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ham radio magazine

Amateur Radio Stamps

from Around the World

hr

focus on communications technology

THE ALL NEW PRIVATE PATCH IV BY CSI HAS MORE COMMUNICATIONS POWER THAN EVER BEFORE

- **Initiate phone calls from your HT or mobile**
- **Receive incoming phone calls**
- NEW! **Telephone initiated control . . .**
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- • Pulse dialing
- • Toll protection
- • Secret toll override code
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- ✓ Dialtone disconnect
- • CW identification
- • Activity timer
- • Timeout timer
- ✓ Telephone initiated control
- ✓ Regenerated DTMF selective calling
- • Ringout
- ✓ Ringout or Auto Answer on 1-8 rings
- • Busy channel ringout inhibit
- ✓ Status messages
- ✓ Internally squelched audio
- • MOV lightning protection
- ✓ Front panel status led's
- ✓ Separate CW ID level control
- ✓ 24 dip switches make all features user programmable/selectable.

- ■ Connects to MIC and ext. speaker jack on *any* radio. Or connect internally if desired.
- ■ Can be connected to any HT. (Even those with a two wire interface.)
- ■ Can be operated simplex, through a repeater from a base station or connected directly to a repeater for semi-duplex operation.
- ■ 20 minutes typical connect time
- ■ Made in U.S.A.

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TS-140S

HF transceiver with general coverage receiver.

Compact, easy-to-use, full of operating enhancements, and feature packed. These words describe the new TS-140S HF transceiver. Setting the pace once again, Kenwood introduces new innovations in the world of "look-alike" transceivers!

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Optional Accessories:

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All-mode multi-bander

- 6m (50-54 MHz) 10 W output plus all HF Amateur bands (100 W output).
- Extended 6m receiver frequency range 45 MHz to 60 MHz. Specs. guaranteed from 50 to 54 MHz.
- Same functions of the TS-140S except optional VOX (VOX-4 required for VOX operation).
- Preamplifier for 6 and 10 meter band.

Complete service manuals are available for all Kenwood transceivers and most accessories. Specifications, features and prices are subject to change without notice or obligation.

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ham radio
magazine

AUGUST 1988

volume 21, number 8

contents

Joe Reisert is on vacation.

on the cover: Amateur Radio stamps from around the world from the collection of Raymond Schuessler a philatelist from Venice, Florida.

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REFLECTIONS

Let's dust off that used equipment!

We received some interesting letters following Joe Schroeder's June editorial "Novice enhancement and the future of Amateur Radio." Some lamented the relatively high cost of new equipment and others felt, like Joe, that the best bet would be a market survey asking present and former operators what helped or hindered their developing Amateur Radio interest. One ham, returning to the hobby after 20 years, found the latest equipment to be reasonably priced and of good quality.

Novice enhancement has given beginning Amateurs increased operating privileges, but can they afford the cost for new equipment to get on the air? Someone just starting in the hobby may not want to sink a small fortune into his rig until he knows what he really wants. And how much does a Novice really need: a radio that covers 10 through 80 meters, CW and SSB capabilities — that's about it. This may seem like an oversimplification, but how many Novices need all the bells and whistles? For those who can afford it fine; for those who can't...

Here's a pitch for you. A good majority of us have lurking in our basements a veritable storehouse of used equipment. Stuff that we've outgrown as we've upgraded our shacks. It's my bet that there are numerous Novices out there that would just love to put this equipment to use. Starting immediately, on a space available basis, we'll run free classified ads for our subscribers to sell old, used equipment. Here's a perfect opportunity for you to help a new ham get on the air.

You don't want to sell it? Then why not become an Elmer and help that new ham by lending him your perfectly good, but long forgotten, transceiver along with some assistance in establishing his first station?

How many of you remember your first station? I'm sure most of us can credit a certain special person (our Elmer) for his invaluable time and assistance in helping us to put that first, hesitant CQ on the air. I know I do...thanks Bill, K1BH.

Marty Durham, NB1H
Technical Editor

As you can see by the enclosure, we're hard at work on the new Ham Radio Magazine. We think you'll be excited by it. Your suggestions in informal surveys have resulted in a major effort on our part to make HR the magazine you want. Every month there'll be at least two projects of the weekender type — simple, easy-to-build ideas that will add to your Amateur operation. New layout, fresh graphics and plenty of surprises are in store for Ham Radio readers.

Your input is most important to us. Let us know what you think. Starting next month, there'll be an evaluation card for you to fill out and return. So, after you've been through the September issue, send a note, call, or look us up at a show. We'll be waiting to hear from you.

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3 Choices 70 W/45 W/25 W

Three Choices for 2m!

TM-2570A/2550A/2530A

Feature-packed 2m FM transceivers

The all-new "25-Series" gives you three RF power choices for 2m FM operation: 70 W, 45 W, and 25 W. Here's what you get:

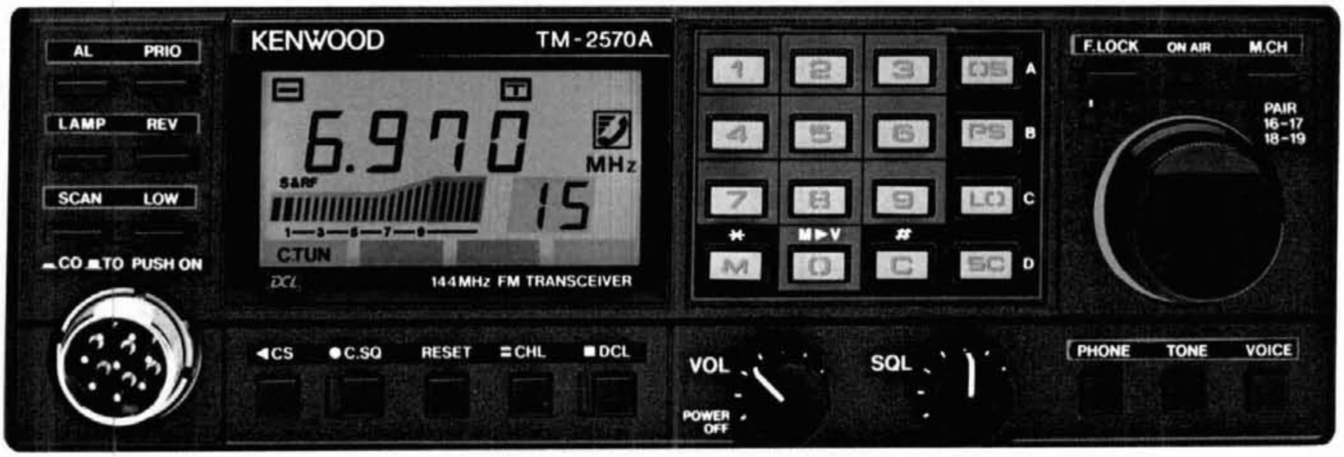
- Telephone number memory and autodialer (up to 15 seven-digit phone numbers). **A Kenwood exclusive!**
- High performance GaAs FET front end receiver
- 23 channel memory stores offset, frequency, and subtone. Two pairs may be used for odd split operation
- 16-key DTMF pad with audible monitor
- Extended frequency coverage for MARS and CAP (142-149 MHz; 141-151 MHz modifiable)
- Center-stop tuning—**a Kenwood exclusive!**

- New 5-way adjustable mounting system
- Automatic repeater offset selection—**another Kenwood exclusive!**
- Direct keyboard frequency entry
- Front panel programmable 38-tone CTCSS encoder **includes** 97.4 Hz (optional)
- Big multi-color LCD and back-lit controls for excellent visibility
- The TM-3530A is a 25 watt version covering 220-225 MHz. The first full featured 220 MHz rig!

DCL Introducing... Digital Channel Link

Compatible with Kenwood's DCS (Digital Code Squelch), the DCL system enables your rig to **automatically** QSY to an open channel. Now you can automatically switch over to a simplex channel after repeater contact! Here's how it works:

The DCL system searches for an open channel, remembers it, returns to the original frequency and transmits control information to another DCL-equipped station that switches **both** radios to the open channel. Microprocessor control assures fast and reliable operation. The whole process happens in an instant!



Actual size front panel

Optional Accessories

- **TU-7** 38-tone CTCSS encoder
- **MU-1** DCL modem unit
- **VS-1** voice synthesizer
- **PG-2N** extra DC cable
- **PG-3B** DC line noise filter
- **MB-10** extra mobile bracket
- **CD-10** call sign display
- **PS-430** DC power supply for TM-2550A/2530A/3530A
- **PS-50** DC power supply for TM-2570A
- **MC-60A/MC-80/MC-85** desk mics.
- **MC-48B** extra DTMF mic. with UP/DWN switch
- **MC-43S** UP/DWN mic.
- **MC-55** (8-pin) mobile mic. with time-out timer
- **SP-40** compact mobile speaker
- **SP-50B** mobile speaker
- **SW-200A/SW-200B** SWR/power meters
- **SW-100A/SW-100B** compact SWR/power meters
- **SWT-1** 2m antenna tuner

Complete service manuals are available for all Kenwood transceivers and most accessories.
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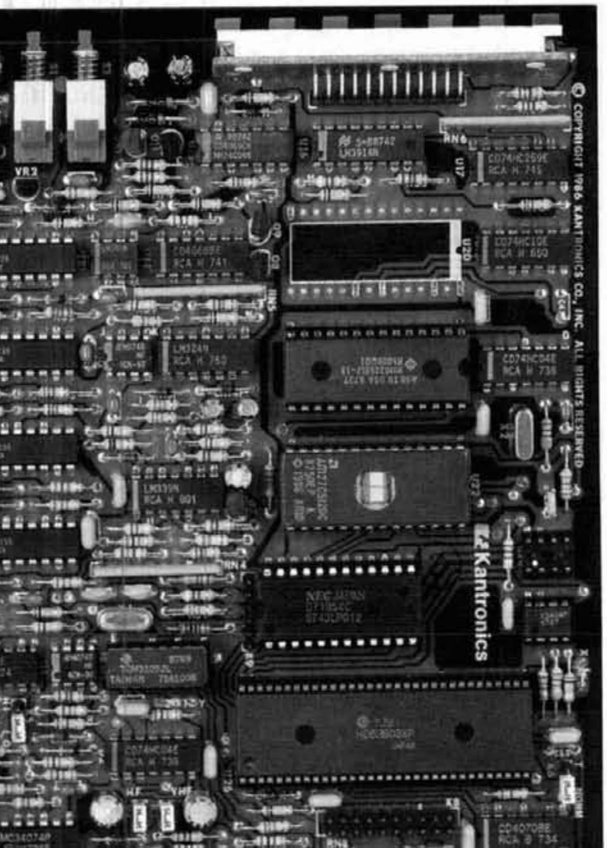

Whatever your interest, you'll find the Kantronics All Mode™ at the top of the pack. CW, Radio-teletype, AMTOR, ASCII, WEFAX and Packet, "KAM handles them all." HF and VHF simultaneous operation? You bet! The KAM can operate RTTY or AMTOR on HF while communicating Packet on VHF. Believe it. It's the only true dual-port on the market.

World-Class

Swedish and German hams have noticed KAM's engineering and are some of our biggest fans. The Japanese scrutinized our features and gave us ideas for extras like a subject field for the Personal Packet Mailbox™, listings of digipeater paths and more CW characters and functions. We are shipping KAM around the world.

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You'll be the envy of the airwaves with all the modes and features KAM brings to your fingertips. In addition to Packet, ASCII, AMTOR,

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So join the fun, join the Top of the Pack.

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comments comments

re-discovering ham radio

Dear HR:

I found the "Reflections" editorial in the June 1988 issue to be very interesting. I am one of the very new Amateurs you mention, and have come back after retirement, having let my General ticket expire in the 60s.

I would point out that the "well-established" factor is probably a very important one, because the basic cost of ham gear is quite high, compared to (say) photography. Also, as to why guys drop-out, I can tell you that it was the same very high cost of SSB gear that discouraged me from hanging-on when I was younger and had lots of very important growing-family expenses.

My surprise in finding that SSB gear was so good, and reasonably priced in CB units is one of the main things that got my interest up again! And, sure enough, I found one rig that did a very neat job, at quite reasonable cost! I'll hand that along to my daughter, hopefully, now that I've upgraded my equipment.

I really had no idea just how very good the gear can be today; or how very astute the average hams on-air are! I tend to do a lot of listening, and find that there are so very many guys who are actively involved in evaluating and improving their antennas, feedlines, tuners, etc. I have also read a lot of the detracting comments by the QRP people and have an old friend who is a CW freak.

It really seems to me to be a pretty healthy mix, except for the few bad-actors. Your comments on putting the situation in the hands of professionals seems reasonable. I suggest that really believable illustrations showing rig setups and compact beam antennas would help get people to pick up more of the magazines, and commence the day-dreams that lead the way!

Yours was the very first ham magazine that I started buying, again...then subscribed to, for I didn't want to miss any. I give you the highest marks on all accounts.

As a matter of general interest, I'd like very much to see a no-holds-barred comparison review of the hf linear amps available, as many as possible! I've heard lots of comments on amps, and rigs in general on-the-air, and have been very glad that I paid attention!

Ralph Marler, KC1JG,
Portsmouth, New Hampshire
03801

legal usefulness of amateur radio

Dear HR:

I disagree strongly with Joe Schroeder, W9JUV, in his "Reflections" in the June issue. Amateur Radio as we know it really does need an overhaul or it simply won't sell, market survey or no.

The problem is not Novice enhancement nor the current licensing structure. It lies in our extremely narrow definition of "Amateur". As it stands, in spite of the marvelous technical capability we have, Amateur Radio is useless as a service to the average person on the streets. Case in point: June 1988, *QST*, page 78 states that ordering a pizza via local autopatch is illegal because it is a "business communication". If I can't do something as trivial as that via Amateur Radio, what good is it?

People buy things because they are useful. Up to a point you can sell people on something that doesn't meet a real need, but not very long and not very many. If we were to broaden the definition of "Amateur" to permit the kind of communications that most people want on domestic frequencies (VHF and up, *no international communications*) we would find a lot of response out there. If I could order a pizza, talk to my wife about who has called in while I was out on a sales call, talk about my business (short of advertising on the air), it would be useful, and I could recommend it to my friends and encourage them to get involved. Now I suggest buying a cellular phone.

I have long been involved in Amateur Radio because I enjoy the technical aspects of it. But after the thrill of talking beyond the sound of my voice wears off, I look for usefulness. Perhaps I am spoiled. I returned recently from several years on a large island in the Pacific. Four hf frequencies tied over two hundred families together across several hundred miles of impassable jungle. We arranged transportation, ordered groceries, flight followed aircraft, managed people, all under difficult conditions. I know what radio is like when it is useful.

I am convinced that unless Amateur Radio in the United States is opened up to more legal usefulness, it simply will not be there when the emergencies arise, and our frequencies will be taken away.

Bill McLagan, WA7AQN,
Corvallis, Oregon 97330

market survey of Amateurs good idea

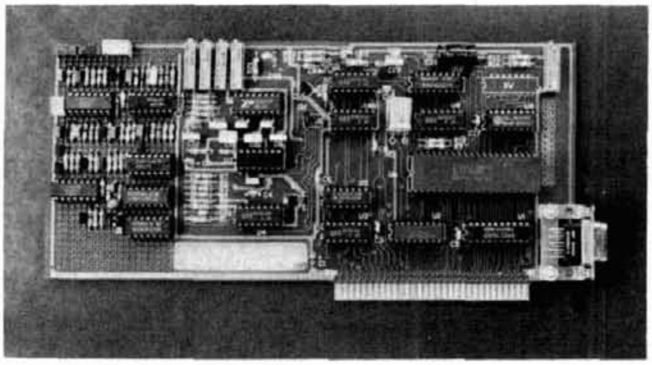
Dear HR:

I strongly support portions of Joe Schroeder's June 1988 Reflections! I am especially in agreement with his comments about marketing and marketing analysis.

New, Amateurs, younger ones in particular, must have a difficult time understanding how to operate today's overly sophisticated transceivers during early entry into operating. Perhaps a worse consideration for a beginner is the price tag associated with even the lowest priced modern rigs. We have entered into an era of \$6,000+ transceivers, and the bottom of the scale is on the order of \$1,000. It is not difficult to visualize the shock coeffi-

(continued on page 94)

Fast, reliable modem cuts connect time



a 4800 baud modem for VHF/UHF packet radio

Do you sometimes feel guilty of hogging your local packet network when you have a large file or message to transfer? Here's a modem that can cut down on your connect time.

A wide variety of radios now work with this modem. Reliability is high enough that our local digipeater (VE3PKT) has been switched exclusively to 4800 baud and has been running trouble free for many months. We will show how you can add a 4800 baud modem to the HAPN-1 packet radio adapter. It fits nicely into the card's "prototype area" for experimenters.*

A software switch provided with the HAPN-1 adapter lets you change from the standard (built-in) 1200 baud modem to this one. The interface between the packet card and radio is arranged to accommodate both modems; all it takes to switch from one speed to the other is a keyboard selection.

Although the bandwidth used in VHF and UHF voice operation could support data rates higher than 4800 baud, HAPN chose 4800 baud for the following reasons:

- Most existing VHF or UHF radios can be used.
- No major changes to your radio or TNC (terminal node controller) should be required.
- Alignment and setup should be easy.
- It uses no exotic or difficult to obtain parts.
- It uses the same bandwidth as normal 2-meter voice operation.
- 4800 baud provides nearly four times the effective data rate of 1200 baud.

The modem contains an on-board squelch circuit that activates in approximately 10 milliseconds, typically 10 to 30 times faster than the squelch in most radios. As a result, clear-to-send delays (Tx-delay) and turnaround times are shorter, reducing "wasted channel" time.

principles of operation

Most packet radio TNCs include a modem; other telecommunication groups treat the modem as a separate entity. Its purpose is to transform the serial, digital data into a form compatible with the transmitting medium — in our case, a VHF 2-meter radio. It also must take a noisy, undulating voltage from the radio receiver and change it into a digital data stream acceptable to the TNC. Our current packet radio system requires the TNC to know when the radio channel is in use; this is the modem's job too.

transmitting duobinary codes

The digital data coming into the modem is a stream of ones and zeroes that modulate the transmitter's rf

*The HAPN-1 adapter is a terminal node controller on a board that plugs into a slot on an IBM PC or compatible microcomputer.[1] HAPN is also designing a version to work with the TAPR TNC-2 compatible unit. It will reside on a "daughter board" that plugs into J4, a connector provided by TAPR for an external modem, and work off a single +12 volt supply. The board will contain a multiplexer making it possible to switch between 1200 and 4800 baud easily. This board is currently in the prototyping stage.

By Glen Leinweber, VE3DNL; Max Pizzolato, VE3DNM; John Vanden Berg, VE3DVV; and Jack Botner, VE3LNY; Hamilton and Area Packet Network, Box 4466, Station D, Hamilton, Ontario, Canada L8V4S7.

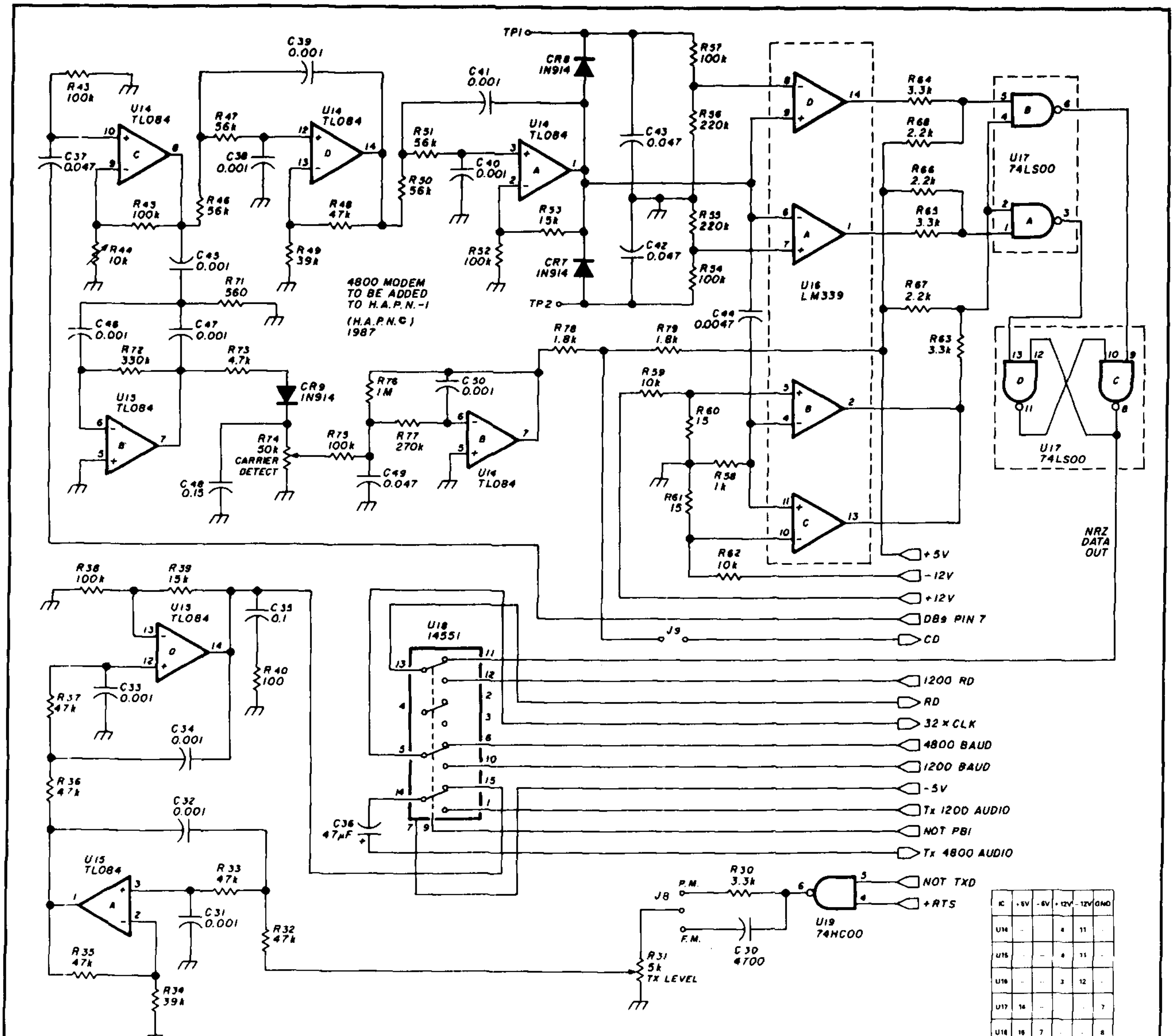


fig. 1. 4800 baud modem.

carrier. This modem uses a duobinary coding system where a 0 to 1 transition momentarily shifts the carrier *up* in frequency, then back to center. The carrier is shifted *down* in frequency and then back to center by a 1 to 0 transition. If two or more consecutive ones come along, the carrier shift occurs only for the first 1, returning back to center for the rest. Similarly, a string of two or more zeroes shifts the carrier down in frequency only for the first 0, returning to center for the rest. Because the frequency of the carrier is changed in frequency only for the first 0, returning does not require a data randomizer to avoid data-sensitivity errors caused by the carrier drifting from the center of the channel.

