommended for its fast operation and ability to hot-switch several amps. K1, the other relay in my unit, is a small two-pole sealed 28-volt relay. I have tried other types, and the surplus 28-volt leaf-type relays will follow a key at moderate speeds. The extra noise created can be damped with felt between the relay and the chassis. Reed relays may of course be used, and some of the heavier ones may handle moderate powers.

![Diagram](image)

**fig. 3. Vox modifications for use with cathode-keyed rigs. Value of resistor in tube cathode circuit is for B+ = 300 volts. Zener-diode voltage is 60 volts dc at 1 mA.**

*device considerations*

The transistors are on the expensive side, but satisfactory substitutes can be found. As an example, Poly Paks lists the 2N2222 at five for a dollar. While their $V_{ce}$ is 30 Vdc, they should work well if care is taken to hold the supply voltage to 24 Vdc or less. The power dissipation of Q1 and Q2 is negligible, but that of Q3 depends on the relay current required. As an example, with the key down, Q3 is saturated with 120 mA through it in my vox unit, but the voltage across it is less than a volt. The power dissipated is less than 120 mW. When the key is released, however, the voltage across the transistor rises, and the current drops. At the point where 12 volts are across the transistor, 60 mA may flow through it for a short-term dissipation of 720 mW. The average dissipation, however, would be under 500 mW, and a 2N2222 could be used for Q3, but with little margin. At this point, a 2N2218A would be a good substitute (and far cheaper) for the 2N2219A.

If you wish to use whatever you can dredge up from the junk box, try the following measures to compensate for lower-beta transistors: decrease the values of R1, R2, R3 and R5. Operation with 12-volt relays requiring more current than those listed may also require a decrease in these resistor values.

---

2. Modifications necessary to author’s ssb generator described in ham radio, December 1970 for use with this vox circuit.

52 *yr* July 1971
construction

My unit was built on a 1-1/2 x 2-inch piece of perf board, which was mounted on the rear of my transmitter chassis. R4, C3 and S1 are on the transmitter front panel, and R2 is on the chassis rear apron beside the perf board. Shielded wires to these controls are a must to avoid rf feedback. The antenna relay should be located remotely from the rest of the circuitry, and leads going to it should be well bypassed.

other uses

The applications of this circuit are numerous. It could be added to a transmitter to eliminate throwing of switches to go from transmit to receive, or to control a linear you may have added to your station. It could be set up for battery operation with low-current relays and used on Field Day to mate someone’s transmitter with someone else’s receiver. It could also be used to key a tape recorder to record slow-scan tv or someone’s voice. Or, how about recording passing satellite signals? Whatever your use, happy voxing!

reference


"All right buster! Back to your radio and never mind the skirt selectivity."
how to design a frequency calibrator for your receiver

Complete design procedure for a novel marker generator consisting of a constant-current source, unijunction oscillator and tuned output amplifier

Recent changes in amateur band-edge assignments for various license classes, and lack of crystal calibrators in many popular transceivers, has resulted in a rash of magazine articles on crystal calibrators. Some circuits are better than others and make provisions for 25-, 50- or 100-kHz checkpoints.

If you need a quick and handy crystal calibrator for your receiver, by all means refer to any number of previously published articles. However, if you have a little time and want to learn a bit more about electronics, then read on.

The circuit presented here is absolutely not in the category of, "wire the parts together according to the given values and layout and you will have..." category. Rather, adequate design data is provided so you can calculate the required component values and make a breadboard with a minimum amount of the test equipment. The end result will be a useful, working calibrator that provides 100-kHz and 1-MHz reference points. More important, you'll learn a bit about electronics and why it isn't really too formidable to design and build simple circuits rather than going to the store for another piece of gear, or slavishly copying someone else's design without the foggiest notion of what to do if it fails to work when it is plugged in.

the calibrator

The circuit in fig. 1, as opposed to the usual crystal-calibrator oscillator, relies primarily on the frequency stability of a low-frequency pulse generator that is used to supply impulse energy to a high-Q tank circuit tuned to 1 MHz. Although the oscillator is not crystal controlled the short-term stability will be more than adequate; long-term stability is primarily dependent upon the quality of key com...
ponents and regulation of the supply voltage.

The circuit can be broken into four easily understood sub-parts. Pnp transistor Q1 and its associated resistors (R1, R2 and R3) form an adjustable current source flowing from the collector of Q1. This current, I1, can be set to the desired value by adjusting the base voltage V1 with potentiometer R2. Current I1 will be very nearly (neglecting some fine points concerning base-emitter diode potentials):

$$I_1 = \frac{E - V_1}{R_1}$$

fig. 1. Stable frequency marker does not require a crystal-controlled oscillator stage. Component values are discussed in the text. Capacitor C6 and the antenna are used to transmit the marker signal to the receiver. Resistor R8 drops the B+ supply to the zener-diode voltage of CR2.

Current I1 charges C1 linearly to an increasing higher voltage until the threshold firing potential of the unijunction transistor is reached; at this point C1 is rapidly discharged through R4 into Q2. This process repeats indefinitely since Q2 will revert to a non-conducting state whenever the emitter voltage falls below a minimum called the valley voltage and current I2 is less than the holding current.

If an oscilloscope were used to look at the voltage across C1 it would display a very good sawtooth waveform; a linear voltage ramp due to the constant current I1 with a very fast return to near ground when Q2 conducts. Therefore, two parts of the circuit are easily understood: Q1 is a constant-current source and C1 is a timing capacitor that determines how long it takes to reach the trigger voltage of Q2.

Transistor Q2 is nothing more than a simple unijunction transistor pulse generator. Whenever the emitter voltage reaches a certain fraction of the supply voltage E, a triggering voltage is reached which causes conduction between the two base junctions, thus causing B1 to suddenly jump up to a level near the emitter voltage. If the emitter voltage drops below some specified minimum conduction between B1 and B2 ceases. Thus, looking at R6 with a scope would show a squarewave pulse every time Q2 conducts.

Transistor Q3 is normally not conducting. The base is normally at ground potential through R7, and the voltage required to make Q3 conduct is at least two diode voltage drops – CR1 and the base-emitter diode of the transistor. Therefore the base must reach at least 1.0 to 1.2 volts before Q3 will be turned on.

However, each time a pulse appears at R6 it will be coupled to Q3 base by C2 briefly turning on Q3. If C2 is fairly small it will differentiate the squarewave pulse at R6 (a voltage spike will be observed at the base of Q3). The final portion of the circuit consists of Q3 and its resonant tank circuit. Rather than being an ordinary tuned amplifier, this circuit could be called an “impulse driven resonator.” Each time Q3 conducts because of a voltage spike from C2 energy is fed to the collector tank circuit. If the tank circuit has high Q it will continue to ring at the resonant frequency even though the initial energy supply is removed (Q3 stops conducting). The initial sine-wave energy at the resonant circuit will slowly diminish in amplitude but will be replenished when Q3 fires again. If the tank circuit is tuned to 1 MHz you have a 1-MHz marker plus plenty of harmonics to use as higher band-edge markers.
Although the foregoing discussion should be enough to get the circuit playing, a few more words should reduce the amount of "fiddle-time." Since you want a stable oscillator the supply voltage should be constant; a large electrolytic capacitor, C5, and an appropriate zener regulator can be used. The voltage is best chosen in the range of 12 to 28 volts dc.