All these transitions are smoothed out by a four-pole low-pass filter before they reach the radio's modulator. The filter prevents spurious sidebands from interfering with adjacent channels (see **fig. 1**). The shape of the waveform going into the rig's modulator must be carefully controlled. Most rigs amplify the microphone signal with rather nonlinear amplifiers that can severely distort these waveshapes. You can get the best results when the signal is tapped into the frequency modulator directly, bypassing the rig's audio stages.

What happens with a rig using a phase modulator? A phase modulator can be accommodated by modifying the shape of the waveform input. A jumper, J8, in the modem chooses one of two waveshapes to be filtered for either frequency (FM) or phase (PM) type modulators. This modulation scheme works well with frequency synthesized radios. Tap points in both receiver and transmitter that work for this modem also seem to work for 1200 baud modems.

receiving duobinary codes

After getting into the receiver, the frequency-modulated signals pass into the radio's FM detector. Every detector type (ratio detector, quadrature, etc.) yields the same shape waveform. It will be the same shape whether it is generated from a PM or FM modulator (**fig. 2**). The voltage waveform output is proportional to the frequency excursions of the transmitting signal — positive pulses returning to zero and negative pulses returning to zero. The receiving part of the modem must discriminate between positive-going pulses, no pulses, and negative-going pulses.

After amplification by U14c, the signals are filtered by a four-pole low-pass filter which reduces high-frequency noise (U14d and U14a). Comparators (or slicers) U16d and U16a detect positive and negative going pulses, respectively. U16b and U16c together output a short digital pulse at the center of either positive or negative pulses. These digital signals are combined in U17, which reconstructs the original data.

As with the transmitter, the signal coming out of the receiver's detector must have the correct waveshape. The audio de-emphasis circuit (usually placed immediately after the detector) will distort the pulse shapes enough to cause unreliable operation. This means that tapping the receive signal from the volume control or speaker won't work.

carrier detect

Our packet radio protocol states that if a channel is busy, one shouldn't begin a transmission. Squelch circuits found in every FM radio duplicate this function. The carrier-detect circuit in this modem works much like the squelch, but rather than muting the audio it generates a logic signal for the TNC.

This is a noise-operated circuit. U15b detects high-frequency audio noise (approximately 11 kHz) where neither audio nor modem pulse energy is present. With no carrier present, there's lots of high-frequency noise to raise the voltage at R74. Smoothing this pulsating waveform is U14b, a low-pass filter. It drives a Schmidt trigger (U3 in the HAPN-1 adapter) logic gate that makes a quick, clean, carrier/no carrier decision.

At these higher bit rates, the switching time from transmit to receive and back becomes more important. In some radios much of this time is wasted by slow squelch action. This one reacts in 10 to 15 milliseconds.

modem switch

A four-pole, two-position electronic switch, U18, is

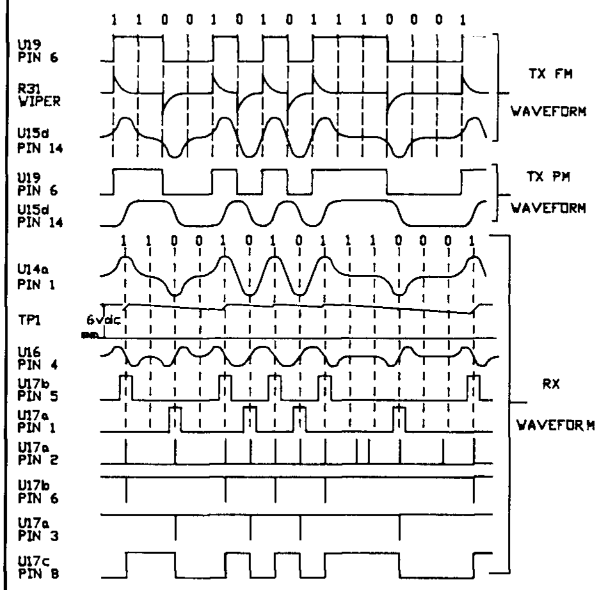


fig. 2. Timing and waveshapes for the 4800 baud modem. Amplitudes are not drawn to scale. There are two possible transmit waveshapes, one for FM and one for PM modulators.

Parts list

Resistors	*1/4 watt, 5 percent*
R60,R61	*= 15*
R40	*= 100*
R71	*= 560*
R58	*= 1k*
R78,R79	*= 1.8k*
R66,R67,R68	*= 2.2k*
R30,R63,R64,R65	*= 3.3k*
R73	*= 4.7k*
R59,R62	*= 10k*
R39,R53	*= 15k*
R34,R49	*= 39k*
R32,R33,R35,R36,R37,R48	*= 47k*
R46,R47,R50,R51	*= 56k*
R38,R43,R45,R52,R54,R57,R75	*= 100k*
R55,R56	*= 220k*
R77	*= 270k*
R72	*= 330k*
R76	*= 1 M*

Potentiometers = 3386W Type 3/8 square single-turn adjustment
R31 = 5k
R44 = 10k
R74 = 50k

Capacitor voltage rating: at least 16 volts, 10 percent tolerance or better and to have spacing of 0.2".

C31,C32,C33,C34,C38,C39,C40, C47,C50	*= 1000 pF*
C30,C44	*= 4700 pF*
C37,C42,C43,C49	*= 0.047 μF*
C35	*= 0.1 μF ceramic bypass*
C48	*= 0.15 μF*
C36	*= 4.7 μF tantalum*

Diode = Switching /signal-silicon
CR7,CR8,CR9 = 1N914 or 1N4148

Jumpers
J8 = three post jumper
J9 = two post jumper

Sockets = 5 x 14 pin
Sockets = 1 x 16 pin

Integrated circuits
U14 = TL084
U15 = TL084
U16 = LM339
U17 = 74LS00
U18 = 14551
U19 = 74HC00

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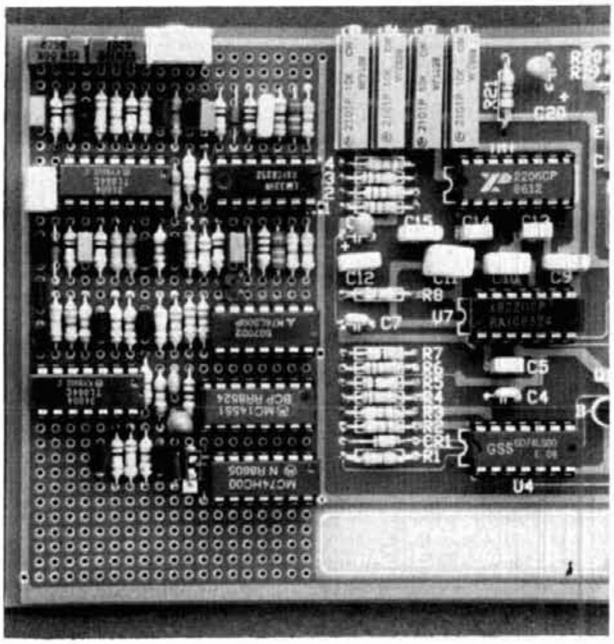

photo A. Close-up of the 4800 baud modem on the HAPN-1 prototype area.

included to allow software switching from one modem to the other. A logic signal from an unused output line of the 8273 (U6, pin 36) controls the switch.

Since each modem operates at a different bit rate, one of the poles switches the 8273's 32X clock (pin 25) input from the standard 1200 baud position to the 4800 baud position. Another switch position selects the digital data output from one modem or the other. The serial data comes from the switch's pole into the 8273 data input (U4, pin 13).

Because this is a MOSFET switch, it can deal with analog and digital signals. The transmit signal going to the rig's modulator can be routed from one modem or the other by the third switch. Turning the 8273 control port (port B) bits on and off puts the switch under software control. The node customization program supplied with the HAPN-1 adapter provides a modem select menu; choose the modem/baud rate by pressing one of the function keys. The modem/baud rate remains in effect until the customization procedure is used to change the selection again.

construction

The prototype area at the end of the HAPN card is the perfect place to build this modem. (See **photo A.**) Power supply lines (+12 volts, −12 volts, +5 volts, −5 volts) are available, as are all the TNC interface points. Interfacing is shown for the HAPN-1 card; later versions of the card have traces to the interface points brought out to the prototype area, making modem construction a little easier.

You must use small components. The parts layout

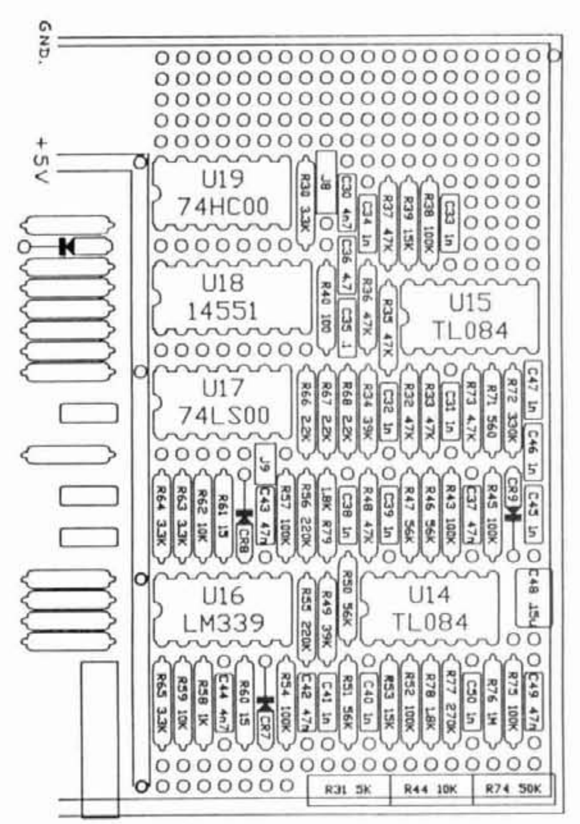

fig. 3. Parts layout diagram from the top of the prototype area.

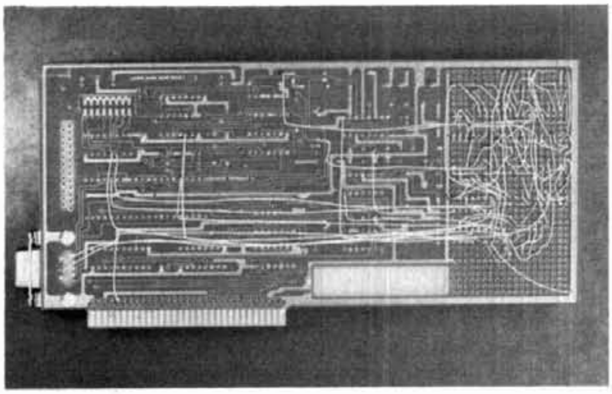

photo B. Bottom of the HAPN-1 adapter showing the wiring added for the 4800 baud modem.

in **fig. 3** assumes all capacitors have a lead spacing of 0.2 inch. Resistors of 1/4 watt have their leads bent to 0.4 inch.

Insert the components according to the layout diagram, and solder them to the board. Then cut the leads off and make the interconnections. A small soldering iron and fine wire (like wire-wrap wire) are a must. Take care with the interconnections; the parts

Table 1. Modem pin designations on HAPN series boards

Signal name	HAPN-1	HAPN-1.1	HAPN-1.2
Rx 4800 audio	DB-9 pin 7	square pad 01	square pad 01
Tx 4800 audio	DB-9 pin 8	square pad 02	square pad 02
−12 volts	C22/R20	square pad 03	square pad 03
32xCLK	U6 pin 25	square pad 04	square pad 04
1200 baud	U8 pin 4	square pad 05	square pad 05
4800 baud	U8 pin 3	square pad 06	square pad 06
Not TxD	U6 pin 29	square pad 07	square pad 07
+RTS	U9 pin 12	U9 pin 12	square pad 08
+12 volts	U11 pin 4	square pad 08	square pad 09
+5 volts	5volt rail	square pad 09	square pad 10
Tx 1200 audio	DB-9 pin 4	square pad 10	square pad 11
1200 RD	U7 pin 7	square pad 11	square pad 12
RD	U4 pin 13	square pad 12	square pad 13
Not PB1	U6 pin 36	square pad 13	square pad 14
CD	U3 pin 9	square pad 14	square pad 15
−5 volts	edge connector B5	square pad 15	square pad 16

Note: Edge connector pin B5 is the fifth pin from the bracket going to the fifth hole on the top row.

are placed very close together and finding a wiring mistake after the modem has been assembled is no fun. (See **photo B**.)

Cut the following two printed circuit traces so the multiplexer chip (U18) can switch from one modem to the other under program control:

1. Cut the default 1200 BPS trace at "SW" (next to P1).
2. Cut the trace going to U4 pin 13. This will be at different locations, depending on the board revision you have:

- HAPN-1 — fat trace on the component side, going to U4 pin 13.
- HAPN-1.1 — short trace between square pad no. 11 and square pad no. 12.
- HAPN-1.2 — short trace between square pad no. 12 and square pad no. 13.

Table 1 shows how the new modem interfaces with different revision boards. The later boards have been enhanced with pads at the prototype area making it easier to add the modem. Square pads are immediately adjacent to the prototype area, in a vertical row. They are consecutively numbered from the top of the board to the bottom.

voltage hookup

Look up the signal name in **table 1** and locate the appropriate interface point for your board.

GND — from any wide ground trace at the side of the prototype area to U17 pin 7, U18 pin 8, and U19 pin 7. Also complete ground side connections to all components needing ground (see schematic, **fig. 1**).

+12 volts — to U16 pin 3, U14 pin 4, and U15 pin 4. Also connect +12 volts to R59.

−12 volts — to U16 pin 12, U14 pin 11, and U15 pin 11. Also connect −12 volts to R62.

+5 volts — to U17 pin 14, U18 pin 16, and U19 pin 14. Also connect +5 volts to R66, R67, R68, and R79.

−5 volts — to U18 pin 7.

Finally, make up a cable for the radio with the following:

- "Rx audio" to DB9 pin 7
- "Tx audio" to DB9 pin 8
- "PTT" to DB9 pin 1
- "GND" to DB9 pin 3

modem/radio interface

One project goal was to maintain the functionality of the existing modem while allowing easy switching between the two. It was also desirable to keep the interface between the modem and the radio as simple as possible.

A quick survey of local hams shows that most would have to change the tap points into their radio for the new modem. *Choose the wrong tap points and this modem will not work!* At this time a wide variety of radios have been adapted successfully with little modification.

transmitter interface

The 4800 modem transmit signal must go directly to the FM or PM modulator in your transceiver. Connections to the microphone jack will not work. Tapping at this point also seems to work well with 1200 baud modems, as long as the level is readjusted to match the new tap point. Because this tap point bypasses the limiter stages in the audio chain, take care not to over-deviate. Deviation should be kept to about 3 kHz by adjusting R31 on the modem. Use shielded cable to connect the modem to your radio.

If you choose the correct tap point, your radio will still operate properly when used for voice work but

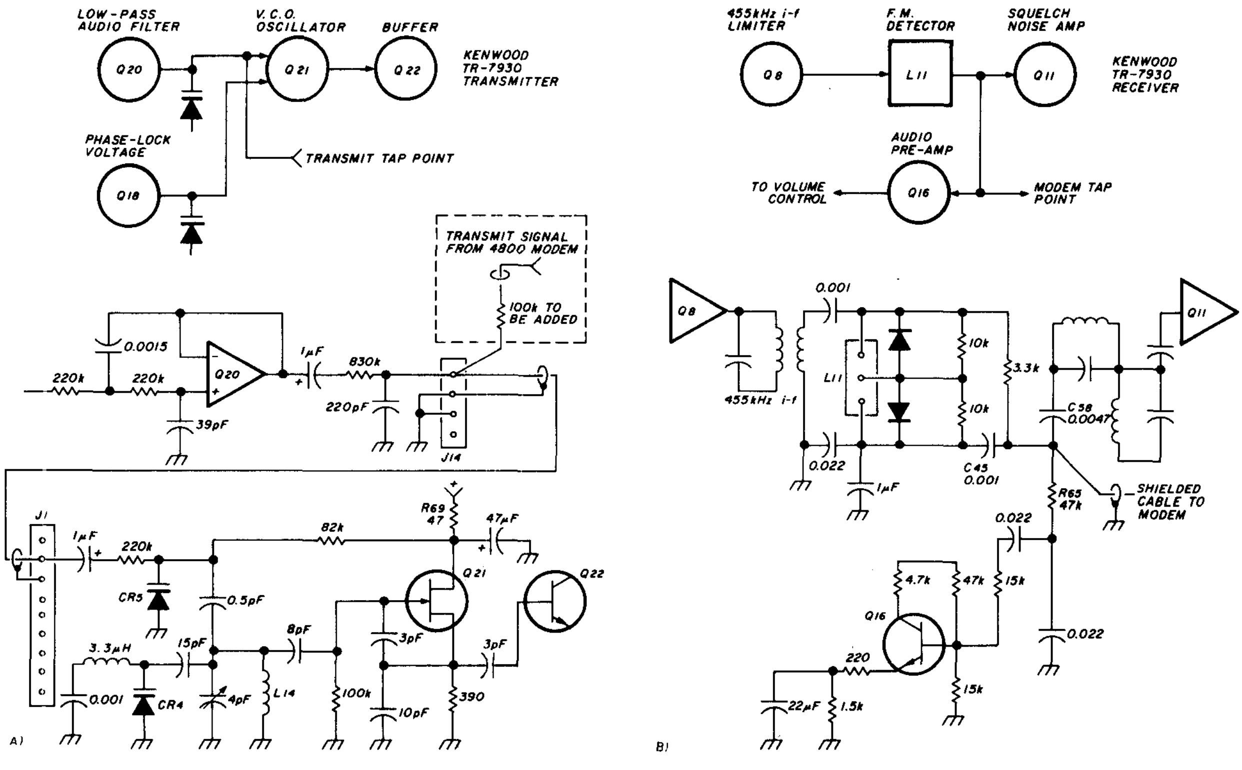

fig. 4. Interface of 4800 baud modem to Kenwood TR-7930 rig. This is typical of many rigs in use today. Find the modulation stage in the transmitter (A), and the FM demodulator in the receiver (B).

you will have to disconnect the modem interface cable to get full voice modulation. When it is used for packet communication, it's a good idea to unplug the microphone to prevent room noise pickup.

You must determine which modulation type your radio uses. If you have a phase modulator, install a jumper between the center pin of J8 and the pin connected to R30. If your rig uses a frequency modulator, install the jumper between the center pin of J8 and C30.

Many radio manuals include a block diagram. This is a useful guide to determine what form of modulation your radio uses. FM is always applied to an oscillator circuit; either a crystal-controlled oscillator or a voltage-controlled oscillator (VCO). If it's FM, your rig's schematic will show a voltage variable capacitance (varactor) diode coupled closely to the frequency determining inductors and capacitors (or crystal) of an oscillator circuit.

Phase modulation is always applied to a stage following an oscillator, never to the oscillator itself. PM could be produced using either a voltage variable capacitance diode or a transistor stage called a "reactance modulator".

The point in your radio where the Tx audio should be introduced must be very close to the modulator. Your rig's audio processing stages will probably end in a low-pass filter before going into the modulator. The tap point will be between the low-pass filter and the modulator itself. If possible, tap in at a high impedance point; the modem shouldn't have to drive an impedance lower than about 400 ohms.

Figure 4A shows an example of the transmitter interface to a Kenwood TR-7930 transceiver.

receiver interface

You cannot use a connection into your rig at the speaker or volume control for this modem. Your rig must be tapped directly at the FM detector before the audio is de-emphasized. The de-emphasis circuit (a resistor/capacitor combination) is rarely identified on schematic or block diagrams. It nearly always follows the squelch pickoff point, but is often placed before any audio gain stages.

Most radios use a squelch circuit called a "noise-operated squelch" that gets its operating signal from the FM detector, before de-emphasis. Tap for the modem at *exactly* the point where this squelch circuit joins the FM detector. The input circuit of the modem is ac coupled, and is high impedance (100k). It can accommodate signal amplitudes from 2 mv to 200 mv rms.

Some integrated-circuit detector chips include an audio preamp that may supply too much signal for the modem. You can accommodate these larger signals by soldering a resistor (10k to 33k) in parallel with R45.

Use shielded wire between the receiver interface point and the modem. Keep the length as short as possible — avoid a run of more than 10 feet. If you must keep your radio at some distance from your TNC, construct a buffer stage at the detector so that it is not loaded by the capacitance of a long run of shielded cable.

The existing interface for the push-to-talk circuit doesn't need to be changed. Route all signals through the nine-pin connector at the back of the board. You may leave the existing 1200 baud lines on this connector (pins 2 and 4) intact, wiring the new transmit and receive lines to pins 7 and 8. Once you get the new modem running successfully, try switching to 1200 baud using the new tap points in your radio. An adjustment of the 1200 TX level control (P3) should be all that's necessary.