Any old pnp transistor can be used for Q1. A value of 10k ohms for R2 and R3 is a reasonable starting value. Similarly, R4 isn't too critical since it is only used to limit the initial current surge into Q2; something in the neighborhood of 1000 ohms is reasonable.

Any problem likely to be encountered is in the choice of R1 and C1. A basic impulse rate that is a submultiple of 1 MHz is desirable so 100 kHz seems like a good basic frequency for the sawtooth at C1. However, current I2 must eventually diminish to a value less than the holding current for Q3 (on the order of 1 mA).

If I1 is greater than the holding current for Q2 (check the manufacturer's specs for this value) then Q2 will latch-up in the conducting state. Therefore the current selected for I1 must be less than the Q2 holding current or R4 made very large, which is not desirable. Similarly, to obtain a pulse rate of 100 kHz into Q2, C2 must be charged to the trigger voltage of Q2 at precisely that rate, every 10 microseconds. To pick the proper value for C2 once I1 has been selected use the equation

\[ \frac{\Delta V}{\Delta T} = \frac{I1}{C1} \]

where the symbol \( \Delta \) means "rate of change." More simply, the voltage change at C1 (called \( \Delta T \)) is equal to the ratio of the current I1 divided by the capacitance charged, C1 in this case. Since you know I1 (or can vary it slightly) and \( \Delta T \) is 10 microseconds, then the value of C1 is easily determined since the required value of \( \Delta V \) is the triggering voltage for Q2. (The triggering voltage is typically 0.25 to 0.5 the supply voltage.)

The unijunction transistor Q2 is fairly non-critical as to the values selected for R5 and R6. Resistor R5 usually ranges from 300 to 600 ohms; 100 ohms is a ballpark value for R6. Since you want some differentiation of the pulse delivered to Q3, capacitor C2 might be anything from 1000 pF to as much as 0.01 μF.

Resistor R7 keeps Q3 reverse biased by draining off the reverse base-leakage current; for most small-signal transistors this leakage is so small that 100K ohms is a fair value for R7. Nearly any npn transistor will work adequately at Q3 such as an old 2N706 or 2N708.

The tank circuit (L1-C3-C4) should resonate at 1 MHz; a high-Q inductance is needed. This is easily obtained by using a ferrite toroid core and many turns of small wire. Capacitor C3 should provide most of the required capacitance, with C4 used for fine tuning. Alternatively, if L1 is variable C4 may be omitted. A wire antenna can be attached to the tank circuit to couple energy to your receiver.

Circuit calibration may be accomplished by zero-beating the output against WWV. The primary variable will be R2 to obtain zero beat, with C4 used to obtain maximum power output. However, C4 will alter the output frequency slightly so some juggling back and forth between R2 and C4 will be needed initially.

Frequency stability will rival that of most crystal oscillators if two precautions are observed: The supply voltage must be stable, and C1 must not change capacitance radically with temperature. To a lesser extent, more expensive unijunction transistors have more stable trigger voltages that contribute a constant output frequency.

One nice feature of this circuit, aside from its low cost, is that if 100 kHz is picked as the basic pulse frequency, 100-kHz markers can be heard throughout the lower amateur bands and used as additional reference points.
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integrated circuits

Many broadcast equipment manufacturers have taken advantage of digital ICs when designing new equipment. Such devices as JK flip-flops, divide-by-12 counters, divide-by-16 counters, 4-bit binary counters, etc. have found their way into a-m and fm broadcast transmitters. Radio amateurs and amateur radio equipment manufacturers might like to take a look at some of the possibilities.

One popular a-m broadcast transmitter uses two divide-by-2 binaries, fig. 1. The crystal oscillator frequency is set in the stable frequency range from 2 to 4 MHz spectrum. If the broadcast transmitter transmits between 540 and 1080 kHz, two 2-to-1 counters provide a net count down of four. If the transmitter must operate between 1080 and 1600, a single 2-to-1 counter is used to divide the frequency.

Digital ICs of this type generate square waves but this is no problem. Output resonant circuits of appropriate Q can convert the square wave to a pure sine wave. The input to the counter should be a square wave; this can be accomplished with a simple limiter at the output of the crystal oscillator.

Some modern fm transmitters use elaborate digital counter chains such as fig. 2. This arrangement permits the frequency-modulated oscillator to operate at the fundamental frequency of the fm station. An automatic-frequency phase-lock system keeps the oscillator on the assigned frequency well within FCC tolerance (±2000 Hz on the fm broadcast band).

In one fm broadcast transmitter an output from the basic oscillator is applied

One of Motorola's newer MRTL digital ICs is the MC880P, a decade counter that also divides by five or six with the proper external connections.
to a 16,384-to-1 counter and then to a phase comparator. The crystal reference oscillator operates in the 1.5- to 2-MHz range, depending upon the assigned frequency of the fm station. This reference frequency is divided by 256 and applied to the phase comparator. The phase comparator develops a dc reference voltage which keeps the transmit oscillator on frequency.

For such a divider system, the digital ICs must be capable of operating at very high frequencies. Such units are available at low cost. For example, a 120-MHz J-K flip-flop has a unit cost of approximately $7.50. A flip-flop with a maximum input frequency of 85 MHz can be purchased for about three dollars. A divide-by-16 counter with a maximum frequency of 30 MHz can also be purchased for about $7.50. A search of the surplus market may yield the same or similar units at even lower prices.

practical frequency dividers

What are some of the possibilities for amateur equipment? Amateurs are accustomed to using frequency multipliers that develop signals related harmonically to a crystal oscillator or vfo. A digital divider system permits decreases in frequency. For example, a divide-by-2 counter following a 40-meter vfo that tunes from 7 and 8 MHz will give an 80-meter output between 3.5 and 4 MHz. Two 2-to-1 dividers would provide a net division of 4 and put the signal into the 160-meter band, fig. 3.

Digital ICs that can be connected as astable multivibrators can also be made to multiply. Is it possible to build an IC substitute for the common frequency-multiplier chain?* The arrangement of fig. 4 might be feasible as an all-band signal source or as an accurate all-band signal source and calibrator. Two-times the 7.5-MHz master-oscillator signal provides a WWV check point at 15 MHz.

Reconstructing a sine wave from a square wave output is no great problem with resonant circuits or multisection integrators. However, you are working with pulse waveforms and their multi-frequency makeup, so proper shielding and grounding is important.
This scheme is attractive for all-band QRP operation and it matches the various QRP modes of cw, a-m, dsb and phase-type ssb. There is also merit in terms of the direct-conversion receiver because you can work both down- and up-frequency from a single high-stability beat oscillator.

For vhf operation IC frequency dividers can be used to put the transmit oscillator on the transmit frequency, doing away with the multiplier chain. A possible system for 2- and 6-meter operation is shown in fig. 5. A divide-by-8 circuit brings a fundamental 6-meter signal down to the 7-MHz range where it is compared with a crystal oscillator, vxo or stable vfo. The two signals are applied to a phase comparator (also available as a digital IC). A dc afc voltage is developed for controlling the fundamental frequency oscillator, holding it on frequency. The fundamental frequency oscillator uses a voltage-variable capacitance diode that responds to the phase-lock afc system.

For 2-meter operation an 18-to-1 frequency divider brings the fundamental frequency down to the 8-MHz range for comparison. Otherwise, the system is the same as 6-meter arrangement. Also, this configuration is adaptable to various modes of modulation. Frequency modulation may even be accommodated. However, frequency division must be greater to prevent the modulating frequencies from affecting the phase-lock operation.

---

**fig. 4.** An all-band high-frequency signal source using a single 40-meter oscillator.

**fig. 5.** Using IC frequency dividers in frequency-determining systems for 6 and 2 meters.

---

**simple rf divider**

The feasibility of this frequency-control circuit was checked out with a low-cost MDTL clocked R-S flip-flop, wired externally to operate as a J-K flip-flop. The frequency divider was used with the fet circuit described in the June issue.

The output of the Pierce crystal oscillator, fig. 6, is fed directly to the clock input of the flip-flop. A shaping diode is connected between pin 2 and common. The flip-flop is biased with a 9-volt transistor radio battery.

A tuned fet rf amplifier follows; it is operated in class A because of limited drive from the flip-flop. Nevertheless, approximately 200 milliwatts of rf output is developed. But more important, a beautiful 80-meter sine wave may be observed at the output. A local 80-meter QRP contact using a 40-meter crystal is something a bit different from the ordinary.
This QRP transmitter for 80 meters uses a 40-meter crystal and IC 2:1 frequency divider.

high-power audio

An unusual two-section high-power audio amplifier, the RCA HC-1000, is capable of delivering 100 watts into a 4-ohm load with a peak current of 7 amperes. The total supply voltage is 75 volts. An output transformer can be added to step up the impedance when required; this may be necessary if the unit is used to supply audio to a vacuum-tube modulated amplifier.

The price of the HC-1000 is in the $60 bracket. This might shake you a bit but consider what it would cost to build a vacuum-tube modulator capable of de-

fig. 6. This QRP transmitter for 80 meters uses a 40-meter crystal and IC 2:1 frequency divider.

fig. 7. Internal circuit of the miniature RCA HC-1000 100-watt audio power amplifier.
livering 75 to 100 watts of audio? Consider too that the entire HC-1000 module is 3 by 3-1/2 inches and weighs but 100 grams.

The amplifier consists of two separate sections mounted on a common base plate. One section serves as the complete driver and includes 23 resistors, 7 capacitors, 6 diodes and 9 transistors. Two power output transistors and two diodes are contained in the second section.

A schematic diagram of the HC-1000 is shown in fig. 7. The input stage (Q1 and Q2) is a differential amplifier with a constant-current bias source (Q3). Note the temperature-stabilizing diodes in the base circuit of Q3.

The collector of Q1 supplies output to the base of a class-A amplifier (Q5). Transistor Q5 supplies drive to the two pairs of output transistors. The collector of Q5 is connected to the collector of Q4; Q4 is also a constant-current source but its purpose is to supply a bidirectional current in proportion to the current through Q5. It acts as a level translator to ensure that no dc offset voltage is applied to the output transistors. Such a dc voltage would be contributed by Q5 if it were not balanced out by the voltage developed by Q4.

The protection circuit within the dashed block prevents damage to the this stage is high enough to attain good gain from the class-A amplifier (Q5).

The HC-1000 circuits in fig. 8 are designed for a positive and negative power supply (fig. 8A) or a negative power supply (fig. 8B). Circuit 8A includes an output transformer for providing a proper match to a specific load resistance.

\[\text{fig. 8 Practical audio power amplifiers using the HC-1000. Circuit in (A) requires both positive and negative voltages; circuit in (B) requires only negative supply voltage.}\]

\[\text{A schematic diagram of the HC-1000 is shown in fig. 7. The input stage (Q1 and Q2) is a differential amplifier with a constant-current bias source (Q3). Note the temperature-stabilizing diodes in the base circuit of Q3.}\]

\[\text{The collector of Q1 supplies output to the base of a class-A amplifier (Q5). Transistor Q5 supplies drive to the two pairs of output transistors. The collector of Q5 is connected to the collector of Q4; Q4 is also a constant-current source but its purpose is to supply a bidirectional current in proportion to the current through Q5. It acts as a level translator to ensure that no dc offset voltage is applied to the output transistors. Such a dc voltage would be contributed by Q5 if it were not balanced out by the voltage developed by Q4.}\]

\[\text{The protection circuit within the dashed block prevents damage to the}\]

\[\text{module when an improper load is placed on the output. Transistors Q9-Q11 and Q8-Q10 are Darlington pairs that develop a high-power output across a low impedance load. The input impedance to}\]

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Portable solid-state equipment that is designed for low power drain often excludes the use of "high-drain" pilot lamps. The circuit in fig. 1, designed by S. Thomas and described in The Radio Constructor, flashes the light after the switch is turned off. The circuit is applicable to any transistor equipment that uses a 9-volt battery. When switch S1 is on the capacitor is charged through the diode; when the switch is turned off the 6-volt lamp is connected across the capacitor, causing the bulb to flash brightly. The circuit draws negligible battery current; in Mr. Simon's unit the leakage current drawn by the capacitor was measured at 6 μA.

The capacitor cannot discharge the equipment circuits because of the diode. However, if the equipment has a large-value capacitor across the power supply, it will discharge through the diode into the lamp, increasing the length of the flash. With most equipment it would probably be possible to eliminate the diode and connect the capacitor and lamp directly to the negative supply lead, although this should be checked experimentally.

receiver incremental tuning for the swan 350

Although receiver incremental tuning is not an absolute necessity, at times it is a pleasant convenience. The circuit in fig. 2 is quite basic and may be added easily to the Swan 350.

Most of the smaller component parts may be mounted on a small 6-lug terminal strip which is mounted under the left-rear mounting nut of the vfo printed-circuit board (as viewed from the front with the Swan on its back). This provides a short, direct connection between C1 and the collector of the oscillator transistor, Q1, by soldering to the lead which comes from the dial set and tuning capacitors; this lead is connected to the vfo board at the small solder blob immediately in front of the mounting screw that is used to mount the terminal strip. Use a piece of good stiff wire here to prevent any unwanted fm-ing due to vibration.

Location of the other components is not critical. In my unit CR2 and R4 were mounted on a terminal strip adjacent the voltage regulator tube, V16. The relay was mounted immediately behind the vfo box near the two elongated chassis cutouts. The R17 pot was mounted on the front panel between the dial window and the plate tuning control. Although I
fig. 2. Incremental tuning circuit for the Swan 350. Relay K1 is a miniature 12-volt spdt relay such as the Potter & Brumfield KMSD. CR2 is a 30-volt, 400-mW zener.

mounted the calibrate pot on the front panel above the RIT pot, it may be mounted internally on a small bracket. The wires were routed through the small chassis hole near the vfo amplifier tube.

Calibration is accomplished by first setting both pots to the middle of their ranges. Feed in a crystal-calibrator signal and pull out on the RIT knob, leaving it at center. Now zero beat the calibrate signal with the main tuning knob. Push the RIT knob in (off) and adjust the calibrate pot for zero beat. This insures the transmit and receive frequencies are the same with the RIT function disabled while allowing manual control of the receive frequency with the RIT on.