The HAPN card allows two sources of carrier detect — one derived from the demodulator chip (XR2211), the other from an external (squelch-derived) source. A jumper at J1 or J2 selects one of these sources. Jumper J9 selects a third option, the 4800 carrier detect. Because this circuit detects 1200 baud packets, 4800 baud packets, and even voice, remove the jumper on J1 or J2 and install it permanently at J9.

Figure 4B shows an example of the receiver interface to a Kenwood TR-7930 transceiver.

test and alignment

Check the four power supply lines for shorts with an ohmmeter before plugging the modified card back into your computer. After installing the adapter, but before connecting your radio, make sure the dc voltages on all the signal pins of U14 and U15 are 0 volts. Connect your radio and go to a clear channel.

Measure the voltage at TP 1 and adjust potentiometer R44 for about 9 Vdc. This voltage gives the peak amplitude of the audio signal, and should drop to about 6 Vdc during a 4800 baud packet. If R44 adjusts out of range, change R45 up in value if the TP 1 voltage is too low, down in value if it's too high.

Now adjust R74 as you would a squelch control. Use the HAPN "T25" test program to look at the "carrier detect" function. You can also set R74 by looking at U14b pin 7. Adjust for −5 Vdc on a clear channel. It should rise to approximately 0 volts when a carrier is present, or when the radio is disconnected from the modem.

The transmit level control R31 is more difficult to set properly, since you probably have no way of measuring deviation. The 4800 baud deviation should be 3 kHz, a little less than voice deviation of 5 kHz. You might have another station compare the level of your 4800 baud packets with a voice transmission, ideally with a scope. Start R31 off at minimum, increasing it slowly. Setting R31 too high may over-deviate your transmitter and the monitoring station will see only that waveform amplitude is not increasing, although you may be causing adjacent channel interference. Remember that by connecting directly to the modulator you have bypassed the audio limiting circuits; the only thing limiting deviation is R31 in the modem.

The existing factory limiter setting in your radio (which should be close to 5 kHz) can also be used as a reference for setting the 3-kHz deviation for 4800 baud. Hook up your scope at the selected 4800 baud modulating point, apply a signal into the microphone input (use a signal generator or whistle into the mike), and increase the amplitude until you can see limiting on the scope. Note the peak amplitude. This will be your 5-kHz deviation reference. Take 60 percent of this value and use it for adjusting the 4800 baud transmit level (R31). You can also use the same level when adjusting your 1200 baud transmit level (P3).

acknowledgments

This modem is an adaptation of the design by Ken Smith, VE3HWB, so a great deal of credit must go to him. Ken's original article, "Packet Radio with the 1802," was published in the *Ipso Facto* newsletter of the Association of Computer Experimenters (ACE), April 1979. Thanks also to HAPN members VE3IUV, VE3NAV, and VE3MCF for their efforts in building and testing the prototypes, and their contributions to this article.

available from HAPN

The HAPN-1 adapter revision 2 is still available from HAPN as described in the August 1986 article for the same price. Revision 2 contains a number of extra traces in the prototype area to simplify the addition of a second modem there.

We also have a printed circuit board for a stand-alone version of the 4800 baud modem, the HAPN-M, available for $25 U.S. postage paid. The modem is identical to the one described in this article, except that it has RS-232C drivers in the interface to the TNC. It may be used with any RS-232C compatible TNC, or TTL levels if the RS-232C interface circuits are bypassed.

We would like to remind HAPN-1 users who build this modem that a software update may be required to fully support the modem switch. Software updates are $5 U.S. each, plus $5 per diskette. (If you use any of the programs on diskette 2, a diskette 2 update is required along with diskette 1.)

Wiring diagrams of the modem and interfacing diagrams for the Santec ST-144/uP handheld and the ICOM IC-27 transceivers are available from HAPN if you send us a self-addressed envelope and an IRC.

HAPN update

HAPN (Hamilton and Area Packet Network) is a nonprofit association dedicated to furthering the state of packet radio. We are presently working on the TAPR-2 TNC version of the 4800 baud modem and on developing drivers for the VADCG V-3 experimental protocol. We believe that widespread use of 4800 baud will go a long way to improve the efficiency of packet radio local area networks, at minimal cost to the users. The V-3 link level driver is being tested, but the network level is yet to be coded. V-3 is a very interesting networking protocol, an outgrowth of VADCG's V-2 protocol. (For further information on V-3 write VADCG, 9531 Odlin Road, Richmond, BC, V6X 1E1, Canada.)

reference

1. Jack Botner, VE3LNY; Ron Bradshaw, VE3IUV; Max Pizzolato, VE3DNM; John Vanden Berg, VE3DVV; "A Packet Radio TNC for the IBM PC," *ham radio*, August 1986, page 10.

ham radio

one hundred years of electric waves

A tribute to Heinrich Hertz

One hundred years ago, in a technical high school in Germany, a teacher working with hand-me-down apparatus made a discovery that would affect generations to come. His equipment consisted of little more than a few electrical conductors and a Leyden jar, yet he stumbled upon the basic principle which became the foundation of modern radio, television, radar, and electromagnetic wave communication.

The year was 1886; the man was Heinrich Hertz. Hertz's initial discovery was followed by a series of research studies that firmly established the existence of mysterious and remarkable "electric waves" — waves which could travel through walls and empty space. Today we call them "radio waves," or "electromagnetic radiation."

Most people think that Marconi was the man responsible for radio. Marconi *was* responsible for the practical application of radio, but Hertz laid the groundwork and did all the research work upon which modern radio is based.[1]

Now, 100 years after Hertz's discoveries, it may come as a surprise to many that his work is still the foundation of modern radio. We don't use spark-gap transmitters in our communications today, and Hertz never heard of a superheterodyne receiver — he didn't even see his electrical waves as potential media for communication.[2] But it is amazing to realize the extent to which Hertz's work is represented in hi-tech, high-performance radio communications.

the path to the goal

Hertz's work can be traced to that of such notables as English scientist Michael Faraday and Scottish physicist James Clerk Maxwell. Of particular importance are Faraday's ideas about electrical and magnetic fields, and Maxwell's theoretical predictions of the existence of electromagnetic waves. In 1887, Hertz was working on a problem concerning the relation between electromagnetic forces and the dielectric polarization of insulators. While working with some spiral coils used for demonstrations during his tenure at the Technical High School at Karlsruhe, he noticed that a discharge of a small Leyden jar through one coil caused a spark across a spark gap of the other. Further investigation revealed that there were very rapid electrical oscillations occurring within the coils.

While still pursuing the problem of the dielectric polarization of insulators, Hertz was, as he says: "..frustrated by the invariable occurrence of strong sparking in the secondary conductor..."[3] Now the secondary conductor just happened to be a loop antenna with a spark gap, used as a detector of electromagnetic waves. Of course Hertz had not designed his loop as an antenna; antennas hadn't been invented yet! He designed the loop as the secondary loop of a transformer. At first his results puzzled him. Later in his discussion he says: "It only gradually became clear to me that the law which I had assumed as the basis of my experiment did not apply here..."[3]

Hertz did not realize at first that his electrical oscillations were producing waves which traveled through space. But he was a dedicated researcher and followed where his findings led. He wrote later: "But when I had established with certainty the existence of actual waves, I...arrived at the phenomena which are discribed in the paper 'On Electromagnetic Waves in Air, and their Reflection.'"[3] Hertz realized that he had discovered the electromagnetic waves Maxwell had predicted with his mathematical equations.

By W. Clem Small, KR6A, R 1, Box 64A, Weybridge, Vermont 05753

Hertz: a pioneer among pioneers

You may be surprised to learn that there were others who predated Hertz in demonstrating electric waves in air.* It seems that he was unaware of their work and made his discoveries independently. Let's take a look at these men.

Lord Kelvin, in the preface to the English edition of Hertz's classic *Electric Waves*[3], referred to Joseph Henry who showed that electrical force can diffuse through space in a manner very much like light waves. In 1842, before Hertz's discovery of electric waves, Henry demonstrated such radiation by showing magnetic effects in steel needles caused by lightning bolts miles distant from the needle. The "sparks" of Henry's lightning bolts now seem to be precursors to the sparks of Hertz's spark-coil transmitter.

Then, in 1871, Elihu Thomson and E. A. Houston reported work in which Thomson sent signals between a spark transmitter and a spark-gap receiver (equipment similar to that which Hertz would use) from the basement to the top floor of the school where they taught. In 1876, Sylvanus Thompson used equipment even more similar to Hertz's, to show that another electric wave discoverer, Thomas A. Edison, was wrong in claiming that he had discovered a "new" nonelectric force. Edison had discovered this new force in 1875 while investigating sparking which occurred during work on an electromagnet with a vibrating armature — a device having much in common with the induction coil of Hertz's spark-gap transmitter. Again, the method of detection was the observation of a visible spark at the point of reception. Edison displayed his electric waves only in conductors, not in air. Because of the strange behavior of these waves, he claimed that his new force was not a form of electricity, but of some "etheric" force. Thompson showed that he was wrong, but unfortunately, didn't go on to show just what it was that Edison had discovered. Then in 1880, David Hughes performed studies which demonstrated the effects of Hertz's electric waves. But when Hughes demonstrated his results to emminent scientists of his day, he was discouraged from pursuing the matter. The scientists claimed he was using the well-known principle of induction, rather than displaying something new.

Thomson and Houston, Thompson, Edison, and Hughes all seem to have demonstrated the effects of what were later to become known as radio waves, but none of them pursued the discovery to the same extent as Hertz. Much later, after wireless communication was a reality, Edison sold the patent on his etheric force to Marconi for $30,000.

Perhaps even more startling is the work of E. A. Dolbear, who in 1882 gave the first demonstration of transmission and reception of the human voice with his "electrostatic telephone." Although he did use an induction coil in his transmitter, Dolbear's apparatus differed from Hertz's significantly. Another early wireless pioneer, a dentist named Mahlon Loomis, is often considered a precursor to Hertz for his work with the "aerial telegraph." In 1872, using an aerial and a ground at each site, Loomis used his apparatus to signal for 14 miles between two mountain tops. But his apparatus was also quite different from Hertz's, and Loomis's work is generally thought to have been based on atmospheric conduction rather than electric waves. Some historians believe that Dolbear's work also was not with electrical waves, but by induction — a popular means of early "wireless" communication. Others might deny the inclusion of Henry's or Edison's work in the list of Hertz precursors. Yet other historians would include all those I've mentioned above as legitimatly predating Hertz in the discovery of wireless waves.

It is obvious that a number of men were experimenting with an intent to develop a wireless system using apparatus remarkably like that which Hertz later used to discover electric waves. Yet none of them was able to convince the scientific world that he had indeed found a worthwhile new means of signaling without wires. Before the scientific world would be willing to accept such a claim, Maxwell had to use his mathematics to justify the reasons for believing in such radiation, and Hertz had to provide solid experimental verification of those predictions. Where many had tried, one succeeded.

Hertz's legacy

In the 100 years since the discovery of electromagnetic radiation, there have been tremendous gains in the science and technology of radio communications. We have advanced from the early spark coils and coherers through crystal detectors, arc transmitters, radio-frequency alternators, vacuum tubes, transistors, and on to solid-state devices. Today's technology shows impressive strides beyond Hertz's crude apparatus. But how far have we really come?

Although he didn't foresee the potential his discovery held as a basis for communications, Hertz pioneered the development of some of the most modern communication technology we have today. For instance, the parabolic dish antenna, important to microwave communications, is a direct descendent of Hertz's parabolic reflector antenna. The dipole antenna was also Hertz's discovery and basic to much of his early work. Today dipole antennas are a component

---

*W. von Bezold, G. F. Fitzgerald, and Oliver Lodge are three other pioneers in the study of electric waves. None of them actually demonstrated electric waves in space, but did precede Hertz with work which had specific implications that could have led to his findings.

of most TV receiving antennas, used extensively in high-frequency work or as the feed antenna in microwave dishes. The world's first loop antenna was the single turn of Hertz's loop with spark-gap receiver. Today, virtually every AM broadcast-band receiver uses a loop antenna. Our contemporary microwave dielectric antenna is a spinoff of his early work on the quasi-optical properties of electric waves as they interact with dielectric materials.

On the other hand, the original Hertzian transmitter, the venerable induction coil with spark gap, has been outlawed since 1938. But I found reference as recently as 1971 to engineering research on the use of electrical spark to generate electromagnetic waves.[4]* The ghost of Henrich Hertz is everywhere!

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3. Heinrich Hertz, *Electric Waves*, 1893. English language translation by MacMillan and Co., reprinted 1962, Dover Publications, Inc., New York, pages 5 and 11.
4. K. Landecker, L.V. Skatterbol, and D. Growdie, "Single-spark Ring Transmitter," *Proceedings of the IRE*, 1971, volume 59, no. 7, page 1982-1090.

*This happens to be the most recent reference to a spark transmitter I've come across.

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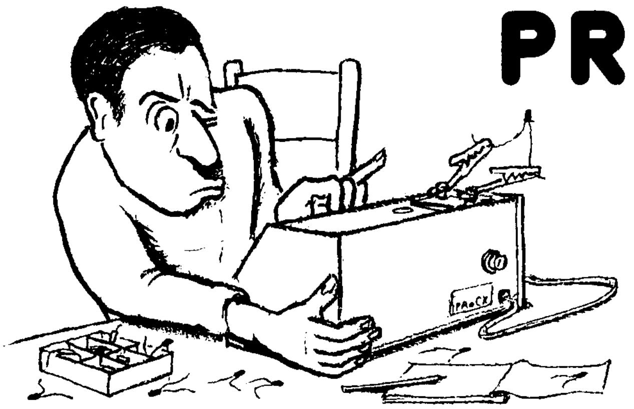

PRACTICALLY SPEAKING

Joe Carr, K4IPV

impedance matching

One of the first things an Amateur learns is that the antenna impedance must be matched to the transmission line, and that the transmission line impedance must be matched to the output impedance of the transmitter. This is because maximum power transfer between a source and a load occurs when the system impedances are matched. In other words, more power is transmitted from the system when the load impedance (the antenna), the transmission line impedance, and the transmitter output impedance are all matched with each other.

Of course, the trivial case is where all three sections of our system have the same impedance. For example, you could have an antenna with a simple 75-ohm resistive feedpoint impedance (typical of a half-wave dipole) and a transmitter with an output impedance that will match 75 ohms. In that case, you need only connect a standard impedance 75-ohm piece of coax between the transmitter and the antenna. Job done!

But there are other cases where the job is not so simple. In the case of the standard antenna, for example, the feedpoint impedance is rarely what the books say it should be. That ubiquitous dipole, for example, is nominally rated at 75 ohms but even the simplest antenna book tells us that value is merely the theoretical free-space impedance. At locations closer to the earth's surface that impedance could vary over the approximate range of 30 to 130 ohms and may have a substantial reactive component; so much for standard coaxial cable.

There is a way out of this situation. You can construct a matching system that will marry the source impedance to the load impedance. This month we will examine several matching systems that might prove useful in a number of situations.

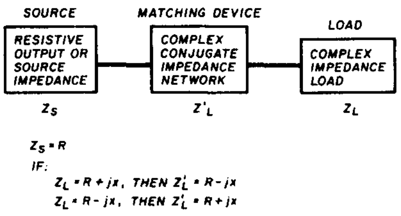

fig. 1. Impedance matching requirement between resistive source impedance and complex load impedance.

impedance-matching approaches

Antenna impedance may contain both reactive and resistive components. In most practical applications you are searching for a purely resistive impedance ($Z = R$), but that ideal is rarely achieved. A dipole antenna, for example, has a theoretical free-space impedance of 73 ohms at resonance. But as the frequency applied to the dipole is varied away from resonance, a reactive component is added. When the frequency is greater than resonance the antenna tends to look like an inductive reactance, so the impedance is $Z = R + jX$. Similarly, when the frequency is less than the resonance frequency the antenna looks like a capacitive reactance, so the impedance is $Z = R - jX$. At distances closer to the earth's surface the resistive component may not be exactly 73 ohms, but may vary from about 30 to 130 ohms. Clearly, whatever impedance coaxial cable is selected to feed the dipole stands a good chance of being wrong.

To match a complex load impedance like an antenna to a resistive source (the most frequently encountered situation in practical radio work), interpose a matching network between the load and the source (**fig. 1**). The matching network must have an impedance that is the complex conjugate of the complex load impedance. For example, if the load impedance is $R + jX$, the matching network must have an impedance of $R - jX$; similarly, if the load is $R - jX$, the matching network must be $R + jX$. In the sections that follow we'll take a look at some of the more popular networks that accomplish this job.

L-section network

The L-section network is one of the most used, or at least most published, antenna-matching networks in existence. It rivals even the pi-network. A circuit for the L-section network is shown in **fig. 2A**. The two resistors represent the source (R1) and load (R2) impedances. The elementary assumption of this network is that R1 < R2. The design equations are:

$$R1 < R2 \text{ and } 1 < Q < 5$$

$$X_L = 6.28FL = Q \times R1$$

$$X_c = \frac{1}{6.28FC} \quad (1)$$

$$Q = \left[\frac{R2}{R1} - 1\right]^{1/2} \quad (2)$$

$$\text{or } Q = \sqrt{\left(\frac{R2}{R1} - 1\right)}$$

also,
$Q = X_L/R1 = R2/X_c$

It's probable that you'll see this network published in conjunction with less than quarter-wavelength long-wire antennas. Those books and articles typically call for a "good ground" for the antenna to work properly. But they don't tell you what a "good ground" is or how you can obtain it. Unfortunately, at most locations a good ground means burying a lot of copper conductor — something that most of us can't afford. In addition, the person who is forced to use a long-wire instead of a better antenna often can't construct a good ground under any circumstances because of landlords and/or logistical problems. The very factors that prompt the use of a long-wire antenna in the first place also prohibit any form of practically obtainable good ground. But there is a way out — radials. A good ground can be simulated with a counterpoise ground constructed of quarter-wavelength radials. These radials have a length in feet equal to $246/F_{MHz}$, and as few as two of them will work wonders. I've used just one radial tacked to the baseboard of a student boarding house room at college and achieved superior results over the poor ground that I'd been able to obtain previously in my third floor abode.

Another form of L-section network is shown in **fig. 2B**. This circuit differs from the previous one in that the roles of the L and C components are reversed. As you might suspect, this switch brings about a reversal of the impedance relationships. In this circuit the assumption is that driving source impedance R1 is larger than load impedance R2 (R1 > R2). The equations are shown below:

$R2 > R1$

$X_L = R2\,[\,R1/(R2 - R1)]^{1/2}$ or

$$X_L = R2 \cdot \sqrt{\frac{R1}{(R2-R1)}} \quad (3)$$

$X_c = (R1R2)/X_L$

A final form of L-section network is shown in **fig. 2C**. Again, assume that driving source impedance R1 is larger than load impedance R2 (R1 > R2).

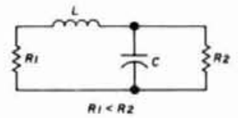

fig. 2A. Classic L-section network.

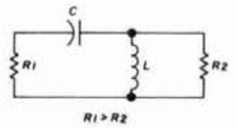

fig. 2B. Reversed L-section network.

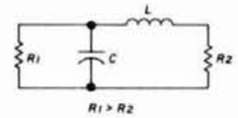

fig. 2C. Inverse L-section network.

In this circuit, the elements are arranged like those in **fig. 2A**, except that the capacitor is at the input rather than the output of the network. The equations governing this network are: $R1 > R2$ and $1 < Q < 5$

$$X_L = 6.28FL = [(R1R2) - (R3)^2]^{1/2} \quad (4)$$

$$\text{or } = \sqrt{(R1R2) - (R3)^2}$$

$$X_c = \frac{1}{6.28FC} = \frac{R1R2}{X_L} \quad (5)$$

$$C = \frac{1}{6.28FX_c} \quad (6)$$

$$L = \frac{X_L}{6.28F} \quad (7)$$

So far, we have considered only matching networks that are based on inductor and capacitor circuits. But there is also a possibility of using transmission line segments as impedance-matching devices. Two basic forms are available: quarter-wave sections and the series matching section.

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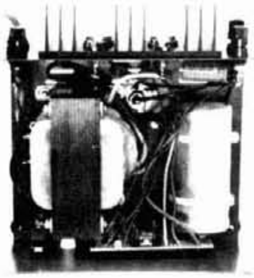

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RS-5A	4	5	3½ × 6⅛ × 7¼	7
RS-7A	5	7	3¾ × 6½ × 9	9
RS-7B	5	7	4 × 7½ × 10¾	10
RS-10A	7.5	10	4 × 7½ × 10¾	11
RS-12A	9	12	4½ × 8 × 9	13
RS-12B	9	12	4 × 7½ × 10¾	13
RS-20A	16	20	5 × 9 × 10½	18
RS-35A	25	35	5 × 11 × 11	27
RS-50A	37	50	6 × 13¾ × 11	46

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VS-50M	37	22	10	50	6 × 13¾ × 11	46
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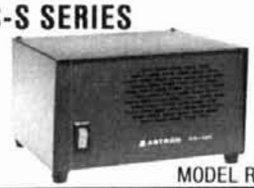

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RS-10S	7.5	10	4 × 7½ × 10¾	12
RS-12S	9	12	4½ × 8 × 9	13
RS-20S	16	20	5 × 9 × 10½	18

pi networks

The pi network shown in **fig. 3** is used to match a high source impedance to a low load impedance. These circuits are typically used in vacuum

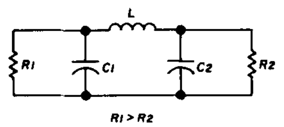

fig. 3. Pi-network.

tube rf power amplifiers that need to match low antenna impedances. The name of the circuit comes from its resemblance to the Greek letter "pi". The equations for the pi network are:
$R1 > R2$ *and* $5 < Q < 15$

$$Q > \left[\frac{R1}{R2} - 1\right]^{1/2} \qquad \textbf{(8)}$$

$$\text{or } Q > \sqrt{\frac{R1}{R2} - 1}$$

$$X_{C2} = \frac{R2}{[R2/(R1(1+Q^2) - 1)]^{1/2}} \qquad \textbf{(9)}$$

$$\text{or } \quad X_{C2} = \frac{R2}{\sqrt{\frac{R2}{(R1(1+Q^2) - 1)}}}$$

$$X_{C1} = R1/Q$$

$$X_L = \frac{(R1\ (Q + (R2/X_{C2})))}{Q^2 + 1} \qquad \textbf{(10)}$$

split-capacitor network

The split-capacitor network shown in **fig. 4** is used to transform a source impedance that is less than the load impedance. In addition to matching antennas, this circuit is also used for interstage impedance matching inside communications equipment. The equations for design are:
$R1 < R2$

$$Q > \left[\frac{R2}{R1} - 1\right]^{1/2} \qquad \textbf{(11)}$$

$$\text{or } Q > \sqrt{\left(\frac{R2}{R1} - 1\right)}$$

$$X_L = R2/Q$$

$$X_{C1B} = \left[\frac{R1\ (Q^2 + 1)}{R2} - 1\right]^{1/2} \qquad \textbf{(12)}$$

$$\text{or } X_{C1B} = \sqrt{\left(\frac{R1(Q^2 + 1)}{R2} - 1\right)}$$

$$X_{C1A} = \frac{R2\ Q}{Q^2 + 1} \qquad \textbf{(13)}$$

$$\left[1 - \frac{R1}{Q\ X_{C1A}}\right]$$

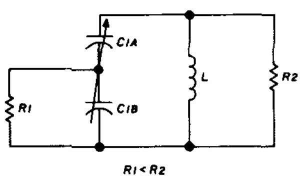

fig. 4. Split-capacitor network.

transmatch circuit

One version of the transmatch is shown in **fig. 5.** This circuit is basically a combination of the split-capacitor network and an output tuning capacitor (C2). For the hf bands, the capacitors are on the order of 150 pF per section for C1, and 250 pF for C2. The roller inductor should be 28 μH. The transmatch is essentially a coax-to-coax impedance matcher, and is used to trim the mismatch from a line before it affects the transmitter.