The installation of the circuitry upsets the dial calibration very slightly; it was found the dial-set capacitor easily restored calibration. With the circuit constants shown, ± 3.5 kHz frequency deviation was obtained. With this amount of shift you may take a station from zero-beat and move the signal out of the passband of the filter in either direction.

Paul Pagel, K1KXA

crystal-controlled multivibrator

The crystal-controlled oscillator circuit shown in fig. 3 uses no tuned circuits. Since there is no reactance in the circuit except for the small gimmick capacitor, the circuit will oscillate at any frequency from 2.5 kHz to 15 MHz by simply changing the crystal. Rf output voltage is approximately the same as the supply voltage, which can be from 6 to 25 volts.

I have used this circuit as a wideband frequency spotter, as a marker generator (output is rich in harmonics), and as a crystal activity and stability tester.

When building the oscillator, keep all interconnecting wires as short as possible. Although it is not required in every case, you may need the gimmick capacitor to obtain oscillation. The gimmick is made by twisting together two 2-inch pieces of insulated hookup wire; make sure the two wires don’t short together.

Mike Centore, WN2MQY

fig. 3. Crystal-controlled multivibrator uses no tuned circuits but will oscillate at any frequency between 2.5 kHz and 5 MHz by simply changing the crystal.
versatile resistor decades

Accurate decade standards may be assembled at considerably less than their usual cost by using one of the switching arrangements shown in fig. 4 and 5. The precision components represent the greatest cost of a decade standard; therefore, any reduction in the number of components directly reduces cost.

fig. 4. Zero through 9 ohms are obtained by switching various combinations of four standard resistors. For higher resistance values the resistors are increased by factors of ten. The switch is a 2-pole 10-position rotary.

Only four precision resistors or capacitors are required in this design, instead of the usual ten. This savings may be used to simply reduce cost, or if you wish, to buy closer tolerance components for a more accurate decade.

Several construction precautions should be observed. Low-resistance decades require very low contact resistance switches to preserve accuracy. This requirement may be met by parallel wiring two decks of a conventional rotary switch, instead of single decks shown in fig. 4.

In capacitance decade's low-value capacitors must be well spaced from all metallic components to reduce errors due to stray capacitance effects. Also, wide spacing between capacitor terminals and jumpers is required. In the low-capacitance and high-resistance decades, rotary switches with ceramic insulation are recommended.

The economical decade switching systems shown here may be extended to the design of other useful decades including inductance, zener diodes and back-to-back diode clippers.

Gene Brizendine, W4ATE

vfo buffer amplifier

The solid-state vfo I described in the August, 1970 issue of *ham radio* was designed to provide a high-quality stable signal at low output to replace crystals in low-power solid-state transmitters. It is essential in any vfo that oscillator loading be as small and constant as possible (to produce a chirpless signal). This was achieved in my vfo by voltage regulation and by using a low-load buffer stage. The third stage was designed to match the high-impedance output of the jfet buffer stage to the low-impedance input of a solid-state transmitter. Consequently, there is little amplification of the oscil-

fig. 5. Nine individual capacitance values are provided by switching combinations of four capacitors. Switch is a 2 pole 10-position rotary.

fig. 6. Solid-state vfo amplifier provides constant high-impedance load to the vfo. RFC1 is a Millen 34300-50.
If you need more output for this or similar solid-state vfo you may be interested in adding the simple one-stage amplifier shown in fig. 6. This amplifier will provide plenty of power to the driver stage of a transistor transmitter up to the five-watt class, and can be built for under $3.00 using all new parts. This circuit will fit nicely into the W3QBO vfo minibox; or, it can be built into the associated transmitter.

The components can all be neatly mounted on a 5-lug terminal strip as illustrated in fig. 7. The schematic shows a 100-ohm resistor and two .05-μF bypass capacitors for power-lead decoupling, a practice that should always be followed. The Motorola 2N4124 transistor sells for 60 cents; many other transistors (such as the Motorola 2N3904) will work well in this circuit but usually they will cost much more.

C. Edward Galbreath, W3QBO

vhf a-m modulation monitor

If you have a dc-coupled oscilloscope in the shack, such as the EICO 460, here is a low-cost and simple method of keeping track of your percentage of modulation. At vhf the usual techniques of envelope patterns and trapezoidal patterns become very difficult, if not impossible. The method shown in fig. 8 is based on the fact that the plate voltage applied to an amplitude-modulated stage varies between zero and twice the dc supply voltage for 100% modulation of a properly adjusted a-m transmitter.

Connect the vertical scope input to the modulated dc which feeds the modulated rf stage. A resistive voltage divider (no capacitors) is necessary if the voltage is high enough to be dangerous. Select a convenient sweep rate of about 100 Hz or so. Position the horizontal trace so it coincides with one of the lower graticule lines. Apply plate voltage to the modulated stage (with no modulation) and adjust the vertical gain control to move the horizontal trace to the center graticule line. The scope is now set up to show modulation amplitudes varying around the dc supply voltage.

Audio modulation gain should be adjusted to keep the scope pattern between the limits of the lower (zero volts dc) graticule line and the corresponding graticule line above the center. Fig. 9 shows the relationships. For my equipment, with a 750-volt dc power supply, I chose a resistive voltage divider of 100k and 10k. A suitable ratio permits convenient measurement of the final dc supply voltage without exposure to lethal high voltages.

Harry Ferguson, K7UNL

fig. 9. Modulation percentage is less than 100% if waveform is between limits shown here. Equipment setup is described in text.
Dear HR:

W6NIF's article on QRP technique in the December issue was interesting and valuable. But it seems to me that QRP has another facet which might be of immediate concern to more amateurs. Personally, I have the utmost respect for those, like Al Wilson, who persist with real flea power. I wish I had the time and patience to do so. However, to me practical QRP means power inputs of the order of five watts.

Now that the southern gentlemen at Ten-tec have introduced so many of us to this fascinating QRP world we may learn what we should have known for years. Most of us regularly use from five to one-hundred times more power than we need, or ought to use. We QRM the world for our ego's sake.

For almost a year now, I have not used more than eight watts dc power input to the final stage, and I have had more fun in the game than ever. Using both a Ten-tec rig, and a number of homebrew jobs, I have enjoyed as many solid QSOs as I formerly did with a ninety-watter. In fact, most folks worked do not know I'm QRP until I tell them. And I use a most unpretentious antenna, an 80-meter zepp, up only about 25 feet. Folks with good antennas, and perhaps more skill, do better. But I've worked 20 countries, 24 states, and all parts of Canada, and relished it immensely. Furthermore, I don't feel like an "ugly American."

To me, this is amateur radio, as contrasted with the expensive, tinselled world of "commercial" ham radio that one hears, particularly in the phone bands, where power seems valued for its prestige alone. Less-than-one-watt QRP is interesting and may constitute a valid achievement. But few of us have the time, the patience and perhaps the skill for this. All of us, however, could cut our power input to one-tenth of its present level, have as many fine QSOs as ever and thereby vastly improve the American amateur's electronic world image. This in itself, in these times, would seem worthwhile.

C. F. Rockey, W9SCH
Deerfield, Illinois

fire extinguishers

Dear HR:

The January article, "Fire Protection in the Ham Shack," is a very important and timely subject. However, I question the statement about Freon not being as toxic as carbon tetrachloride is. My experience indicates that Freon is highly toxic when exposed to high temperatures.