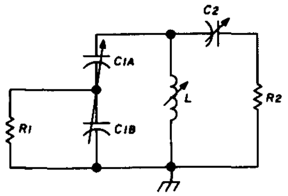

fig. 5. Transmatch variant circuit.

Perhaps the most common form of transmatch circuit is the T-network shown in **fig. 6.** This network costs less than some of the others, but has a problem. While it does match impedance (and thereby "tune out" VSWR on coaxial lines), it also has a high-pass characteristic so does not reduce the *harmonic output of the transmitter.* The T-network, therefore, does not serve one of the main purposes of the antenna tuner — harmonic reduction. An alternative network, called the SPC transmatch, is shown in **fig. 7.** This version of the circuit offers harmonic attenuation as well as matching impedance.

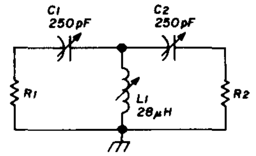

fig. 6. T-network transmatch circuit. This circuit has a substantial high-pass characteristic so it will not suppress harmonics.

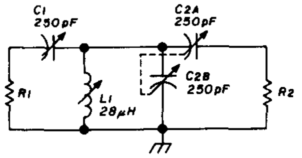

fig. 7. Revised T-network, the SPC transmatch, suppresses harmonics.

coaxial cable baluns

A balun is a transformer that matches a BALanced load (like a dipole antenna) and an UNbalanced resistive source impedance (like a coaxial cable). With the circuit in **fig. 8** you can make a balun that will transform impedance at a 4:1 ratio, with R2 = 4 × R1. The length of the balun section coaxial cable is:

$$L_{ft} = \frac{492\ V}{F_{MHz}} \qquad \textbf{(14)}$$

Where:
L_{ft} is the length in feet
V is the velocity factor of the coaxial cable
F_{MHz} is the operating frequency in megahertz

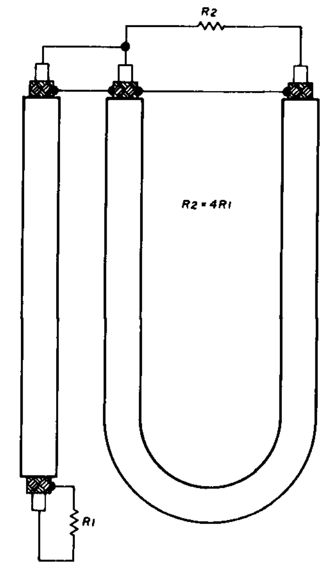

fig. 8. Coaxial cable 4:1 balun transformer.

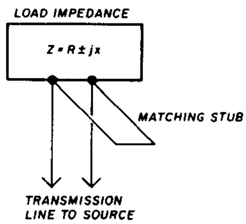

fig. 9A. Basic configuration for stub matching.

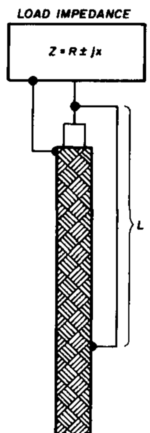

fig. 9B. Coaxial matching section.

matching stubs

You can build a shorted stub to produce almost any value of reactance. Use this information to make an impedance-matching device that cancels the reactive portion of a complex impedance. If you have an impedance of, say, Z = R + j30 ohms you need to make a stub with a reactance of −j30 ohms to match it. Two forms of matching stub are shown in **figs. 9A** and **9B**. These stubs are connected exactly at the feedpoint of the complex load impedance, although they are sometimes placed further back on the line at a (perhaps) more convenient point. In that case, the reactance required will be transformed by the transmission line between the load and the stub.

quarter-wave matching sections

Figure 10 shows the elementary quarter-wavelength transformer section connected between the transmission line and the antenna load. This transformer is also sometimes called a Q-section. When things are designed correctly, this transmision line transformer is capable of matching the normal feedline impedance (Z_S) to the antenna feedpoint impedance (Z_R). You must have a piece of transmission line available that has an impedance Z_O of:

$$Z_o = (Z_s Z_R)1/2 \text{ or } \quad Z_o = \sqrt{(Z_s Z_R)} \qquad \textbf{(15)}$$

Most texts show this circuit for use with coaxial cable. While it is certainly possible, and even practical in some cases, for the most part there is a serious flaw in using coax for this project. It seems that the normal range of antenna feedpoint impedances, coupled with the rigidly fixed values of coaxial cable surge impedance available on the market, combine to yield unavailable values of Z_O. While there are certainly situations that yield to this requirement, many times the quarter-wave section is not usable on coaxial cable antenna systems using standard impedance values.

On parallel transmission line systems, however, it is quite easy to achieve the correct impedance for the matching section. Use the equation above to find a value for Z_o, and then

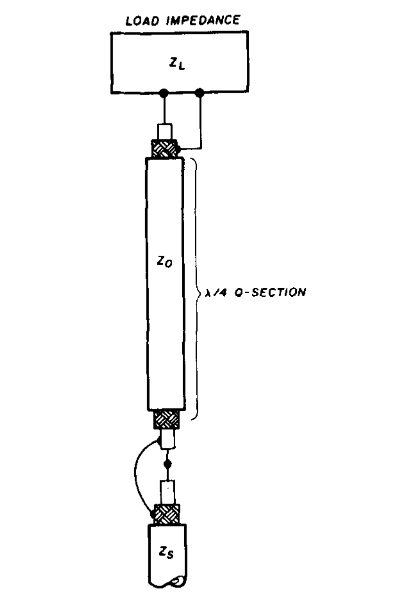

fig. 10. Quarter-wave Q-section matching.

calculate the dimensions of the parallel feeders. Because you know the impedance, and can more often than not select the conductor diameter from available wire supplies, use the equation below to calculate conductor spacing:

$S = D10^{(Z/276)}$

Where:

S is the spacing, D is the conductor diameter (D and S in the same units), and Z is the desired surge impedance. From there you can calculate the length of the quarter-wave section from the familiar $246/F_{MHz}$.

series matching section

The quarter-wavelength section discussed above has several drawbacks: *it must be located at the antenna feedpoint, it must be quarter wavelength, and it must use a specified (often non-standard) value of impedance.* The series matching section is a generalized case of the same idea, and permits you to build an impedance transformer that overcomes most of these faults. According to *The ARRL Antenna Book*, this form of transformer is capable of matching any load resistance between about 5 and 1200 ohms. In addition, the transformer section is not located at the antenna feedpoint.

Figure 11 shows the basic form of the series matching section. There are three lengths of coaxial cable: L1, L2,

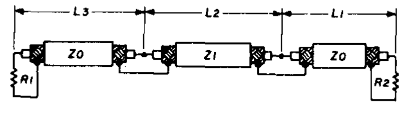

fig. 11. Coaxial matching transformer.

and the line to the transmitter. Length L1 and the line to the transmitter (which is any convenient length) have the same characteristic impedance, usually 75 ohms. Section L2 has a different impedance from L1 and the line to the transmitter, usually 75 ohms. Note that only standard, easily obtainable values of impedance are used here.

The design of this transformer involves finding the correct lengths for L1 and L2. You must know the characteristic impedance of the two lines (50 and 75 ohms given as examples) and the complex antenna impedance. In the case where the antenna is non-resonant, this impedance is of the form $Z = R \pm jX$, where R is the resistive portion, X is the reactive portion (inductive or capacitive) and j is the so-called "imaginary" operator, i.e., square root of -1. If the antenna is resonant, then $X = 0$, and the impedance is simply R.

The first chore in designing the transformer is to normalize the impedances:

$N = Z_{L1}/Z_o$
$R = R_L/Z_o$
$X = X_L/Z_o$

The lengths are determined in electrical degrees, and from that determination you can find length in feet or meters. If you adopt ARRL notation and define A = TAN (L1), and B = TAN (L2), then the following equations can be written:

If: $Z_L = R_L \pm jX_L$

$$TAN\ L2 = B = \pm\sqrt{\frac{(r-1)^2 + X^2}{r(N - (1/N)^2 - (r-1)^2 - X^2}} \quad (16)$$

$$TAN\ L1 = A = \frac{(N - (r/N)) \times B + X}{R + (XNB) - 1} \quad (17)$$

Where:
$N = Z1/Z_o$
$r = R_L/Z_o$
$Z = X_L/Z_o$

Constraints:
$Z1 > Z_o\ [VSWR]^{1/2}$
or, $Z1 < Z_o/[VSWR]^{1/2}$
If $L1 < 0$, then add 180 degrees
If $B < 0$, then Z1 is too close to Z_o
Z1 not equal to Z_o
$Z_o[VSWR]^{1/2} < Z1 < Z_o/[VSWR]^{1/2}$

Physical length in feet:
$L1' = L1\ \lambda/360$
$L2' = L2\ \lambda/360$
Where:

$$\lambda = \frac{984 \times Velocity\ Factor}{Frequency\ in\ Megahertz} \quad (18)$$

The physical length is determined from ARCTAN (A) and ARCTAN (B), divided by 360, and multiplied by the wavelength along the line and the velocity factor.

Although the sign of B may be selected as either + or −, the use of + is preferred because a shorter section is obtained. In the event that the sign of A turns out negative, add 180 degrees to the result.

There are constraints on the design of this transformer. For one thing, the impedances of the two sections L1 and L2 can't be too close together. In general, the following must obtain:

Either,
$Z_{L1} > Z_o \times SWR$
or, $Z_{L1} < Z_o/\ SWR$

ham radio

Analysis of
multi-element arrays;
all-driven-element design

the Quad antenna part 3, circular-loop and octagonal arrays

An array of two or more circular loops (like any other antenna) can have all elements driven, or some driven and the others self-excited, or parasitic. The special case of one driven element is sometimes called the Yagi-Uda configuration; this really applies only to the configuration of one parasitic reflector, a driven element, and one or more parasitic directors, all elements being dipoles.

Part 3 addresses circular-loop and octagonal arrays — initially with two elements, then with more. This is followed by a limited discussion of a particular all-driven-element design.

theory of two circular-loop arrays

The relationships between two circular loops, parallel and on a common axis, are shown in **fig. 1**. Compare this with the single-loop drawing in part 2, **fig. 1**. The important difference is that two loops contribute to the field, and in turn, to the induced currents. They have the same requirement that the component of the field along the wire be zero.

Computational complexity can be reduced if the current on each loop is assumed to be the sum of two currents, of the form:

I1 = Ia + Ib
I2 = Ia − Ib

Those with power-line engineering training will recognize this as a form of "symmetrical component" analysis used for multiphase power lines.

The assumed currents Ia and Ib are the same on both loops. This allows you to solve for the currents using Hallen's[2] method. Unfortunately, this simplification does not help much in practical calculation.

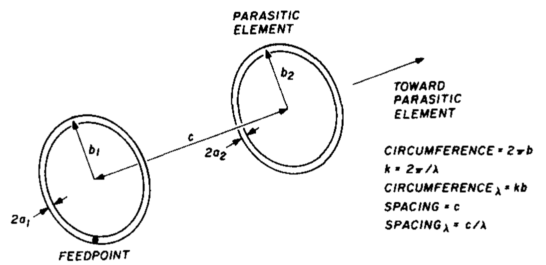

fig. 1. Geometry and nomenclature for a circular loop array. Two quantities are needed to describe each element, and another to specify the spacing, the letter C is used here. For octagons, an added descriptor for the number of sides is needed.

There is no easy way to use the ten curves prepared by Storer[1,3] to derive the currents on the two elements. Theory application is beyond practical small computer use; a large computer is needed. But a number of published results of this theoretical analysis can be applied to practical antennas. These will serve as the basis for some further analyses, for comparison, and also provide some data on the performance of practical designs.

the basic two-loop array

As with the Yagi, the two-loop array with one loop parasitically excited is both a useful antenna and the basis for further array expansion. Practically, these

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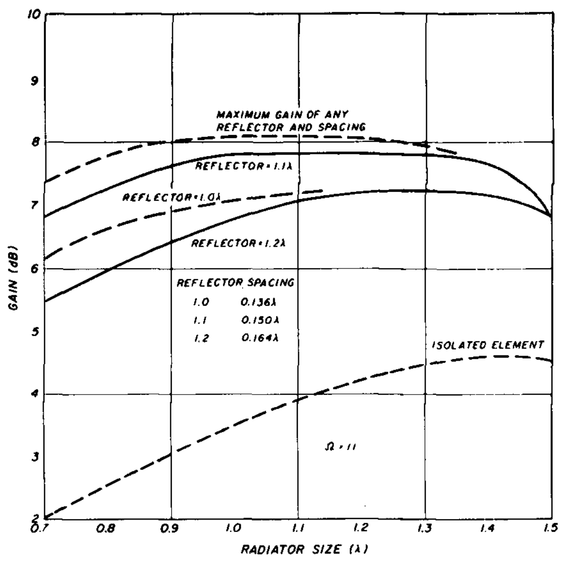

fig. 2. Forward-lobe gain for a reflector-radiator combination, plotted against size of radiator. Separate curves are shown for reflectors of 1.0, 1.1 and 1.2 wavelengths circumference. The top curve shows the maximum gain possible by choice of reflector size and spacing. Gain of an isolated element is shown for comparison. Data from Ito et al.[11]

two-element arrays give the largest increase in performance for a given investment in size and weight.

All the performance data on the designs described here are derived from Ito, Inagaki, and Sekiguchi[11]. Gain values are in dB above isotropic, unless otherwise noted.

gain performance

Figure 2 shows the forward gain performance with the parasitic element tuned as a reflector. The top curve shows the maximum gain with retuning; the nearly parallel curves show the gain for a specific parasitic element size.

For the two-element beam with reflector, the maximum gain is 8.1 dB. The gain is <3 to >5 dB higher than the gain of an isolated radiator of the same size. Over the range of radiator size from 1.0 to 1.25 wavelengths, the optimum gain varies only by 0.1 dB or so. Also, the gain does not vary greatly for changes in reflector size, typically by ±0.6 dB for a change from 1.1 to 1.3 wavelengths loop size. This means that the two-element loop with reflector is a good wideband antenna, with nearly constant forward gain over the wide frequency range of ±15 percent.

Forward gain performance with the parasitic element tuned as a director is shown in **fig. 3**. The top curve shows the maximum gain that can be developed for a given radiating loop size by tuning the director and choosing the best spacing. The nearly parallel curves give the gain for given sizes of the director. Also shown is the gain of a single isolated element.

The maximum two-element gain is 7.3 dB. This represents almost exactly a 3-dB increase over a single loop of the same size. This 3-dB increase is essentially independent of radiator size but is sensitive to director dimension.

The combination of nearly maximum gain and good gain stability led the developers of this data to recommend that the radiator loop be larger than resonant size. Their specific recommendation is 1.2 wavelengths circumference. Some consequences of this are discussed later.

The curves for a 1.2-wavelengths radiator in **figs. 4** and **5** are also useful. The variable for these curves is radiator-parasitic spacing in wavelengths.

As we have seen, maximum gain with the parasitic element as a reflector is 8.1 dB, and for the parasitic element as director it is 7.3 dB. These values show on the curves. Maximum reflector gain occurs at 1.08 wavelengths loop circumference at a spacing of 0.15 wavelength. Maximum director gain occurs at 0.95 loop circumference and a spacing of 0.1 wavelength.

Minimum back radiation with a reflector is −12.1 dB. This nearly occurs over the range of reflector sizes from 1.1 to 1.15 wavelengths circumference, and the range of spacing from 0.1 to 0.25 wavelength. Maximum front-to-back ratio occurs at a circumference of 1.1 wavelengths and a spacing around 0.1 wavelength. It is about 20 dB.

The data in part 1 shows that the optimum director size for minimum back radiation varies markedly with spacing. Minimum back radiation with the parasitic as a director is −3 dB, but this occurs for spacings around 0.6 wavelength, beyond the range of practical use. The forward gain is only 2 dB at this point. The practical minimum backlobe level is essentially 3 dB, occurring over the range 0.8-0.96 wavelength director circumference and a spacing of 0.1 wavelength. The front-to-back ratio is only 4 dB. A director of 0.9 wavelength circumference and 0.15 wavelength spacing will give nearly as good gain and front-to-back ratio.

These data show that the best design values for a two-element circular loop array, and for the radiator-reflector combination for larger arrays, are the same. Maximum performance is obtained from

- Radiator circumference, 1.2 wavelengths.
- Reflector circumference, 1.1 wavelengths.
- Element spacing, 0.15 wavelength.

Radiator circumferences from 1.1 to 1.3 wavelengths give nearly the same performance.

drive impedance

The drive impedance of an isolated loop is a complex

function of loop and conductor diameter. These factors apply with a parasitic element present plus the added complexity of the changes introduced by the currents on that element. Because of this there is very little data on feed impedances in scientific or engineering literature. It is necessary to use the limited amount available to develop trends and then depend on measurements to design the antenna feed. Fortunately this is not difficult, given the wideband characteristics of loop antennas.

The paper by Ito, et al.[11] includes a single set of curves that give useful information about the radiator-reflector combination. Data is for a reflector of 1.1 wavelengths circumference, with an element omega of 11, corresponding to a loop-to-conductor radius of 39. This is typical of a self-supporting UHF antenna.

The following values are developed from the curves; resonance, of course, means that the drive reactance is zero:

- Isolated resonant loop
  Radiator circumference = 1.1 wavelengths.
  Drive resistance = 153 ohms.
- Resonant radiator with reflector
  Radiator circumference = 1.08 wavelengths.
  Drive resistance = 139 ohms.
- Resonant radiator with director
  Radiator circumference = 0.87 wavelength.
  Drive resistance = 250 ohms.
- Isolated 1.2-wavelengths loop
  Drive resistance = 215 ohms.
  Drive reactance = 84 ohms.
- 1.2-wavelengths radiator with reflector
  Drive resistance = 158 ohms.
  Drive reactance = 365 ohms.
- 1.2-wavelengths radiator with director
  Drive resistance = 33.5 ohms.
  Drive reactance = − 132 ohms.

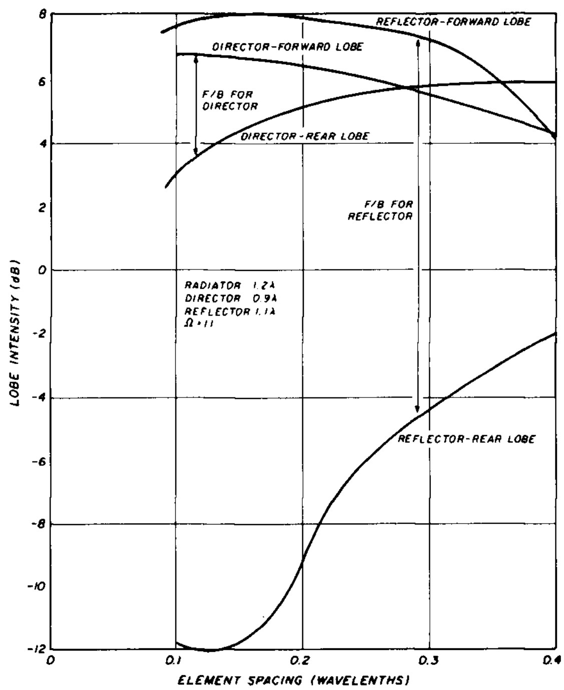

fig. 4. Forward and back lobe intensities for typical radiator-parasitic combinations, plotted against parasitic spacing. As usual for parasitic elements, maximum gain and maximum front-to-back ratio occur for different conditions. For two-element antennas, the reflector at 0.12 wavelength spacing is a good choice. Data from Ito et al.[11]

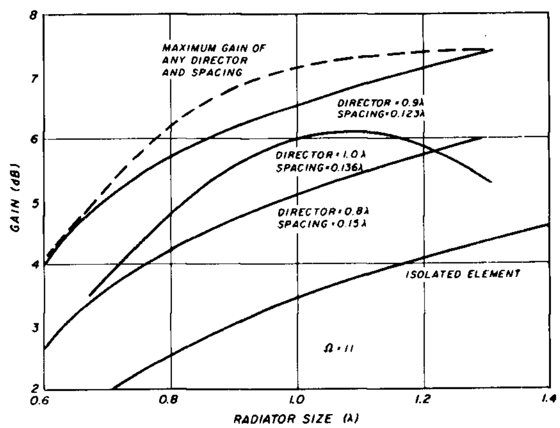

fig. 3. Forward-lobe gain for a director-radiator combination, plotted against radiator size. Separate curves are shown for directors 0.8, 0.9 and 1.0 wavelengths circumference. The top curve shows the maximum gain possible by choice of director size and spacing. Gain of an isolated element is shown for comparison. Data from Ito et al.[11]

The change in impedance is greater for the director and this behavior is much the same as for the two-element Yagi. The reason for the increase in drive resistance for the resonant element with director lies partly in the marked change in length needed to cancel the self- and induced reactances.

Remember that a standard method of matching is to change the length of the driven element, then add a stub to cancel the reactance, leaving the resistance at the value that matches the line impedance. You can also do this with loops, but it may require some loss in loop area and therefore loop gain. A gamma match, or stub-transformer sections, would be a better choice.

For most two-element arrays, a good feed is a 4:1 balun at the antenna, used with 50-ohm line. Solid-state transmitters will probably require a better match to obtain rated output, say by use of a transmatch. A possibility is a gamma match, used by at least one commercial design with good results. The simplest alternative is to use low-loss line, say 75-ohm Teflon™

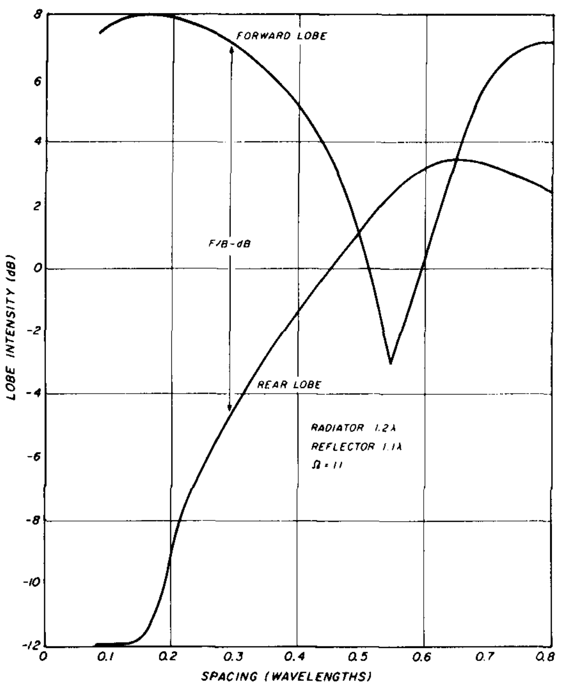

fig. 5. Forward and back-lobe intensities for a reflector-radiator combination over a wide range of spacings. With no change in element size, relative lobe intensities reverse around 0.6 wavelength spacing. Wider spacings can give fair forward lobe performance, but the back lobe remains large. Data from Ito et al.[11]

or foam, or 300-ohm twin lead, plus an appropriate transmatch. A transmatch is a necessity if you want the full advantage of the wideband loop characteristic.

patterns

There is a limited amount of theoretically derived pattern data in current literature. **Figure 6A-C** is replotted from the patterns in Ito et al.[11] which are similar to the corresponding patterns of two-element Yagi antennas[16]. The front-to-back ratio is reasonably good for reflectors in the 1.1-1.2 wavelengths circumference range. Directors of any size give poor front to back, although the forward gain is good, as described above.

None of the theoretical analyses found in the literature show patterns in other planes or for cross-polarization. These will be covered later by approximate analysis.

multi-element arrays

The theory above for two-element antennas has been used to examine the properties of multi-element circular-loop arrays, by Ito et al.[11] and by Shoamanesh and Shafai.[17,18] Experimental work has been reported by Appel-Hansen.[13] Their work is summarized in **figs. 7** and **8** and shows the gain versus array length. Also shown is the theoretical gain of Yagi antennas derived by Lawson.[19]

The gain for the usual Yagi is determined primarily by array length. The first few directors add about 1 dB per director. Thereafter, the gain increases about 3 dB for each doubling of array length.

Information in **table 1** is taken from Shoamanesh and Shafai's[17] theoretical table. All of the entries are for a director spacing of 0.3 wavelength. This gives maximum gain for the number of elements used, and reasonable front-to-back performance. Gain, expected drive impedance, and minor lobe characteristics plus front-to-back ratio are tabulated.

Arrays constructed from the table values should be

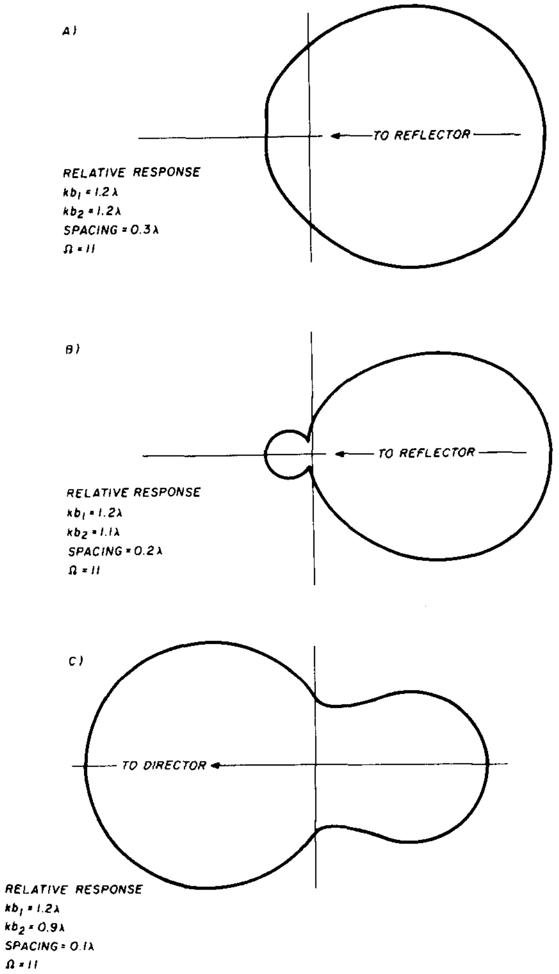

fig. 6. Horizontal plane patterns with horizontal polarization for three selected radiator-parasitic combinations. A and B show patterns with reflectors; C shows a pattern using a director. The front-to-back ratio of a reflector is good for a fairly wide range of conditions. While the director forward gain is also good over a fairly wide range, the front-to-back ratio is always poor. Patterns are scaled from a number plotted by Ito et al.[11]

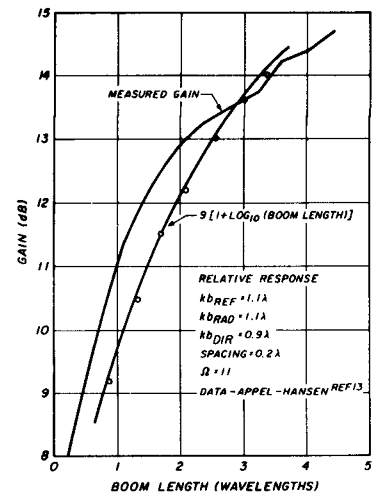

fig. 7. Measured gain of multi-element circular loop arrays, plotted against total boom length. Gain shown is not necessarily the maximum for the boom length given. The arbitrary curve is shown for comparison. Data from Appel-Hansen.[13] See also Lindsay.[12]

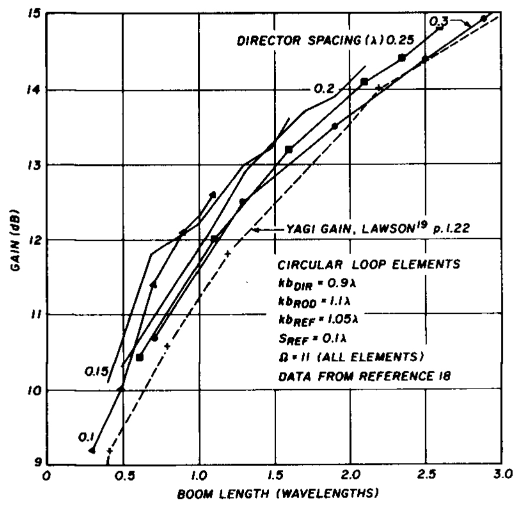

fig. 8. Calculated gain of multi-element circular loop arrays, plotted against boom length. Separate curves are shown for director spacings of 0.1, 0.15, 0.2, 0.25, and 0.3 wavelength spacing. For most boom lengths, a small increase in gain can be attained by using close spacing. There are penalities for this: for example, greater wind load, and usually, smaller bandwidth. Data from Shoamanesh and Shafai.[18]

easy to build in self-supporting form for frequencies in the VHF, UHF, and SHF ranges. By adopting the principle of the bicycle wheel, discussed in a later part of this series, you can build hf designs.

The design values in **table 1** are known to be near optimum for maximum performance. A small increase in gain may be obtained by making some changes in element size and spacing. Unfortunately, there may be appreciable change in minor lobe structure if much retuning is attempted.

The only theoretical data relating to the gain of multi-element circular-loop arrays comes from the same source,[17,18] and is summarized in **fig. 8.** This again shows gain versus boom length, but with individual curves for director spacing. A small but definite increase in gain is usually possible by adding directors, but the limit of improvement is not known. Retuning must be done carefully. Front-to-back ratios vary from about 10 to over 25 dB from one set of spacings to another, and there are probably changes in bandwidth as spacing changes. Shoamanesh and Shafai[17] give some guidelines for design optimization.

The data in Chapers 2 and 3 of Lawson[19] gives more information on results obtainable by optimization. Conversion of this data to loop design conditions is somewhat tedious. First calculate the self- and mutual reactances for the length and spacing data given by Lawson.[19] Then transform these values to loop size and spacing, using the curves and tables given in this series or the references. The basic computational proc-

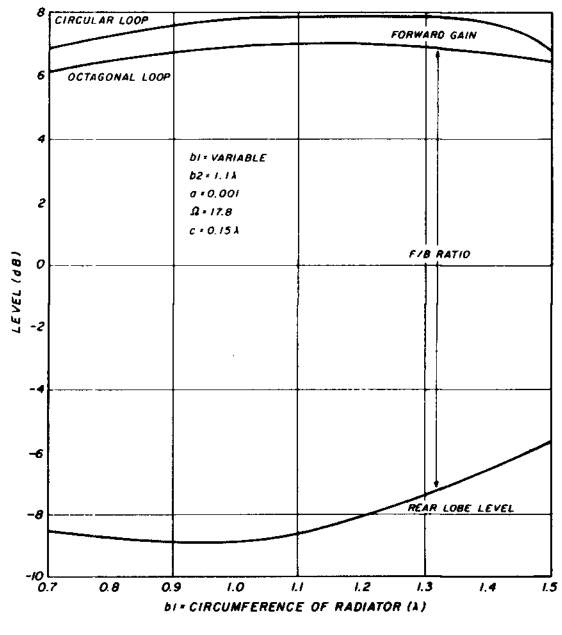

fig. 9. Calculated front and back lobe levels of an octagonal array, plotted against radiator circumference. Radiator circumference is 1.2 and spacing is 0.15 wavelength. The gain of a two-element circular loop is shown for comparison. The variation in gain would be more marked if the size of the reflector were also varied, but this shows again that loop antennas are broadband. The difference in circular and octagonal gain appears to be largely due to calculation technique differences.

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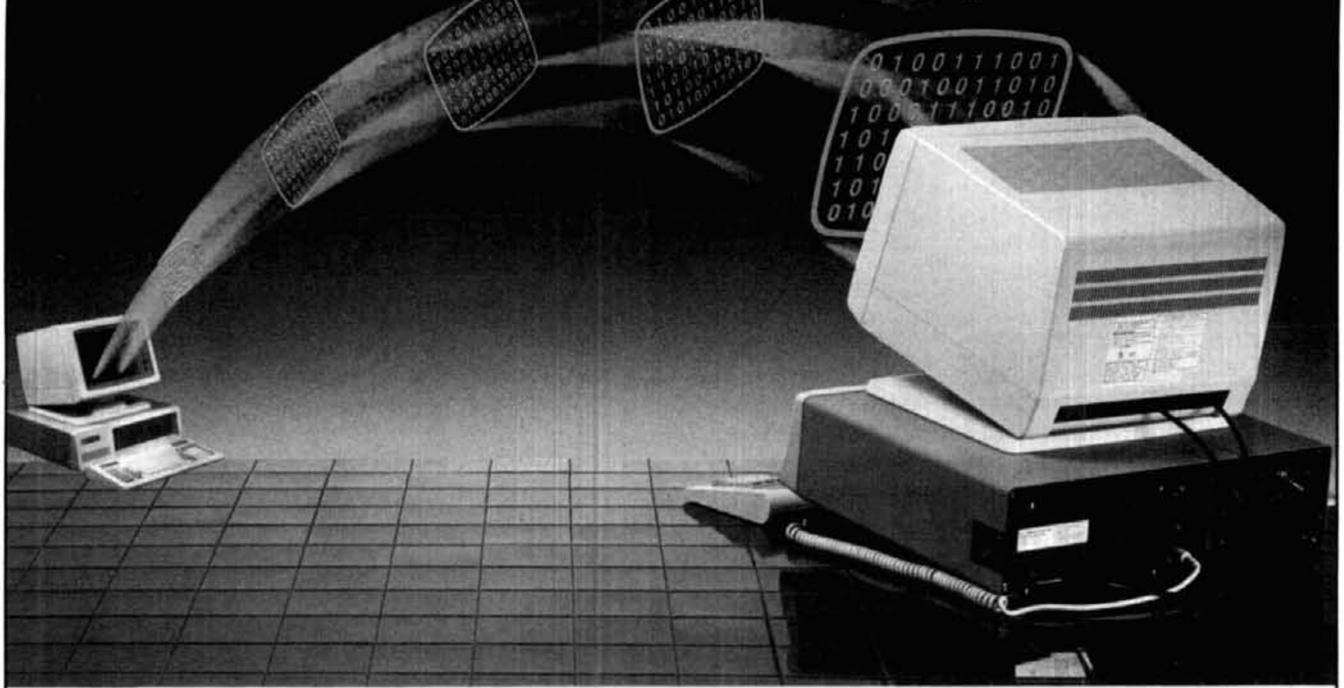

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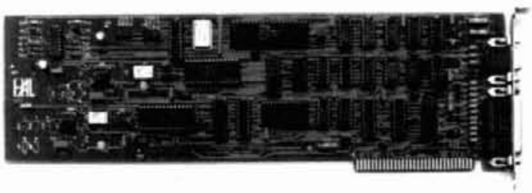

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Table 1. Calculated performance of multi- and circular-loop arrays.

no. directors	boom wave-lengths	gain (dB)	F/B (dB)	H-B/W (Deg)	E-B/W (Deg)	drive:R (Ohms)	drive:jx (Ohms)
2	.70	10.70	15.20	59.00	54.00	58.50	156.70
4	1.30	12.50	25.80	48.00	44.50	44.20	168.00
6	1.90	13.50	14.20	40.50	38.50	56.00	179.80
8	2.50	14.40	14.20	35.00	32.50	63.60	163.30
9	2.80	14.80	16.40	32.50	30.50	52.00	17.50
10	3.10	15.20	23.00	30.50	30.00	45.60	163.10

Reflector = 1.1, radiator = 1.2, and all directors = 0.9 wavelength circumference. Reflector is spaced 0.15 and directors 0.3 wavelength. The nine-director array needs no matching, the others only a capacitive stub across the feedpoint. A balun is not necessary, but is probably helpful in avoiding feedline and tower radiation.

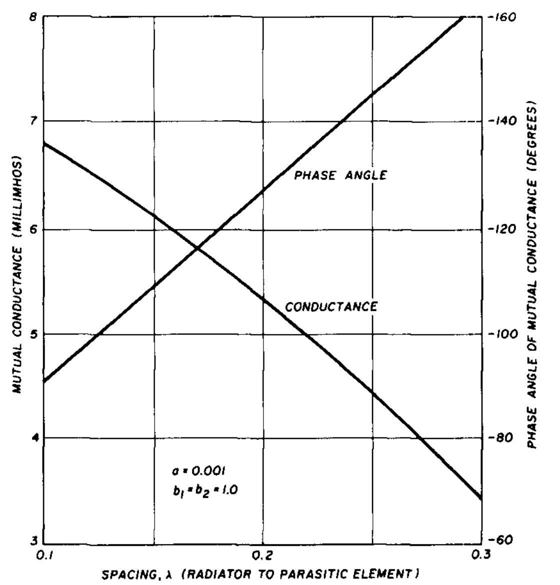


fig. 10. Mutual admittance of two octagonal loops, one wavelength in diameter. For wider separation, the magnitude of the admittance decreases nearly inversely with separation, and the phase linearly. These curves plus the self admittance data given in the second article of the series allow determination of array patterns by use of pattern multiplication techniques.

ess described in Lawson's Chapter 1[19] or in Kraus[20] can be modified for loop anaylsis.

octagonal arrays and loop approximations

Arrays of polygons are not common; circular elements are usually just as easy to build. There is also the matter of added resistance at the joints between segments, if present. The octagonal array data included here is primarily for use in approximating the performance of circular-loop arrays.

Figure 9 is for comparison and gives the gain and front-to-back ratio for a two-element octagonal array. It is very nearly the same as for the two-element circular array of **fig. 2**.

Figure 10 gives the mutual admittances between two 1.0-wavelength elements. Combined with the self-admittance values of **table 1**, these curves allow calculation of the currents in any multi-element array, and in turn the pattern as described by Kraus[20] and used by Lawson.[19] As mentioned above, these curves make the performance data calculated by Lawson[19] useful as an approximation to circular-loop (and other shape) arrays.

patterns of octagonal arrays

Figure 11 shows the MININEC-calculated horizontal-plane pattern of a two-element, bottom-fed array with a parasitic director — an array with nominally horizontal polarization. Radiator and director circumferences are 1.0 and 0.9 wavelengths, and spacing is 0.15 wavelength. The pattern resembles that of an equivalent two-element Yagi, which also shows poor front-to-back ratio. Somewhat more gain could be obtained with a larger radiator and closer spacing.

Figure 12 shows the same calculation for a 1.1-wavelengths reflector. Gain is nearly maximum from this element combination, and the back lobe is reasonably small. This appears to be a good choice for a two-element beam or for the exciter section of a large array.

Figure 13 shows the same calculation for a three-element octagonal array, with 0.9, 1.2, and 1.1 director, radiator and reflector circumferences, with the director spaced at 0.2 and the reflector at 0.15 wavelength. The gain is close to but below the maximum attainable with this boom length. The front-to-back ratio is reasonable. Experience with 2, 10, 15 and 20-meter versions of this combination indicates that better front to back, up to about 30 dB, is possible

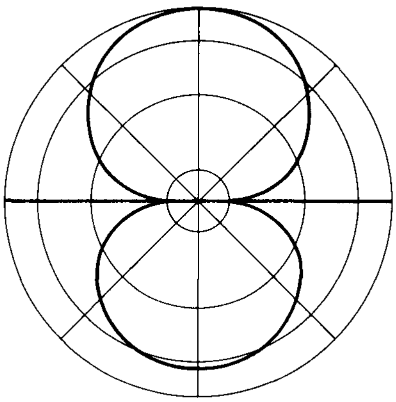


fig. 11. Horizontal plane pattern of the h-polarized component from a bottom-fed director-radiator combination. Circumferences are 0.9 and 1.0 wavelength. Spacing is 0.15 wavelength. Forward gain is reasonable, but the back lobe is large.

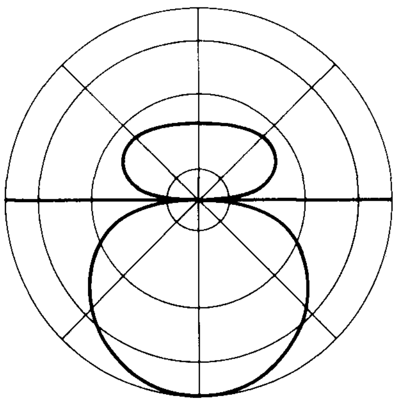


fig. 12. Horizontal plane pattern of a 1.1 wavelength reflector-radiator combination. Other conditions same as in fig. 11. Forward gain is excellent for a two-element antenna. The front-to-back ratio of about 13 dB is good.

with element tuning. **Figure 8** shows that the gain could be increased about 1 dB by a second director at 0.1-wavelength spacing.

Figure 14 shows another pattern for the same beam for the total radiation component. Because of the small cross-polarized component present in loops, the sides of the pattern are filled in, so the front-to-side ratio is poor.

It is my experience that the filled-in pattern is correct for high-angle or E-layer radiation. However, low-angle radiation, typical of F2-layer DX, shows the high front-to-side discrimination of **fig. 13**. Under good conditions, an S9+ signal can be dropped to the noise level if the signal is placed on the 90-degree null. This results in a reduction of 40 dB or more. The same characteristic is noted on 15 meters when E-layer skip is present. Published theoretical analyses shed no light on this performance difference. It appears to be associated with ground reflection. We will return to this subject later in this series.

all-driven arrays

As with dipole elements, loops can be used in driven arrays. Driven arrays are not common in Amateur use because of space requirements. The few occasionally encountered are typically two-element designs. These are also used in place of a single radiator element in some high-performance arrays, partly for gain and front-to-back improvement, but also to improve the effective bandwidth.

Figure 15 shows the MININEC-calculated gain for two 1.0-wavelength loops spaced 0.12 wavelength,

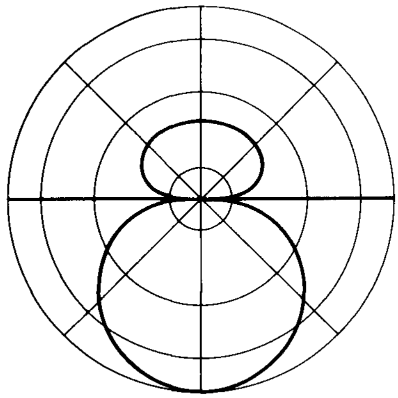


fig. 13. Horizontal plane pattern of a bottom-fed, three-element octagonal array. Circumferences are director = 0.9, radiator = 1.2 and reflector = 1.1 wavelengths. Director spacing is 0.2 and reflector 0.15 wavelength.