For a number of years I was in the air-conditioning trade. In one case a Freon-refrigerant discharge line broke in an air-conditioning system in the basement of a hotel; in the same room with
the broken line there were several gas-fired hot-water heaters. When the freon broke down in the flame it formed phosgene gas — the same results produced by carbon tetrachloride. I was extremely sick from being exposed to the fumes, and it was some time before I was well again. I would suggest ventilation as soon as possible if using a Freon-type fire extinguisher; in fact, in my book, this goes for the use of any aerosol cans.

Orville Gulseth, W5PGG
Clarksdale, Mississippi

**frequency-sensitive resistors**

**Dear HR:**

I am a sales engineer, and the following comments come from 18 years of selling resistors. Contrary to popular belief, deposited carbon-film, metal-film, and the like, are not non-inductive resistors. After the resistive material is deposited on the ceramic core the resistive material is cut into a spiral, with 12 or more turns before the desired resistance value is obtained. The result is a 12-turn coil of resistive material plus some capacitance thrown in for good measure.

If you want a true non-inductive resistor you must tell the manufacturer what frequency you will use, and then stay close to it. For all-around general-purpose non-inductive resistors for all frequencies the old carbon-composition resistor is hard to beat.

Ed Aymond, W5UHV
Dallas, Texas

**more uses for the ST-6 RTTY demodulator**

**Dear HR:**

Although the ST-6 was not designed with computer work in mind, the time constants are adequate even for 220 Baud. Computers use 8-level 100-speed teleprinters such as the model 33 or 37. This is 110 Baud, considerably shorter pulses than the normal 5-level 100-speed teleprinters used on many MARS frequencies.

The ST-6 operates in a normal manner even at 200 Baud, with the change of two resistors and one capacitor in the low-pass filter. I am using such a modified unit at home in conjunction with a cathode-ray type computer terminal.

The ST-6 can also be used with the AK-1 AFSK unit (*QST*, February, 1965) and a phone patch as a computer interface between the phone line and the computer terminal. (The AK-1 also performs in excess of 220 Baud.) Such use would not appeal to many hams at this time, but the possibility is always there if you need it.

Irv Hoff, W6FFC
Los Altos, California

**motrac receivers**

**Dear HR:**

In the December, 1970 issue, the ham notebook recommended the Motorola Motrac receiver for use in repeaters. It should be noted that there are two basic types of Motrac receivers.

The type-L receiver uses a bipolar rf amplifier stage and is a poor choice for just about any fixed-station application. Its desensitization characteristics are 5 to 10 dB inferior to the tube-type G receiver, and 10 to 15 dB worse than the old type-A receiver. The intermod characteristics are even worse: 10 to 15 dB more than the G, and 20 to 25 dB more than the A. The later type-M receivers use a fet mixer in the front end; it is about equal to the old type-A in desensitization, and far, far better in the intermod department.

The order of preference for Motorola receivers is the type-M (new Motrac), type-A (wide-chassis tube type), type-G (narrow-chassis tube type), and last, the type-L (early Motrac).

J. A. Murphy, K5ZBA
Tulsa, Oklahoma
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Simpson Electronics has announced a new low-cost vhf-fm mobile rig for the amateur who wants to operate on two-meter fm. The 6-watt Simpson Model A features four channels, sensitivity of 0.6 µV for 20-dB quieting and separate plug-in transmitter and receiver boards with easy access to all tuning and metering points. The solid-state design uses integrated circuits and diode frequency switching.

The squelch is fully regulated and compensated with squelch sensitivity at 0.25 µV or less. Intermodulation interference rejection is 70 dB minimum. Spurious response attenuation is greater than 60 dB. Selectivity, furnished by ceramic filter, is 13 kHz at 6 dB down and 36 kHz at 60 dB down. Audio output is 2 watts with less than 10% distortion. Current drain on receive: squelched, 250 mA; unsquelched, 480 mA.

The transmitter has ±5 kHz deviation for 100% modulation at 1 kHz and includes instantaneous automatic deviation limiting. Transmitter audio response is +1 dB to -3 dB from 300 to 3000 Hz. Tuning range is 144 to 148 MHz.

The Simpson Model A comes complete with mounting cradle and press-to-talk microphone with coil cord. Simpson furnishes crystals for operation on 146.34/146.94 and 146.94/146.94 MHz. The Simpson Model A is priced at $249, including four crystals. For more information write to Simpson Electronics Inc., 2295 Northwest 14th Street, Miami, Florida 33125, or use check-off on page 94.
Motorola's recently introduced line of low-cost functional circuits now totals twenty devices. Included are flip-flops, voltage regulators, general purpose and audio amplifiers and an electronic attenuator.

Functional circuits provide common circuit functions where discrete transistors cannot economically be used. These are generally circuits where matching or balance or component density can better be achieved on a single chip, and include complex digital and linear functions such as multipliers and demodulators.

Functional Circuits are supplied in new, low-profile, plastic packages specially designed to use minimum printed circuit board area yet maximize pin spacing for easy, reliable soldering. The twenty functional circuits are listed below:

For further information, write to Technical Information Center, Motorola Semiconductor Products, Inc., Post Office Box 20924, Phoenix, Arizona 85036, or use check-off on page 94.

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vhf fm catalog

The recently published 1971 catalog from Gregory Electronics features a complete listing of equipment for the vhf fm operator including General Electric Progress, Pre-Progress and Pacers; Motorola Mobile units, Motrac, Motorcycle Dispatcher, etc; as well as commercial equipment manufactured by Dumont, RCA and Bendix. Gregory Electronics has a wide stock of fm equipment in stock, including gear for low-band (30 to 50 MHz) mobile and base stations, high-band (150-174 MHz) mobile and base stations and uhf (450 to 470 MHz) mobile and base stations, plus remote controls and various parts and accessories. For the serious vhf fm operator the new 1971 Gregory Catalog represents one of the most complete listings of vhf fm equipment, with descriptions, available to the amateur. For your copy, write to Gregory Electronics Corporation, 249 Route 46, Saddle Brook, New Jersey 07662, or use check-off on page 94.

motrac tone kit

The addition of sub-audible continuous-tone squelch to Motorola Motrac radios has been made easy by the new Alpha MK-21 Motrac tone mounting kit. The MK-21 makes possible rapid conversion of previously non-toned Motrac radio units, a heretofore difficult problem. Radio systems employing so called "NON PL" Motracs can be updated and made more efficient, relieving the user from listening to co-channel congestion. Because the Alpha tone unit is completely compatible with existing "Private Line," "Channel Guard," "Quiet Channel" and other sub-audible tone devices, the non-tone Motrac can be put into service in existing toned systems, thus extending the useful life of these fine radios. Also available from Alpha is an optional two-frequency tone unit that allows for selective control of repeaters, base stations, etc. The MK-21 uses the plug in the ST85H encoder or the SS80H encoder/decoder. Simple step-by-step installation instructions are provided, and a wide range of EIA tone frequencies is available.

For information write to Alpha Electronic Services Inc., 8431 Monroe Avenue, Stanton, California 90680 or use check-off on page 94.

uhf quadrature coupler

Multiple-device combining, transmission continuity and mismatch isolation are three major performance advantages afforded by the Motorola MIC5830-31, 3-dB quadrature coupler.