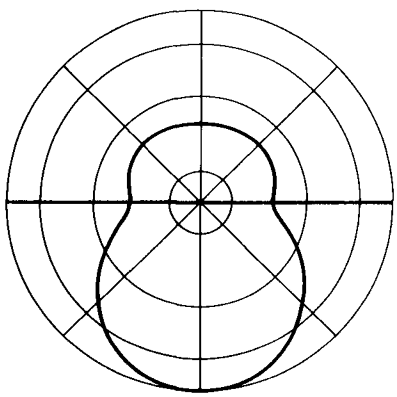


fig. 14. Total component radiation pattern for the array of fig. 13. The vertical component fills in the side-lobe area. See text for practical experience with an antenna of this type.

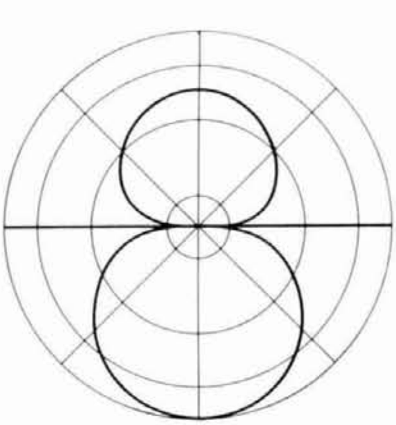


fig. 15. Horizontal component pattern for two one-wavelength loops separated 0.12 wavelength and bottom fed 135 degrees out of phase. The antenna is related to the "ZL-Special", and is useful by itself. The technique is also useful as the feed of large arrays, to give better front-to-back and gain.

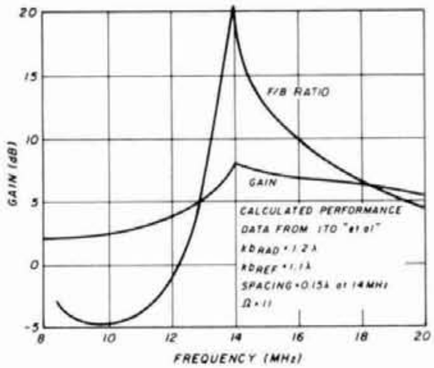


fig. 16. Calculated gain and front-to-back ratio of a two-element array designed for 14 MHz, but operated over the range 8-22 MHz. Forward lobe gain exceeds that of a dipole over the entire range. The back lobe can even be larger than the main lobe, but effective interference reduction is usually possible by rotating the antenna to place the interference in a null. Any antenna of the Quad family is a useful wide-band antenna for occasional operation on other than designated bands. Based on data from Ito et al.[11]

and fed 135 degrees out of phase, like the "ZL-Special" antenna. The gain performance is good, but the back lobe is rather large. Antennas of this type will be studied further when we discuss rectangular loops.

super-wideband operation

Figure 16 shows the calculated performance of a 20-meter two-element array from 8.5 to 20 MHz. The gain curve shows that this parameter exceeds that of a dipole over the entire range. In fact, the performance is reasonable over 7 to 30 MHz, although there is lobe splitting on the higher bands, and main-lobe reversal on the lower ones. Front-to-back ratio is high only near the design frequency, however.

The secret of using this wide bandwidth lies in the transmission-line matching technique used. I prefer Teflon-insulated 75-ohm cable. Open-wire line or twin lead is also good. A matchbox is a necessity. (I think that a matchbox should always be used to simplify using the entire band and to reduce harmonic radiation.) One fact seems clear: if you are using a Quad, you can have multiband operation without a lot of real estate for an antenna farm.

Part 4 deals with the square or Quad loop and some of its close relatives.

references

16. F.E. Terman, *Radio Engineers' Handbook*, McGraw-Hill, New York, 1943 (any edition).

17. A. Shoamanesh and L. Shafai, "Properties of Coaxial Yagi Loop Arrays," IEEE Transactions Antenna Propagation, July 1978.

18. A. Shoamanesh and L. Shafai, "Design Data for Coaxial Yagi Array of Circular Loops," IEEE Transactions Antenna Propagation, September 1979.

19. James L. Lawson, *Yagi Antenna Design*, ARRL, Newington, Connecticut, 1986.

20. John D. Kraus, *Antennas*, McGraw-Hill, New York, 1950.

*References 1-15 are found in part 1.

ham radio

NEW products

high-speed frequency entry for Kenwood transceivers

Kenwood rigs now feature the KW-QSY frequency-entry keypad. The QSYers provide a means for high speed and simple frequency selection.

The QSYer is a tiny computer terminal with its own internal 8-bit microprocessor and support circuitry. Its full-size telephone-type keypad is inclined at a 10 degree angle. The unit is housed in an all-metal enclosure measuring 3.1" x 3.5" x 2" and has an internal speaker that sounds a different tone for each key.

The KW-QSYer works with the TS-940 series (with the Kenwood IF-10B interface installed), TS-440 series (with IC-10 installed), TS-140 series (with IF-10C installed), and TS-711/811 series (with IF-10A installed). It requires an 8-16 volt, 100 mA, external dc supply.

The KW-QSYer (and its sister models for the 757GX, 757GX-II, 767GX, and the IC-735) are available from Stone Mountain Engineering Company. All are priced at $89.50, plus $2.50 shipping. A companion 12-volt dc wall supply for the KW-QSYer is $10. For more information write to Stone Mountain Engineering Company, P.O. Box 1573, Stone Mountain, Georgia 30086.

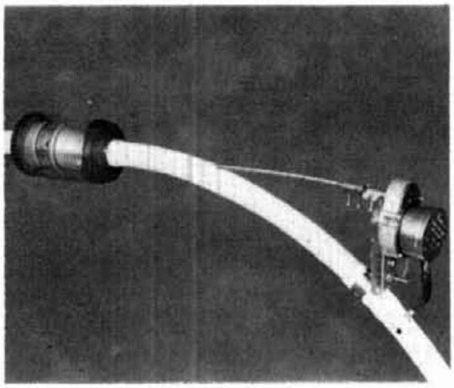
Circle #301 on Reader Service Card.

new twist to old antenna concept

DMQ offeres an antenna designed to cover all frequencies between 13 MHz and 30 MHz, while maintaining a better then 2.1 SWR and handling up to 250 watts P.E.P. Targeted at the Amateur with limited space, it is a loop standing on end with an approximate diameter of 36 inches. The antenna is connected through a standard SO 239 fitting directly to your 52-ohm coax transmission line. No external matching unit, pretuned coax line, ground screen, or radial system is needed.

Frequency resonance is obtained by adjusting a special high-voltage vacuum variable capacitor. The antenna is made of high quality copper; the vacuum variable capacitor is a glass-type design. All metal surfaces are chemically cleaned and covered with two coats of exterior enamel paint.

The antenna has a bidirectional radiation pattern. The high-Q design is stable to frequency and provides a high level of harmonic suppression. Pattern gain is developed throughout the antenna's frequency range.



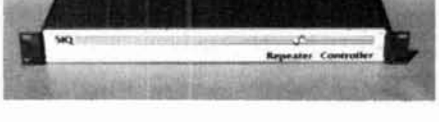
The antenna has a mounting hook, nylon line, and tuning wand supplied. The antenna can be suspended from the ceiling of the Amateur's apartment; outdoor installations are also feasible.

The antenna comes assembled and ready for use. It is factory adjusted for the 15-meter Novice portion of the band. The unit price is $349.50, plus shipping and handling in the continental U.S. For information contact DMQ Technology, 221 Slater Boulevard, Staten Island, New York 10305.

Circle #302 on Reader Service Card.

SIQ repeater controller

A-Tech Electronics announces the SIQ Repeater controller. Using the power of a microcomputer, the SIQ-2 provides basic repeater functions, voice ID, programmable Morse code ID, autopatch, reverse autopatch, audio mixing, linking, and more.



The SIQ controller comes with an rf-proof rack mount box and all 16 I/O lines have rf beads to prevent rf problems. The manual contains detailed information on connecting your radios, programming the features, and user commands. The software listing is provided for making custom modifications.

An optional phone patch board is available. Up to five area codes can be programmed to help control long distance access.

The features are controlled by touch-tone commands. Courtesy tones, tail squelch length, CW ID, sleep/wake up mode, alarms, and other control commands are all remotely programmable. Sixteen I/O lines are provided.

The SIQ rack mount steel enclosure has D-style connectors. The user manual contains hookup and command instructions, an electronic schematic of the system, and source code listing.

The SIQ repeater controller retails for $349.95; the SIQ with phone patch is $449.95. Contact A-Tech Electronics, 1033 Hollywood Way, Burbank, California 91505 for more information.

Circle #303 on Reader Service Card.

new code and theory course audio cassettes

Amateur Radio School announces the addition of "The Video Novice" to their line of code and theory courses on audio cassettes.

The course material contains two VHS video cassettes, each two hours in length, one C90 audio cassette, and a manual study guide. Cassette No. 1 has two hours of theory; cassette No. 2 has one hour of theory and one hour of visual code class.

The course is aimed at the person who has limited understanding of electronics. It covers all the subjects that the person new to amateur radio needs to know with practical demonstrations and explanation. The Video Novice Course is just $39.95 plus $5.00 for postage and handling.

For more information, write to Jerry Ziliak, KB6MT, Amateur Radio School, 2350 Rosalia Drive, Fullerton, California 92635.

Circle #304 on Reader Service Card.

Others May Try to Imitate, But...

Only One Can Be The Best

Morse Code - Baudot - ASCII - AMTOR - Packet - Facsimile - Navtex

Amateur Net Price $319.95

It's a lesson you learn very early in life. Many can be good, some may be better, but only one can be the best. The PK-232 is the best multi-mode data controller you can buy.

1 Versatility

The PK-232 should be listed in the amateur radio dictionary under the word Versatile. One data controller that can transmit and receive in six digital modes, and can be used with almost every computer or data terminal. You can even monitor Navtex, the new marine weather and navigational system. Don't forget two radio ports for both VHF and HF, and a no compromise VHF/HF/CW internal modem with an eight pole bandpass filter followed by a limiter discriminator with automatic threshold control.

The internal decoding program (SIAM(tm)) feature can even identify different types of signals for you, including some simple types of RTTY encryption. The only software your computer needs is a terminal program.

PC Pakratt Packet TX/RX Display

Facsimile Screen Display

2 Software Support

While you can use most modem or communications programs with the PK-232, AEA has two very special packages available exclusively for the PK-232....PC Pakratt with Fax for IBM PC and compatible computers, and Com Pakratt with Fax for the Commodore 64 and 128.

Each package includes a terminal program with split screen display, QSO buffer, disk storage of received data, and printer operation, and a second program for transmission/reception and screen display of facsimile signals. The IBM programs are on 5-1/4" disk and the Commodore programs are plug-in ROM cartridges.

3 Proven Winner

No matter what computer or terminal you plan to use, the PK-232 is the best choice for a multi-mode data controller. Over 20,000 amateurs around the world have on-air tested the PK-232 for you. They, along with most major U.S. amateur magazines, have reviewed the PK-232 and found it to be a good value and excellent addition to the ham station.

No other multi-mode controller offers the features and performance of the PK-232. Don't be fooled by imitations. Ask your friends, or call the local amateur radio store. We're confident the PK-232 reputation will convince you that it's time to order your very own PK-232.

Call an authorized AEA dealer today. You deserve the best you can buy, you deserve the PK-232.

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Join thousands of VHF/UHF pioneers already scanning the cosmos with their FT-736Rs. The most complete, feature-packed rigs ever designed for the serious operator.

Versatile frequency coverage. The FT-736R comes factory equipped for 2 meters and 70 cm (430-450 MHz), with two additional slots for optional 50 MHz, 220 MHz, or 1.2 GHz modules.

Multimode facilities. Every FT-736R is equipped for LSB, USB, CW, and FM operation. Wide/narrow filters for both FM and CW are factory installed—not expensive options. There's even all-mode squelch, too!

Satellite ready. A truly turn-key satellite rig, the FT-736R includes crossband full duplex capability. Plus VFO tracking for one knob tuning on both normal and inverted transponders. And with the optional 1.2 GHz module installed, you're QRV on Modes B, J, L, and JL. *With one box.*

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Operate Fast-Scan TV! Install the optional TV-736 and 1.2 GHz modules, and you're ready to operate fast-scan double-sideband TV with FM audio subcarrier. Black-and-white or color!

Contester's dream! Versatility is a must in VHF contests, as openings are brief. For quick activity checks, use the separate "channel" selector for a speedy trip up the band in selectable steps (SSB *or* FM!). Use the two

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Prices and specifications subject to change without notice. FT-736R shown with 220 MHz option installed.

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Discover the FT-736R at your Yaesu dealer today. But first make plenty of room for exotic QSL cards. Because the ultimate DX is out there. And you *never* know who's listening.

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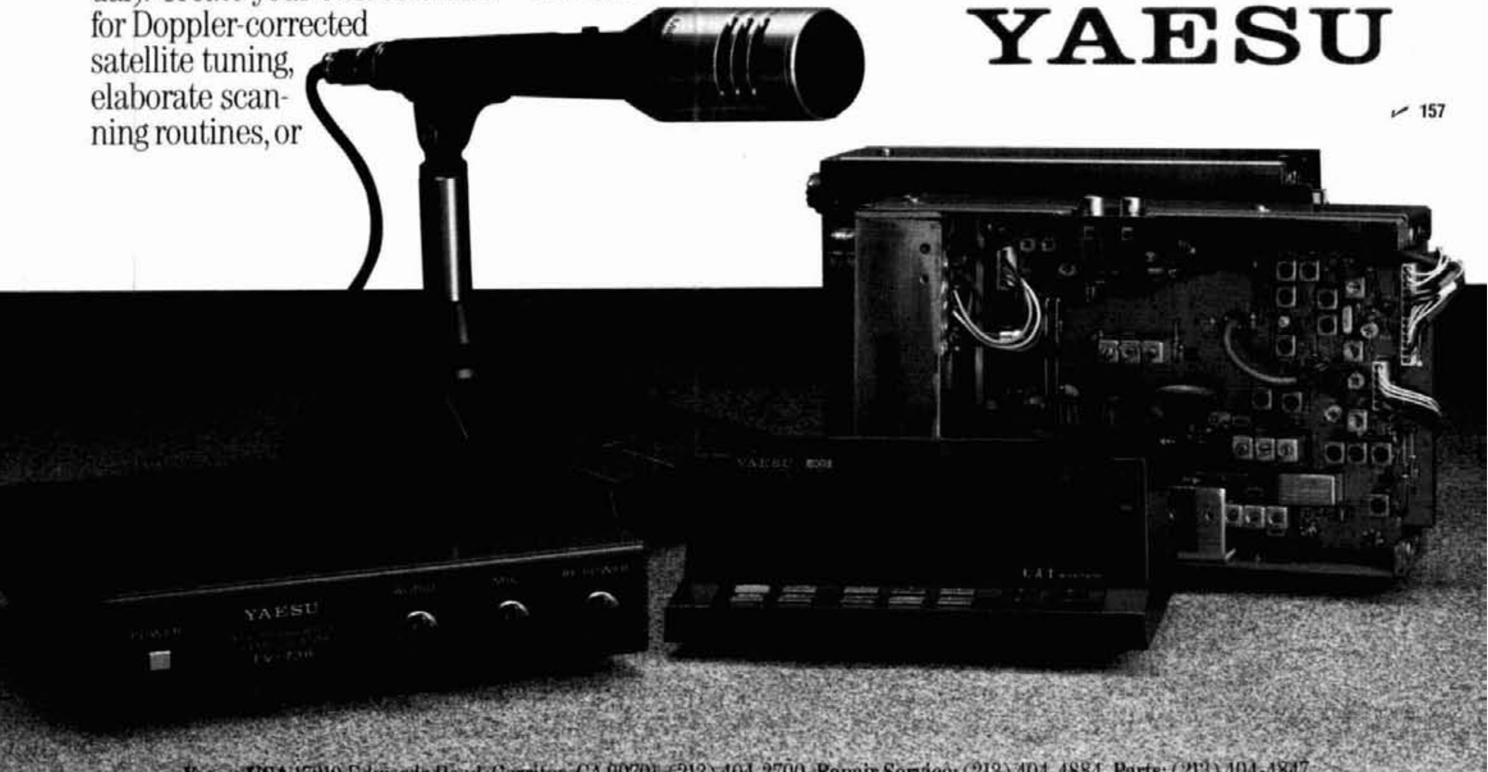

Yaesu USA 17210 Edwards Road, Cerritos, CA 90701 (213) 404-2700. **Repair Service:** (213) 404-4884. **Parts:** (213) 404-4847.

NEW products

new 2-meter mobiles from ICOM

ICOM has introduced the IC-228A, 25 watt, and IC-228H, 45 watt, 2-meter top-of-the-line mobiles. These compact models (5.5" wide by 2.0" high by 5.4" deep and 6.2" deep, respectively) have 13 front-panel controls for ease of operation. Both feature wideband Rx coverage of 138-174 MHz; Tx coverage is 140-150 MHz. Twenty memory channels with a lock-out function store the frequency. It has offset and subaudible tone for each memory. Both models feature programmable scan and memory scan, priority watch to monitor the call channel, a memory channel, or all memory channels every five seconds while operating on another frequency.

An optional UT-40 squelch unit emits a 30-second alarm when the frequency of a received tone equals the set tone frequency.

The suggested retail price of 25-watt IC-228A is $509.00; the 45-watt IC228H is $539.00.

For more information contact ICOM America, Inc., 2380 116th Avenue, N.E., P.O. Box C-90029, Bellevue, Washington 98009-9029.

Circle #309 on Reader Service Card.

tools for coaxial users

Mouser Electronics offers a Simplex Coaxial Cable Stripper, Crimping Tool, and a Strip'n Crimp Tool Kit for working with coaxial cable.

The cable stripper is 3.5" long and can strip most coaxial cable from 3.6 mm to 7.6 mm. It comes with three-bladed preset cassette providing up to 5000 strips per cassette. Use the stripper for precision cutting through sheath, braid, and dielectric simultaneously or separately. Ask for Part No. ME382-CS1/3CBR.

The crimping tool is made of heavy gauge material. It has a controlled cycle mechanism for complete crimp, dual apertures for greater cable range, and a built-in release catch. This tool, Part No. ME382-DC89, comes with instructions.

The Strip'n Crimp Coaxial Tool Kit is a complete tool kit for coaxial users. Each kit contains a dual crimping tool, simplex cable stripper, ten plugs and cable sleeves for the following sizes; RG59, RG62, UR90, URM43, URM90, URM96, or 0.6/3.7 cables. Instructions are included with the kit. Ask for Part No. ME382-SNC5859.

A complete catalog is available free of charge. Contact Mouser Electronics, 2401 Highway 287 North, Mansfield, Texas 76063.

Circle #305 on Reader Service Card.

VR-1 voltage reference

The VR-1 is the latest product in the Sibex line of portable test equipment. The handheld precision voltage source is battery powered, and output is selectable from 10 mV to 10 V, in a 1-2-5 sequence, by the 11-position switch. Both + and − voltages are available at the output terminals. A low battery indicator is provided on the front panel. The unit is housed in a pocket-size plastic case; power is supplied by a standard 9-volt battery inside the case.

Units are available from stock and priced at $89.95. For information contact Sibex, Inc., 1088 Kapp Drive, Clearwater, Florida 34625.

Circle #306 on Reader Service Card.

AR-80LM logic monitor

American Reliance has added the AR-80LM logic monitor to their logic measurement product line.

The custom-IC design provides autodetection of both power and ground pins, making instrument usage an easy, clip-on-and-view operation. The unit also autodetects both TTL and CMOS logic levels.

The unit provides indications for logic high, low, and pulsing inputs. For pulses with repetition rates over 8 Hz, the unit flashes the LED at an 8 Hz rate. This allows use of the unit at clock rates of up to 40 MHz.

The AR-80LM sells for a suggested user price of $79 and includes a storage case and operator's manual. For details contact ARI Media, 9241 E. Valley Boulevard, Suite 201, Rosemead, California 91770.

Circle #307 on Reader Service Card.

new mobile amplifiers and repeater controller

RF Concepts has two new all-mode solid-state rf power amplifiers and a new repeater controller.

UHF amplifiers are: model RFC 4-310, 30 watts in = 100 watts out, maximum input 35 watts; and RFC 4-110, 10 watts in = 100 watts out, maximum input 15 watts. Both use a GaAsFET receive pre-amp with 15-dB gain and a noise figure of 1.75 dB. They require 13.8 VDC, current, 25 ampere. Measurements are 11.5"L x 6"W x 3"H. The RFC 4-310 is priced at $324 and the RFC 4-110 is $349.

The repeater controller RFC 8-RC has a control system capable of handling all the requirements for large multiple-site interconnected systems as well as the simple repeater. The list price is $395.

RF Concepts products can be purchased from Amateur Radio dealers. For details contact RF Concepts, 2000 Humbolt Street, Reno, Nevada 89509.

Circle #308 on Reader Service Card.

Genius at Riverhead

Genius at Riverhead is the story of Harold H. Beverage, developer of the "Beverage Antenna".

This biography tells of Harold's travels and work with many of the leaders in the field of wireless and related sciences.

The 130-page book, with 35 photos, is available through the *ham radio* Bookstore for $15.95 plus $3.50 for shipping and handling.

remote base/simplex phone patch controller

Control your station locally or from a distance

The terrain in my northern Alabama location is hilly and a large mountain blocks most of the targeted coverage area for 2 meters limiting my QSOs. I explored several solutions to the problem, including placing a repeater on a mountain top, and finally decided to use a box hooked to a simplex radio that can be remotely located and controlled from a standard touchtone telephone.

The box can be connected either to the Public Switched Telephone Network (PSTN) as in **fig. 1**, or at a local level with the circuit shown in **fig. 2**. It requires only the telephone and a few extra components. The station can be located in the garage, with the telephone the only radio "apparatus" in the family room. Add a speaker phone for general monitoring and use the handset for private conversation.

making it secure

After completing the hardware design, I addressed the issue of security. Could I limit transmitter access to ham operators only and maintain a reasonable amount of control during operations involving non-hams?