Mismatching of transmitter ports, for example, is reported no longer a problem because the application of a reflected signal at either of the output ports results in signals at the input port attenuated by 20 dB. Insertion loss is as low as 0.25 dB maximum, affording greater output power; phase balance is ±1.5° maximum, furnishing smaller combining losses and less distortion.

Efficiency in higher frequency designs, such as broadband military and ECM equipment is also heightened through elimination of power-robbing, load-balancing passive components which constrict bandwidth. Usable frequency capability ranges from 225 to 400 MHz and 450 to 512 MHz.

The stripline, broadside devices are constructed from Teflon fiberglass board and sealed with a low loss, low dielectric compound. Small size is achieved by meandering the coupled lines.

For complete specifications write to Motorola Semiconductor Products, Inc., Box 20912, Phoenix, Arizona 85036, or use check-off on page 94.
Weighing only 15 pounds, the Swan TB-2 tri-band beam is a real giant killer. With the TB-2 at $69 on a TV type rotator for $30, and a $15 telescopic TV mast, you can easily get the TB-2 60 to 70 feet off the ground. At that height it will outperform 3 or 4 element beams at a lesser height. If you prefer, you can call your local TV shop and they'll put the whole thing up for you at an approximate charge of $30 to $40.

Of course we also manufacture 3 and 4 element beam antennas. If you can mount these on a 60 to 70 foot tower with a more costly heavy duty rotator, then by all means this is the ideal arrangement.

But if your choice is between putting a 3 or 4 element beam on a 30 or 40 foot tower, or the 2 element model at 60 to 70 foot, from a standpoint of dollar value, we recommend the TB-2… it's a giant killer.

It may sound odd for us to be talking you out of buying our more expensive models, but Swan has always been known for giving the radio ham more value for his dollar. In this case, the TB-2 on an inexpensive telescopic TV mast and rotator is a remarkable value.
hep functional circuits

The new series of Motorola HEP audio functional integrated circuits is designed to provide a complete audio system for experimenter projects. The HEP functional circuits are available in three power output levels: HEP type C6004 provides 1 watt of audio and is priced at $2.60; type C6005 provides a minimum of 2 watts and is priced at $4.35; the 4-watt HEP C6006 sells for $5.60. All these units are high-gain devices, include a preamplifier, and will provide full-rated output with an input signal in the 10-to-15-mB range. The circuit can be used with 4-, 8- or 16-ohm speakers. A mail-order source for Motorola HEP devices is Circuit Specialists Company, Box 3047, Scottsdale, Arizona 85257. For more information, use check-off on page 94.

ampress speech processor

The C. E. Cox Company has introduced its new solid-state Ampress speech processor, a high-performance low-cost unit designed to increase talk power and improve speech quality. The Ampress is not a speech clipper, but a variable-gain preamplifier that uses controlled negative-feedback to produce a constant output level automatically. The circuit operates with very fast attack time to accommodate transients. In addition, the Ampress incorporates a "speech enhancement" feature which amplifies voice signals selectively, with frequency response controlled by the compression function. The result is a crisp penetrating signal with carefully exaggerated speech harmonics and high-frequency components to punch through heavy QRM.

The Ampress will work with all amateur rigs, a-m, fm and ssb, and comes in two attractive models: the CCA-1 which operates on three pen-light cells, or the CCA-1R which operates on three rechargeable cells and has an internal current regulator and external ac adapter/charger. The price of the CCA-1 is $29.95; the CCA-1R is $39.95. For more information, write to the C. E. Cox Company, 2415 Broadway, Santa Ana, California 92707, or use check-off on page 94.

understanding solid-state circuits

This new book by Norman Crowhurst presents all the information one might need to become acquainted with practical solid-state circuits. The author has cut away all the unnecessary verbiage on semiconductor theory and gotten right down to the circuits themselves. First there's a brief discussion of the various types of semiconductors and their operating modes; then comes a thorough but practical discussion of linear amplification. The author covers dc and ac feedback, current gain, controlling current and voltage gain, phase inversion and deals with typical everyday circuits.

The next chapter covers power amplification using single and push-pull stages, complementary symmetry and protection circuits. Then comes a thorough treatment of feedback and its applications, fet stabilization, high-frequency losses, equalization, rolloff and filter alignment. Sinusoidal oscillators and function generators are also covered in detail. Other subjects included in this helpful book are gain-controlled amplification, limiting and compression, expansion, attenuators, logic and integrated circuits. 192 pages. Over 150 illustrations. $7.95 ($4.95 paperbound) from Tab Books, Blue Ridge Summit, Pennsylvania 17214, or use check-off on page 94.
for the experimenter!

INTERNATIONAL EX CRYSTAL & EX KITS
OSCILLATOR • RF MIXER • RF AMPLIFIER • POWER AMPLIFIER

1. MXX-1 TRANSISTOR RF MIXER
A single tuned circuit intended for signal conversion in the 3 to 170 MHz range. Harmonics of the OX oscillator are used for injection in the 60 to 170 MHz range. Lo Kit 3 to 20 MHz, Hi Kit 20 to 170 MHz (Specify when ordering) $3.50

2. SAX-1 TRANSISTOR RF AMP
A small signal amplifier to drive MXX-1 mixer. Single tuned input and link output. Lo Kit 3 to 20 MHz, Hi Kit 20 to 170 MHz (Specify when ordering) $3.50

3. PAX-1 TRANSISTOR RF POWER AMP
A single tuned output amplifier designed to follow the OX oscillator. Outputs up to 200 mw, depending on the frequency and voltage. Amplifier can be amplitude modulated. Frequency 3,000 to 30,000 KHz. $3.75

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General purpose unit which may be used as a tuned or untuned amplifier in RF and audio applications 20 Hz to 150 MHz. Provides 6 to 30 db gain. Ideal for SWL, Experimenter or Amateur. $3.75

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Crystal controlled transistor type. Lo Kit 3,000 to 19,999 KHz, Hi Kit 20,000 to 60,000 KHz. (Specify when ordering) $2.95

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for the commercial user
INTERNATIONAL PRECISION RADIO CRYSTALS

International Crystals are available from 70 KHz to 160 MHz in a wide variety of holders. Crystals for use in military equipment can be supplied to meet specifications MIL-C-3098E.

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(CS) for "Commercial Standard"
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More Details? CHECK-OFF Page 94
two-meter transceiver

The new solid-state Comcraft CTR-144 two-meter transceiver combines all the most desirable features possible into a small portable unit. The double-conversion receiver has crystal-controlled first conversion for maximum stability; mosfets are used in the rf amplifier and mixer stages. Noise figure of the receiver is 4 dB. A three-pole Butterworth filter in the front end provides more than 80-dB image rejection, eliminating interference from the aircraft band. An automatic noise limiter and adjustable squelch are built in. I-f bandwidth is 18 kHz.

The transmitter frequency may be controlled by crystal or by the built-in vfo; the crystal oscillator uses standard 8-MHz crystals. The CTR-144 vfo operates at 7 to 9 MHz; vfo output is mixed with 65 MHz to produce 72 MHz output — this is doubled to 144 MHz. Receiver and transmitter vfo tuning are completely separate.

The only transmitter adjustments needed are output tuning and load; a front-panel switch provides selection of either a-m or fm. Power input is 12 watts; power output, 6 watts. The CTR-144 may be operated on its internal 117 Vac power supply, or any 12- to 18-volt dc source capable of 2 amps (the receiver requires only 100 mA). An optional clip-on rechargeable battery pack permits portable operation.

The baked-on epoxy finish of the Comcraft CTR-144 resists scratching and other marring. The panel is brushed aluminum with lettering permanently anodized in. The circuit boards are military-style glass-epoxy types with solder-plated terminals. The CTR-144 is priced at $389.95, including a crystal for 146.94 MHz. For more information, write to Comcraft Company, Post Office Box 266, Goleta, California 93017, or use check-off on page 94.

foreign language QSOs

The use of foreign languages by American amateurs is increasing rapidly. The primary motivation is probably the pleasure afforded by exchanging greetings with a foreign operator in his native language. Europeans have always used amateur radio as an effective means for practicing English, and, now that ssb has made voice contacts so easy, language partners are available who wish to learn English and are willing to trade German, Spanish, French, etc., for practice in English. For the ham with language training or interest, Foreign Language QSOs add a new dimension and a satisfying proficiency to his hobby.

The Foreign Language QSO tapes have several advantages: genuine ham jargon is used throughout; the tapes are prepared by native hams who know the right phrases actually used. The Armed Forces method of language teaching is imitated; you advance through dialogue and questions and answers, thereby increasing your vocabulary and grammatical ability. Also, sufficient material is provided to challenge the person who already has studied a foreign language and wants to sharpen his abilities, especially for amateur radio use. In addition, a complete English translation of all text, and basic information about the structure of the target language is provided.

Foreign Language QSOs are available in tapes or cassettes, English-Spanish or English-German. For more information, write to Foreign Language QSOs, Post Office Box 53, Acton, Massachusetts 01720, or use check-off on page 94.
get the picture!

Shown above is an actual size, unretouched photo of the picture image taken from the Robot Model 70 Slow Scan Television monitor, as it was transmitted by the Robot Model 80 Slow Scan Television Camera.

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More Details? CHECK-OFF Page 94
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omnidirectional fm antenna

The Avanti ARD-257 is a completely new design in vertical omnidirectional 2-meter fm antennas for ham use. The patented tapered skirt configuration produces 4.17 dB gain (measured over a 1/4-wave ground plane) plus a low angle of radiation that has proven effective in eliminating dead spots. The ARD-257 uses no coils or transformers so it will not detune or burn out and is unaffected by temperature and humidity. Small projected area provides easy mounting and reduces wind load and icing problems. The antenna comes complete with coax lead, mounting hardware and fiberglass mast current eliminator. In addition, other frequencies are available from 140-175 MHz for marine, business use, etc.

The bandwidth of the ARD-257 is specified at ±3.5 MHz; vswr is 1.5:1 or less. Nominal input impedance, 50 ohms; power handling capability, 1000 watts; length, 65 inches; weight, 3 pounds; wind survival, 120 miles per hour; price, $44.95. For more information, use check-off on page 94 or write to Avanti Research & Development, Inc., 33-35 West Fullerton Avenue, Addison, Illinois 60101.
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15 tubes, 435 to 500 Mc. Easily adapted for 2-way voice or code on any Mobile, Television Experimental, and Citizens Bands. With tubes, less power supply in factory carton. BRAND NEW..... $16.95

TRANSMITTER has 4 tubes: WE-316A, 2-666, 777
RECEIVER has 11 tubes: 2-975, 4-786, 3-777
RECEIVER fits any 40 Megacycles
SIZE: 10-1/2" x 13-1/2" x 4-1/2". Shpg wt 25 lbs.

SPECIAL PACKAGE OFFER: BC-645 Transceiver, Dynamoscope and all accessories, including mounting, UHF Antenna Assemblies, control box, complete set of connectors and plugs. Brand New
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HEADSET
Low impedance. With large earphones and cushioning. 4-ft cord and plug. Reg. $12.50. OUR SPECIAL PRICE... $2.95
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Freq. Band: Used: BRAND NEW
10-300 Kc. $14.95 $17.95 $21.50
100-200 Kc. $18.95 $21.50 $27.95
TELEPHONE HANDSET, W.E., type...
LIKE NEW... $2.95

TC-344 CODE KEYER
self-contained, automatic, reproduces code signals from paper tape. 5 to 12 WPM. Built-in speaker. Brand new with tech manual, backup reel and AC line cord...
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Airplane Beacon Receiver 200 to 400 Kc. Operates from 24V DC 1.5A. Continuous tuning, vol control, on/off switch and phone jack. Very sensitive, Compact. Complete with tubes, NEW...
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20 to 27.9 Mc. Output approx. 30 watts. 10 crystal controlled channels. Complete with tubes, NEW...
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ARC-822 540 to 1600 Kc Receiver with tuning graph...
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TELEPHONE HANDSET, W.E., type...
LIKE NEW...

SC-552 TRANSMITTER-RECEIVER, with tubes. LIKE NEW...

BC-624 RECEIVER 100-156 Mc, with tubes, exc. used...
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BC-625 TRANSMITTER 100-156 Mc, with tubes, exc. used...
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RAY-3 NAVY RECEIVER high freq. AM, like new...
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FULL WAVE SILENIA RECTIFIER 110V 150 Ma, New...
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AM-300/AIC PUSH-PULL AMPLIFIER
4 tube PP power amplifier with dynamoscope, works on 28 VDC. Automatic gain control.
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BC-733 RECEIVER
Receives radio signals being transmitted by US satellite on approx. 108 Mc. AM, crystal-controlled on 6 preset freq. in 108.3 to 110.2 Mc range. Operates on 12/24 V DC & 220 VDC 60 Mc. Complete with tubes. Can be converted to FM Receiver...
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ANTENNA UNIT designed for 115 V 800 to 1400 cps. Tubes included are two 15E and one 15R. Complete with shock mounts and blower motor. $9.50

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25 Watt, CW, MCW, Voice, Crystal controlled on 4 pre-selected channels, range 2000 to 5200 Kc by use of 3 plug units, included. Complete.
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DUAL AMPLIFIER
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Input 6 VDC 3.6 Amps. Output 250 VDC 0.30 Amp.
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**HAL TOUCHCODER II KIT**
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**HAL TOUCHCODER II KIT** $55.00
Complete parts kit, excluding keyboard, for the W4UX CW code typers. All circuitry on one 3 x 6" G10 glass PC board. Plug-in IC sockets. Optional contest ID and RTTY features available. New keyboard under development.

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Drilled G10 glass PC board accepts 6 16 pin DIP IC’s in plug-in sockets. Each IC pin fanned out to two pads. Plugs into standard 22 pin edge connector (.156" finger spacing). $5.50

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HAL now offers a parts kit for the AK-1 AFSK osc. Drilled G10 glass PC board plugs into 12 pin edge connector for compatibility with the HAL ST-6, or for ease of use alone. Requires 12vdc. $27.50. Board only $4.00. Shipping extra.

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**ORDERING INFORMATION**
Postage is not included in the prices of HAL products. Please add 75¢ on small parts orders, and $2.00 on larger kits. Shipping is via UPS when possible, and via insured parcel post otherwise. Please give a street address. Catalog of all items 24¢ postage.