I solved the first problem by using an access code to activate the transmitter. To control operations involving non-hams, I decided to limit all communications from the telephone line to a 30 second maximum transmission time. If the telephone line carrier keeps the transmitter on past this time, the transmitter drops out and allows no further transmissions from the telephone until the box receives instructions from the control operator.

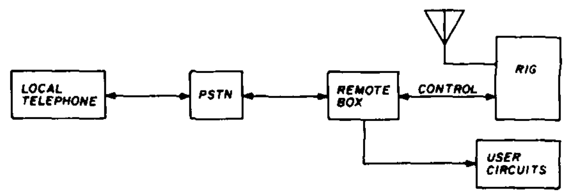

fig. 1. PSTN operating mode diagram.

operation

Begin operation by calling the remote unit from a remote telephone. After the selected number of rings you will hear the remote unit activate. You are now in the receive or monitor mode. Always listen for traffic already in progress before transmitting.

To transmit, enter your access code then press the # key and then the 9 key. After transmitting, depress the 9 key and the transmitter will deactivate. To transmit again, you need only hit the 9 key.

Terminate the call by hanging up or hitting the #; the remote unit automatically shuts down. Time-out timers allow transmissions of only 30 seconds or less.

Once the access code is entered, you can go into vox mode at the remote site by entering # and 0. The transmitter keys whenever you speak into the telephone. If the transmitter is keyed for longer than the allowed time, the remote unit will deactivate it and prevent further transmissions until the carrier from the telephone drops out and instructions are received from the control operator. To exit this mode enter # and

By Roger Owens, AA4NX and **Jeff Owens, KK4LA**, P.O. Box 277, Owens Cross Roads, Alabama 35763

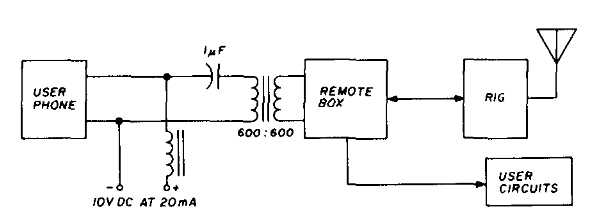

fig. 2. Private line operating mode diagram.

0 from the local site. This returns the remote to monitor mode.

status indicators

Several indicators built into the software routines determine the status of the remote unit:

- CD—Main carrier detect.
- RADCD—Carrier detected is from the radio receiver.
- TELECD—Carrier detected is from the telephone line.
- OH—Remote unit is in the off-hook condition.
- PTT—Remote unit has the transmitter keyed.
- ACCESS—Remote unit has accepted access code.

Table 1 lists commands which activate specific output port pins. They are used to turn on NPN switching transistors that drive external control relays. These relays in turn activate additional functions through touchtones (DTMF) from a telephone or radio.

Mobile operation requires a touchtone generator. To call, enter your access code then send the * and 0 command to the remote unit. This takes the unit off hook and keys the transmitter for 3 seconds to acknowledge the dial tone. When the transmitter drops out, dial your number, listen for ring back and wait for an answer. The remote unit automatically goes into the vox mode. The operator has control of the remote unit and can terminate the call. Calls are limited to 3 minutes; all long distance calls are prevented.

digital circuitry

A microprocessor reduces the number of components (see the block diagram in **fig. 3** and circuit in **fig. 4**). I used the 80C31 because of its timers, onboard RAM, interrupt structure, and special function registers. The 80C31 also has various op-code instructions which operate on internal and external bytes and bits for programming ease.

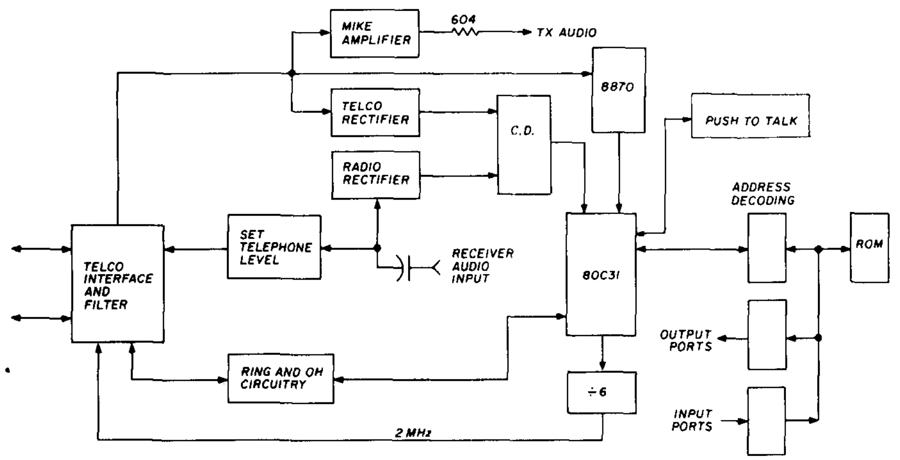

fig. 3. Functional block diagram.

Table 1. User defined port definitions.

	Output bit-function	Output bit-function
Port A		
	1—TELCAR	5—SPARE
	2—RADCAR	6—SPARE
	3—PTT	7—SPARE
	4—OH	8—SPARE
Port B	**Output bit-function**	**Output bit-function**
	1—#1	5—#5
	2—#2	6—#6
	3—#3	7—#7
	4—#4	8—#8
	(User defined)	

The microprocessor is configured as follows: Port 0 is used as a multiplexed port in conjunction with the 74HCT373 eight-bit latch to separate the lower order address from data. This occurs each time address latch

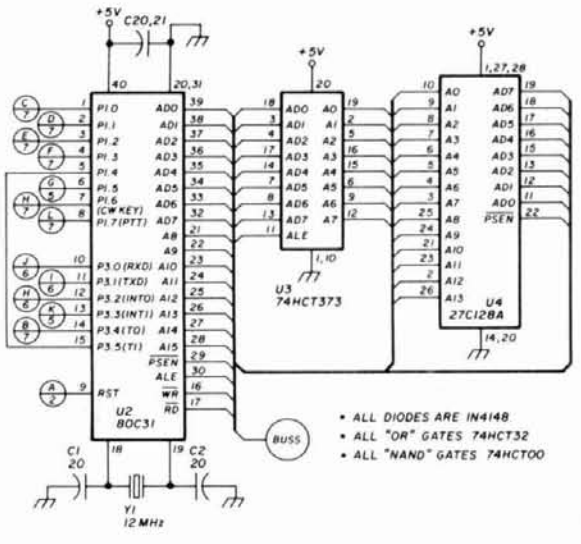

fig. 4. "Brain" of controller is 80C31 microprocessor.

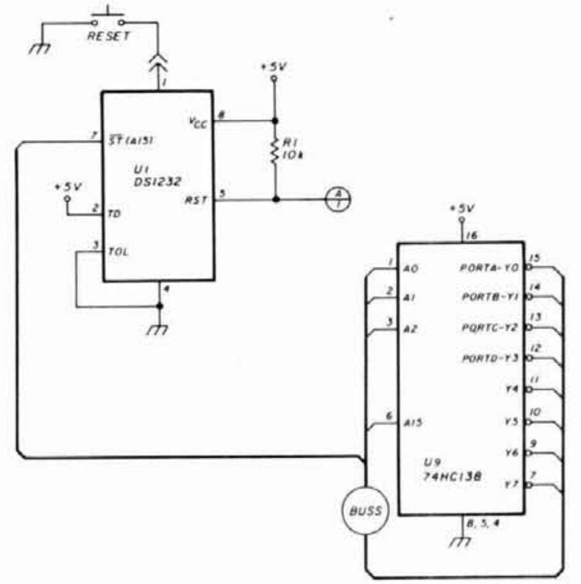

fig. 5. Dallas Semiconductor DS1232 is used as reset and watch dog timer.

enable (ALE) goes high. Port 2 serves as the higher order program address lines.

I selected this microprocessor, driven by a 12-MHz crystal, for its proper timer operation (which I will describe later). Port 1 serves as both the input and output port for the system. Port 1 bits, 0 through 3, are used as input data from the DTMF receiver. Port 1 bit 4 is used for an output pin for the 1-kHz clock, generated by the real-time clock routine in the software.

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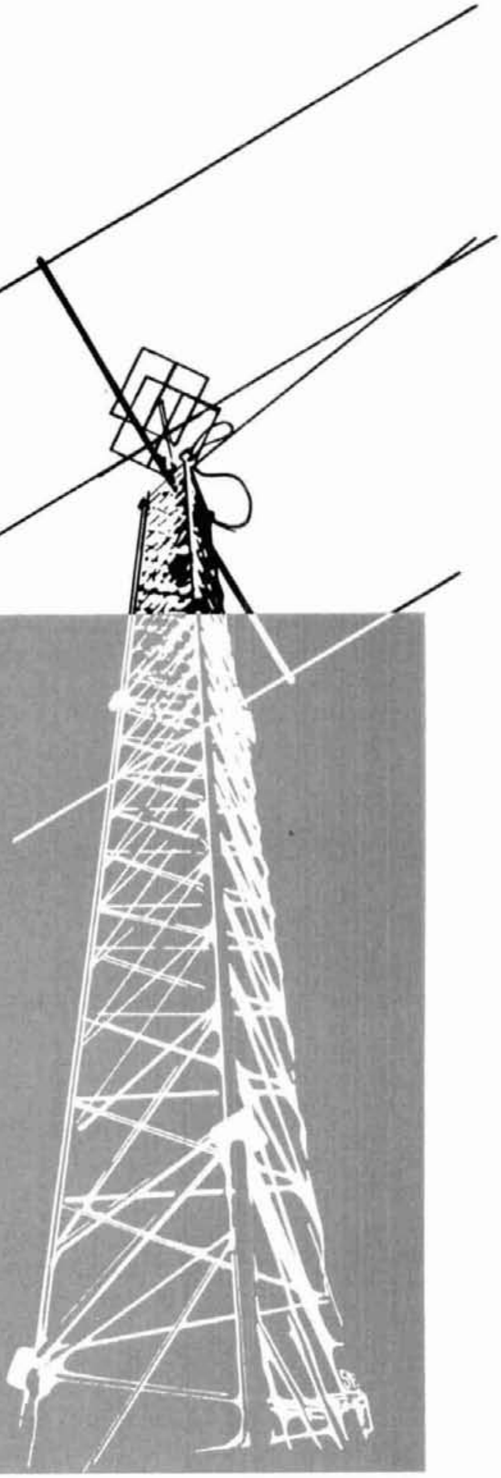

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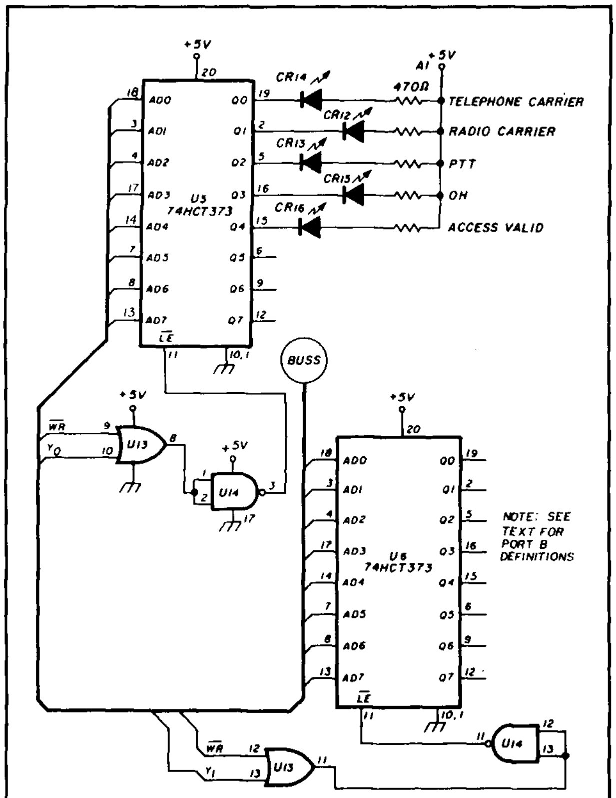

fig. 6. Eight bit latches are used for input and output ports.

Port 1 bit 5 is used as an output control pin to make the off-hook (OH) relay active. This signal is generated when the unit is in private line (no dc), has detected the correct amount of ring cycles, or senses telephone line current. The tone generator is used for warning beeps and CW signal; Port 1 bit 6 is used to turn it on and off. Port 1 bit 7 is used as the push-to-talk (PTT) signal to the radio transmitter whenever a transmission is requested.

Port 3 provides the system's interrupt scheme. Input pin 2 is an edge-triggered interrupt used for main carrier detection. Input pin 0, in conjunction with the main carrier detect bit, tells the microprocessor that the carrier is from the telephone lines. Input pin 1, along with the main carrier detect bit, tells the microprocessor that the carrier is from the radio.

Input Port 1 pin 3 is an edge-triggered interrupt that indicates the presence of a ring signal or telephone off-hook current.

Input Port 1 pin 4 tells the microprocessor that the carrier is a valid DTMF signal.

Input Port 1 pin 5, the input to a timer interrupt, generates a 1-second interrupt to drive the time-out timers and long delays. The remaining bits of Port 3 generate the system read and write signals.

The microprocessor reset is input on pin 9. A Dallas Semiconductor DS1232 is used as the reset and watchdog timer in this system. To prevent a reset signal from being generated, this reset circuit (**fig. 5**) must be written to by software at a periodic rate. A reset signal is also generated if the power drops below a predetermined level. This chip can save you trips to your remote site, but is not necessary for this application. A simple RC network can also be used to generate a reset signal on power-up.

The program memory used is a 16K x 8 EPROM (27C128A), as seen in **fig. 3**, chosen to allow for expansion.

I needed extra input and output ports to provide for the input and output of control signals. The 74HCT138 is used to decode external addresses for these ports. Only four ports are used; four more are held in reserve for expansion. All input and output ports (see **fig. 6**) use an eight-bit latch (74HCT373). Ports A and B are used for output; Ports C and D are for input.

The write signal for the output ports (see **fig. 7**) is generated by the selection of an address, NOR'ed with the system write signal. This scheme is used for all

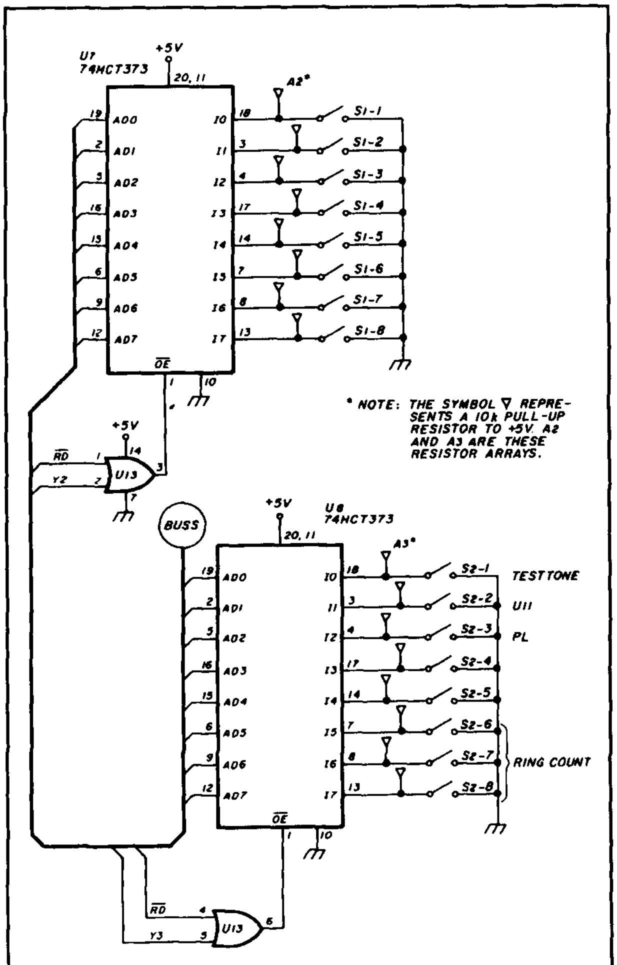

fig. 7. User option inputs are determined switch settings.

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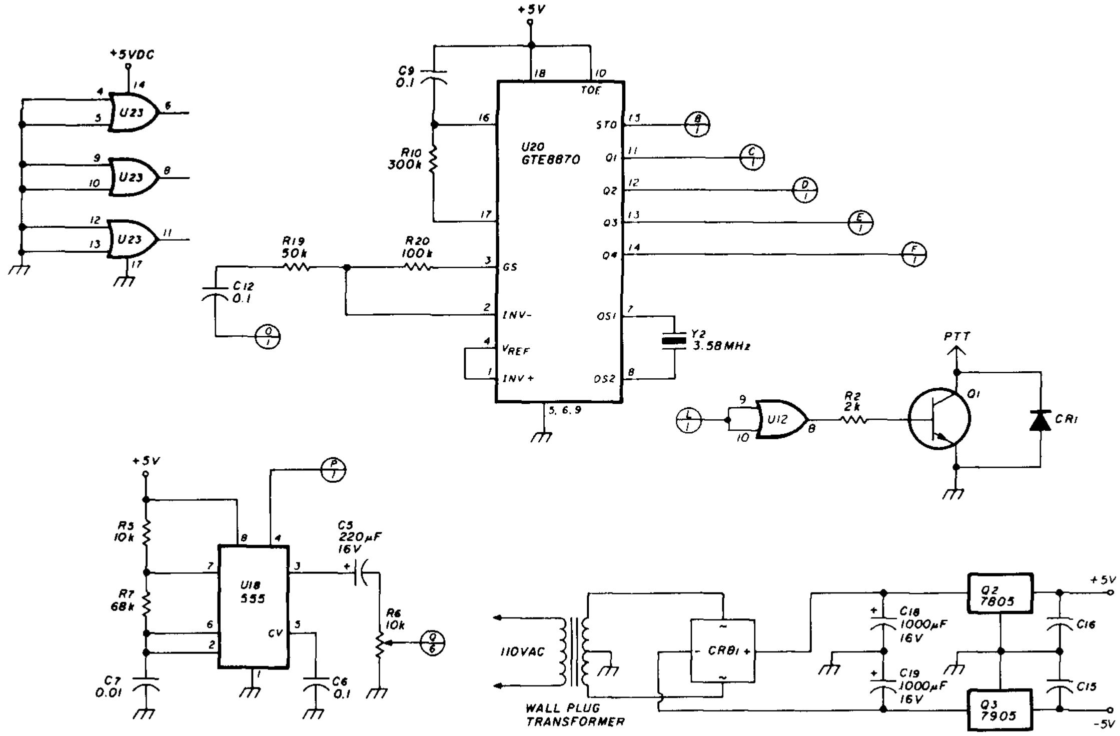

fig. 8. A GTE 8870 is used as a CMOS DTMF chip.

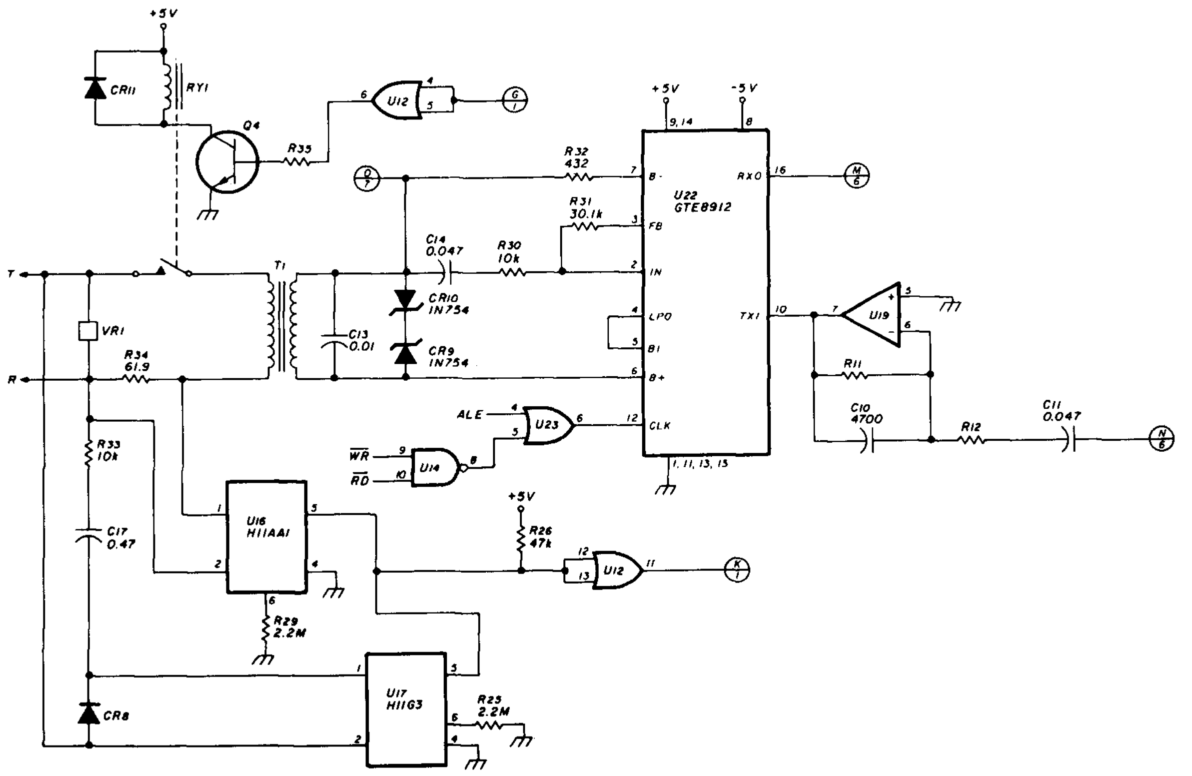

fig. 9. Analog circuitry part of controller.

external output ports. The read signal for the input ports is generated by OR'ing with the system read signal. Each input port bit is activated by opening the appropriate switch. The port pin is then pulled high by a pull-up resistor, telling the microprocessor it needs servicing.

DTMF signal decoding is done by the GTE 8870 CMOS DTMF chip (see **fig. 8**). Command signals may be entered into the system via the telephone line or radio receiver. When a valid DTMF signal is received, four bits are sent to the microprocessor input along with a strobe signal (std) telling the processor that the detected carrier is due to a DTMF signal. The processor then decodes this signal and performs the commanded task.