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**DRAKE R-48, 2-NT, MS-4, 17 novice crystals.** About 100 hours novice use $485.00. F. Ross, 1500 Gondar Avenue, Long Beach, CA 90815.

**UNUSUAL RECEIVER VALUES:** Collins 75SI $295; Collins 755S $395; Hammarlund HQ170 $195; Hammond 90170A/VHF $130; Hammarlund HQ 180AC $299; National NC300 $119; Many more. Get Complete Listing. Stan Burghardt, W0IT, Box 73H, Watertown, S. D. 57201.

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**HAMFEST:** Indiana Radio Club Council's annual picnic Sunday, July 11th, LaPorte County Fairgrounds, LaPorte, Indiana. Large Flea Market with reserved locations available for large exhibitors and vendors and the midway and the midway and the midway and the midway will be held. Mobile FM Clinic. Prizes. Tech Sessions. For flyer, write: Dave Osborn, K9BPV, P. O. Box 272, LaPorte, Indiana 46350.

**SURPLUS CRYSTALS BLANKS:** Range 4100-6800 kHz, 7200-8600 kHz. Assorted frequency selection. 30/$1. Nat Stetinette Electronics, Umatilla, FL 32784.

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**THE CALGARY AMATEUR RADIO Association announces that it will operate station VEGNQ from the grounds of the Calgary Stampede from July 8-17, 1971 inclusive.** The schedule calls for operation from 1900 to 0500 GMT daily. Pre- warded band is 80 long and 40 MHz. Frequencies shall be used at any time. Operating frequencies will be near or at 3.560, 3.780, 3.825, 3.940, 7.020, 7.190, 7.225, 7.270, 14.060, 14.150, 14.250, 14.336, 21.060, 21.240, 21.300, 28.060, 28.500, 28.600 MHz. Several transmitters will be operated simultaneously, callsigns will be accommodated. A special QSL card will be sent to all contacts. A QSO with VEGNQ during this period will count towards the International DX contest for amateurs working for their Calgary Stampede Certificate. Calgary Amateur Radio Association, Box 592, Calgary 2, Alberta.

**OLD TIME RADIO SHOWS.** SASE. Box 724, Redmond, Washington 98052.

**CINCY STAG HAMFEST:** The 34th Annual Stag Hamfest will be held on September 25th at Speaker's Grove, Cincinnati, Ohio. Door prizes each hour, raffle, lots of food, flea market, model aircraft flying, and contests. Identify Mr. Hamfest and win prize. $5.00 cost covers everything. For further details contact, John Bruning, WBDSR, 6307 Fairhurst Avenue, Cincinnati, Ohio 45213.

**BELIEVE IT OR NOT — The International Amateur Radio Society has clubs for every professional association.** Send $1.00 to IARS, 300 East 44th St., New York 17, N.Y. SASE. For full information. Modern Ham Radio, April 1971.

**CANADA AMATEUR RADIO**

**THE ZERO BEATER AMATEUR RADIO CLUB** has their annual Hamfest at the Washington, Mo. City Park on August 1st, starting at 10 a.m. Free Ham Gear Clinic. Door prizes. Contest. Prizes. Tech Sessions. For details contact, John Bruning, WBDSR, 6307 Fairhurst Avenue, Cincinnati, Ohio 45213.

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**THE CHRISTIAN AMATEUR RADIO FELLOWSHIP** will have a station (K91GB/5) on the air at the North American Christian Convention at Dallas, TX July 6-9, 1971. Fred Basye is conducting a workshop July 8 at the convention entitled "Ham Radio — Keeping Touch Around The World."
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Get a big ear on the world with complete amateur band coverage from 160 meters through 2 meters, including WWV and CB reception. Four mechanical filters do it—they provide CW, SSB, AM and FM selectivity. Separate AM-SSB-FM detectors are included, along with squelch and transmit monitor controls. Plus a noise limiter and a variable delay AGC. And a built-in notch filter with front panel adjust for notch depth.

The FRdx includes calibration markers at 100 KHz and 25 KHz, with accurate calibrator checks verified by WWV. A solid-state FET VFO for unshakable stability. And a direct-reading 1 KHz dial affords frequency read-out to less than 200 Hertz.

The FRdx 400 sells for $359.95.

The FLdx 400 Transmitter
Here’s how to set yourself up with dual receive, transceive or split VFO operation. The FLdx 400 with its companion receiver brings you the ultimate in operational flexibility. Flexibility like frequency spotting, VOX, break-in CW, SSB, AM and even an optional FSK circuit.

The completely self-contained FLdx 400 features a built-in power supply, fully adjustable VOX, a mechanical SSB filter, metered ALC, IC and PO. A completely solid-state FET VFO provides rock-solid frequency stability.

We rate the FLdx 400 very conservatively. That rating guarantees you 240 W PEP input SSB, 120 W CW and 75 W AM. The FSK option will go all day at a continuous 75 W. And you get full frequency coverage on all amateur bands—80 meters through 10 meters—with an optional provision for certain other bands that you can personally specify. For all that, you pay just $299.95.

FL2000 B Linear Amplifier.
Ideal companion to the Series 400, this hand-crafted linear is another example of Yaesu's unbeatable combination of high quality and low cost. Designed to operate at 1500 watts PEP SSB and 1000 watts CW, this unit provides superb regulation—achieved by a filter system with 28 UF effective capacity.

Other features include dual cooling fans (one for each tube), individual tuned input coils on each band for maximum efficiency and low distortion, and a final amplifier of the grounded grid type using two rugged carbon-plate 572 B tubes. Ready to operate at only $299.95.

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Here's just half a dozen reasons why the Yaesu FT-101 is the world's best portable rig.

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The FT-101 is a thirty-pound package of DX punch, air-ready when you are, wherever you are. Just add an antenna, feed it 12 or 117 volts, and you're ready to work the world.

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EIMAC's new 8873 family covers the electromagnetic spectrum from DC to 500 MHz.

No need to compartmentalize your thinking when you contemplate EIMAC's new 8873 family of zero bias triodes. This tube for all seasons has three interesting configurations that allow you unprecedented design freedom: conduction cooling to heat sink (8873), axial cooling (8874) and transverse cooling (8875). Your choice to overcome today's design constrictions.

Consider that the 8873 family provides up to 1000 watts PEP input or 500 watts continuous duty input per tube to 500 MHz. Low grid interception allows low drive power to be combined with low intermodulation distortion in linear service.

Observe that while the 8873 family performs in superior fashion as a linear amplifier in SSB service, it is also ideally suited for high gain, class-C FM or AM service in the VHF/UHF range. Electron control by EIMAC's new segmented, self-focusing cathode and unique aligned grid structure provide the key to this improved performance. The grid, moreover, is terminated in a low inductance contact ring about the base of the tube, permitting very effective intrastage isolation to be achieved up to the outer frequency limit of operation.

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Remember the 8873 family of triodes covers the electromagnetic spectrum from DC to UHF with ease, meeting widely divergent requirements in a package you can hold in the palm of your hand. Use these compact tubes in table-top design where space is a scarce commodity or where high density packaging is imperative.

Write EIMAC today for details and circuitry on the 8873 family of grounded grid triode tubes. Another example of EIMAC's ability to provide tomorrow's tubes today. EIMAC, 301 Industrial Way, San Carlos, California 94070. Phone (415) 592-1221.