The tone generator consists of a 555 timer chip, set for a frequency of 1 kHz. The generator is turned on by a signal from the processor. The signal is capacitively coupled and the level set by a 10-k pot — one of the inputs to a summing amplifier that supplies audio to the radio transmitter.

analog circuitry

A description of the telephone interface circuitry (see **fig. 9**) begins with the ring and off-hook current components. The telephone network has a 600-ohm impedance, so transformer T1 is 600 to 600 ohms and meets FCC rules part 68: *this box does not have FCC registration.*

In an on-hook configuration, the dc path is broken by the off-hook relay. When a ring signal is applied across tip and ring, it is coupled through R_{33} and C_{17} from the ring side of the telephone line. The signal is then applied to the input of the H11G3 opto-isolator and CR_8, and the ac circuit is completed through these components and tip side of the telephone line. When the ring signal goes positive H11G3 turns on, pulling resistor R_{26} low, generating an interrupt to the processor during each positive portion of the ring cycle. The processor requires a count of ten cycles out of every cycle for a good ring. Once the accumulated rings reach the count, selected by ring 1 through ring 3 dip switches on Port D, the processor sends a signal to the off-hook relay closing the dc path. This causes current to flow through the 61.9-ohm resistor, generating a voltage drop which turns the H11AA1 opto-coupler on. A signal is then sent to the processor indicating that line current is present. This signal is sampled continuously, and if line current disappears for a certain length of time the processor sends a deactivate signal to the off-hook relay.

The telphone line side of the interface has a device to protect it from the possiblity of over-voltage spikes. The secondary side of the telephone circuit has both transmit and receive signal currents. The GTE 8912 PCM filter splits the signal into either a receive or transmit path. Two zener diodes prevent the PCM filter from overloading.

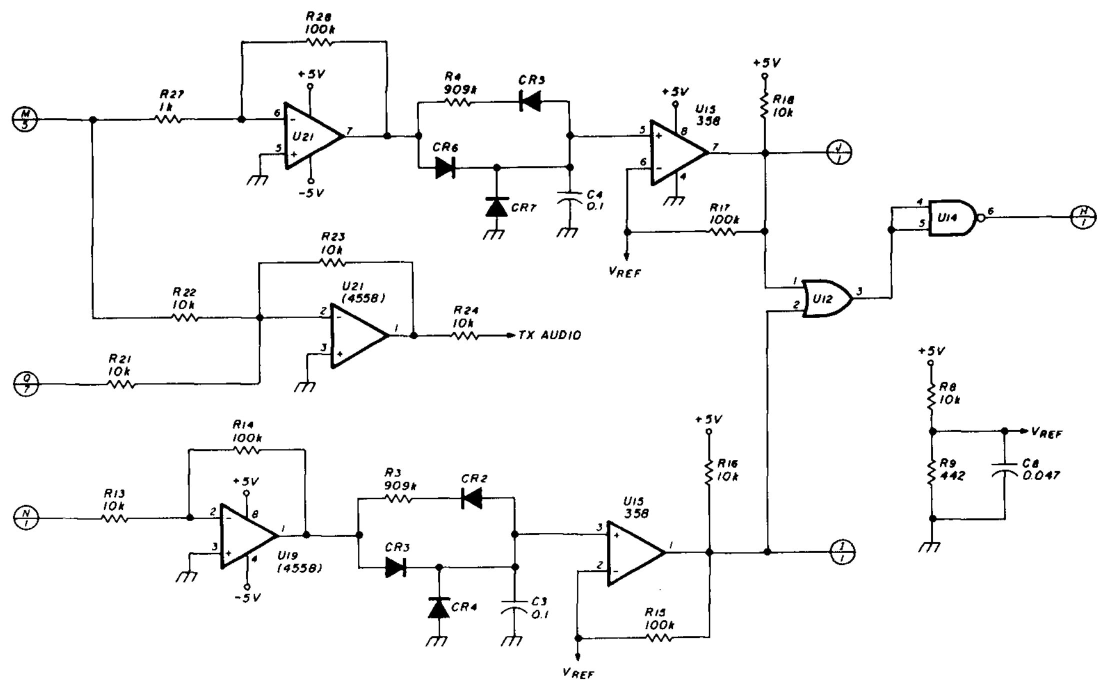

fig. 10. Carrier detect circuitry.

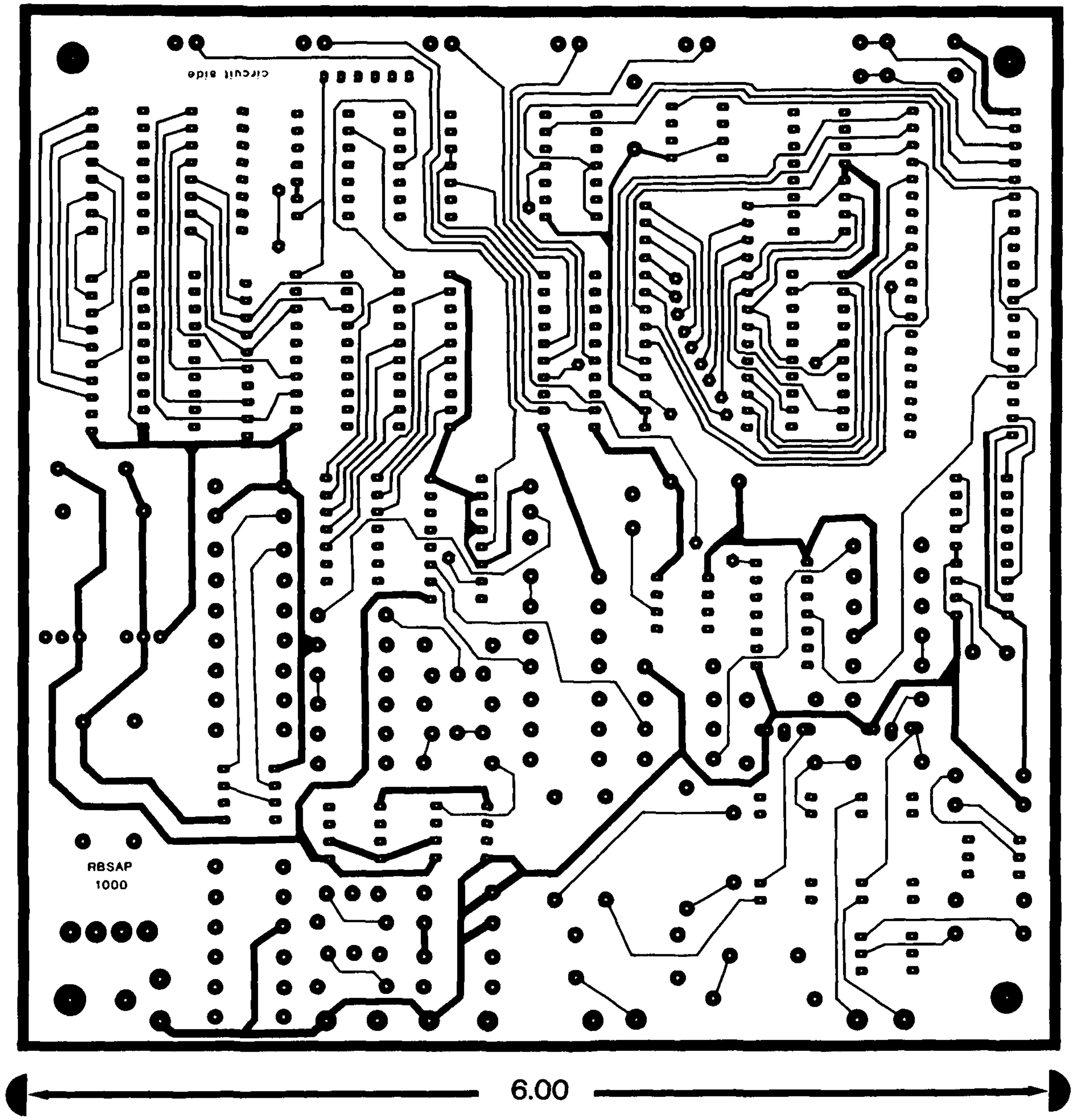

fig. 11. Printed circuit board artwork—component side.

The receive signal enters through C_{14} and R_{30}, with the gain resistor being R_{31}. The telephone output exits on pin 16 of the PCM filter. The radio receive signal enters the PCM filter on pin 10, and drives T1 through a differential amplifier in the PCM filter.

The DTMF receiver input is taken from the secondary side of T1, allowing command signals to be decoded from either the telephone or the radio receiver.

The PCM filter requires a 2-MHz clock signal to provide necessary filter characteristics. This signal is generated by first NAND'ing the system read and write signals, then OR'ing the result with the system ALE. As a result, the microprocessor clock frequency is divided by 6.

audio and carrier detect

The telephone signal to be transmitted leaves the PCM filter at pin 16 and then enters through R_{22} into a summing amplifier, where the CW tones are also mixed when required (see **fig. 10**). The amplifier's output goes to the radio microphone input through a 604-ohm resistor serving as an impedance-matching

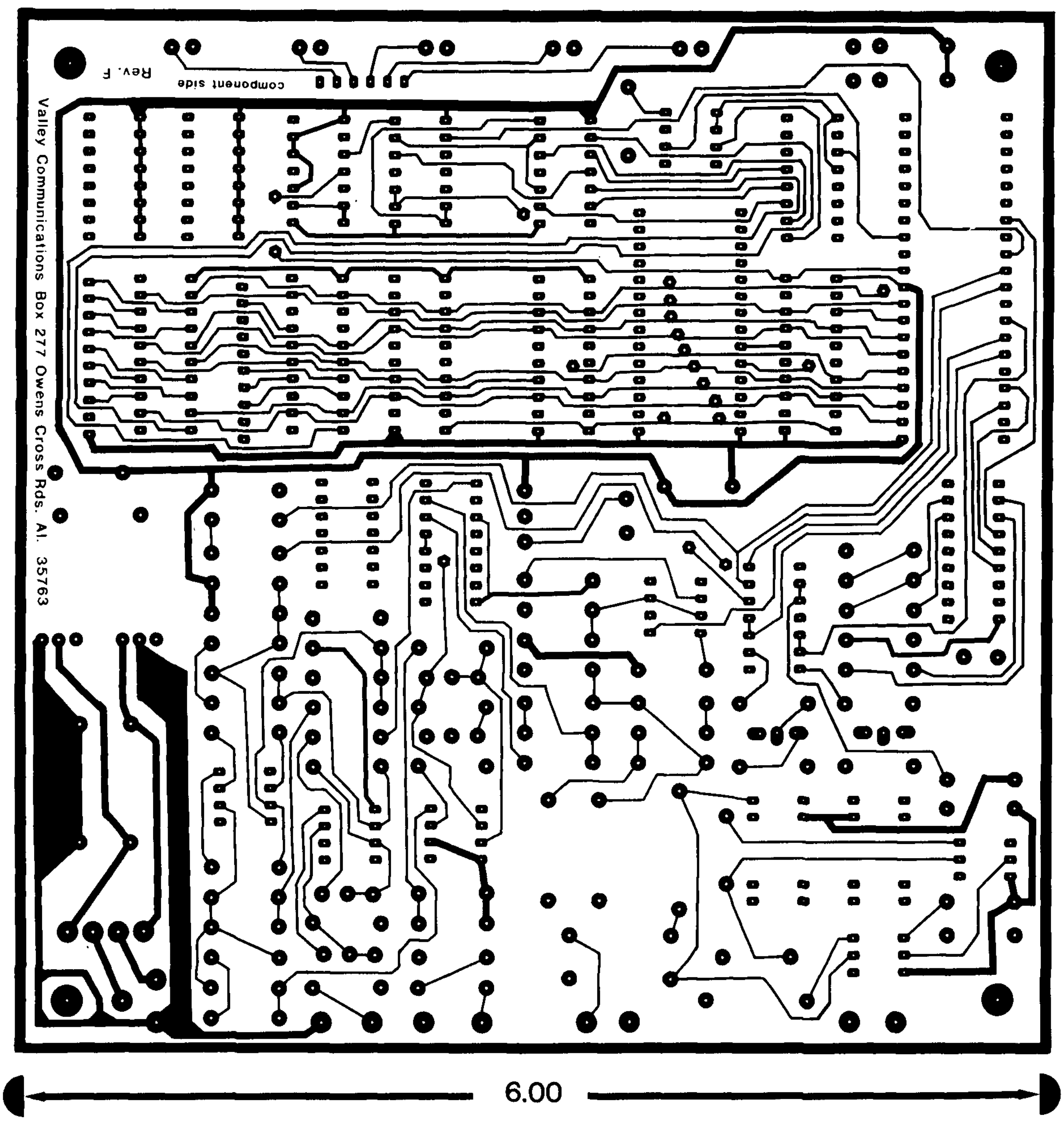

fig. 12. Printed circuit board artwork—non-component side.

device. This op-amp can be either an amplifier, attenuator, or buffer, depending on the ratio of R_{22} and R_{23}. In my application it was a buffer.

The telephone carrier detect circuitry has three parts: signal amplifier, rectifier, and comparator. The amplifier takes the incoming signal and amplifies it to a level sufficient for rectification. The gain is then set by the R_{27} and R_{28} ratio. Diode CR_6 half rectifies the signal allowing a positive voltage to be applied to the filter capacitor C_4. Voltage is applied to the input on a voltage comparator, U_{15}. When the voltage of the input signal rises above the voltage reference at pin 6, the output goes to a high state generating an interrupt through an OR gate. A signal is sent to the processor pin (described earlier) indicating the carrier is from the telephone. Resistor R_{17} provides a hystresis effect in the comparator stage, preventing output chatter if the incoming signal received is close in level to the reference. Diode CR_5 and R_4 are used to forward bias CR_5. This discharges filter capacitor C_4 which removes the signal from the processor. Carrier detection has a fast attack and a slow decay. CR_7

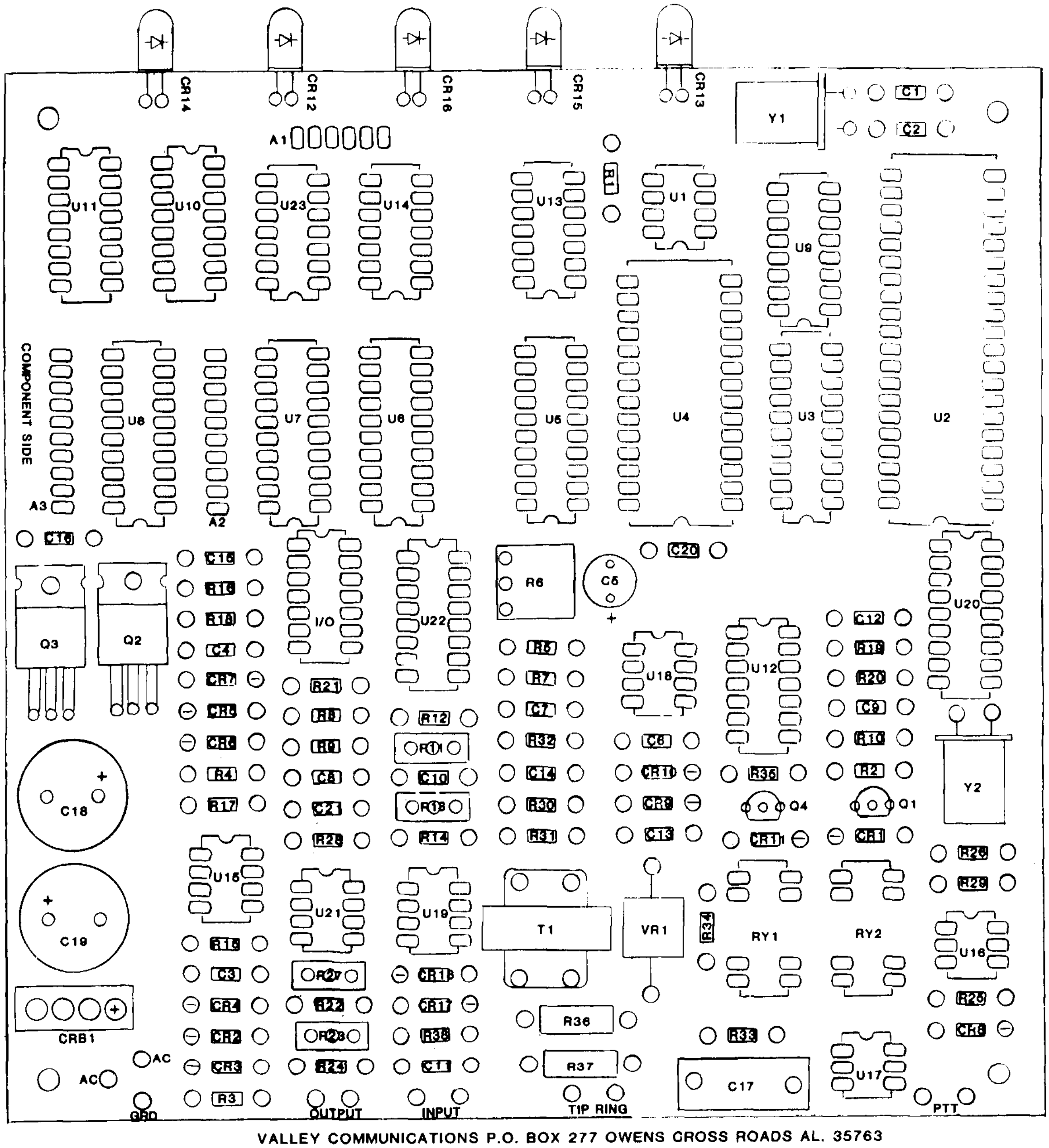

fig. 13. Component layout superimposed on component side artwork.

prevents a negative voltage greater than 0.6 VDC from being applied to the comparator input. This will happen if the carrier stays off long enough — the circuit goes negative.

Radio receive signal path enters the system through C_{11} into a summing amplifier U_{19}. This amplifier takes the signal from the radio and amplifies it to a -9 dBm output on the telephone line. *Be sure your audio input level doesn't go above this level — it is the highest level permitted on the public switched system.*

Approximately 35 mV is all that is required to achieve this level. I found the audio input to the volume control was the best method of obtaining audio from the radio receiver. This level should not be varied during normal operation.

The radio carrier detect circuit is identical to the telephone carrier detect circuit.

strap option

Next select the parameters. Look over the functions of the Port C and D dip switches, and choose the ones for your application. (See **Table 2**.)

Table 2. Port C, D dip switch selections.

Port C (SW-1) Switch No./Function	Port D (SW-2) Switch No./Function
1—4 First digit of access code 0-9	1—Test of 1-kHz tone
	2—Expansion
	3—*Private line (no dc)*
	4—Expansion
5—8 Second digit of access code 0-9	5—Expansion
	6—Ring count 0 (LSB)
	7—*Ring count 1 binary coded*
	8—Ring count 2 (MSB)

construction

Construction isn't critical; I've included the artwork double-sided pc board (**figs. 11** and **12**) and the component layout (**fig. 13**). I used components that were easy to obtain. You can order a printed circuit board or any major parts directly from me. I would be interested in any comments or ideas you may have; for a reply please enclose an SASE. I hope you have as *much fun with this project as I've had.*

ham radio

✓ 140

HAM RADIO TECHNIQUES

Bill Orr, W6SAI

the joys of TVI or, were you on the air last night?

Radio frequency interference (RFI) and television interference (TVI) have been around for years. In the last decade they have been joined by VCR, telephone answering machine, stereo, and cable TV interference along with other irritants that can drive an active Amateur crazy.

More and more household gadgets are susceptible to nearby rf energy. One cause of the proliferation of RFI problems is the deregulation of the telephone companies. Hundreds of new telephone gadgets are on the market, and many of them are poorly designed by manufacturers who know nothing of interference problems. A lot of the gadgets are so small and tightly packaged that there is no room inside them to install filtering.

Most of the VCRs, TV sets, and good AM/FM stereo systems built after 1984 seem to be more rf resistant than their ancestors; this is good news. However, it must be emphasized that the unwanted signal rejection varies between manufacturers and models and it is risky to assume a particular TV set or stereo is TVI resistant! This month's column concerns RFI problems associated with TV/VCR combinations and cable TV hookups.

One of the areas in the TV/VCR/cable field that bears close examination is common mode interference. John Norback, W6KFV, a technical consultant in the field of RFI, provided information on this subject.

common mode interference

The term "common mode current" originated with the computer industry. Before this the power and communication industries called the phenomenon "longitudinal line current" or "parallel line current".

Common mode interference is caused by parallel line current induced in a circuit normally carrying out-of-phase current. The unwanted current can be induced from a nearby Amateur transmitter. The signal is picked up by the TV feedline or cable system. The offending line serves as a good antenna for high-frequency signals.

In a balanced two-wire system (like a 300-ohm TV transmission line) the induced currents in the two wires are in the same phase. The ribbon line responds to the induced current as if the two conductors were tied in parallel to operate as one.

In an unbalanced system, like a coaxial line, the common mode picture is more complex. This is because the induced parallel line currents are not the same in both conductors (the center conductor and the shield). The induced current is much higher on the coax shield than it is on the center conductor (**fig. 1**).

In either case, the induced line current must go somewhere. Unfortunately, it goes into the TV tuner or VCR circuitry, through the various receiver stages, and then via capacitors to ground through the ac power cord of the receiver. Elimination of common mode interference must involve filtering, or breaking, both conductors of the TV signal lead-in.

Common mode interference is particularly bothersome on TV sets that are connected to cable TV systems. Even though the main cable system may be buried, it surfaces in the homes and acts as a pickup antenna for nearby, strong rf signals. Ground loops or poor joints in the system complicate the problem.

a practical approach to common mode interference

Television interference from receiver fundamental overload and transmitter harmonics has been well covered in the literature. The cures, too, are well known: a low-pass filter for the transmitter, a high-pass filter for the TV receiver, and a good ground for the shield of the coax line from transmitter to antenna. A power line filter may be required for the TV set as well as the transmitter. Unfortunately, these cures do not affect common mode interference to any substantial degree.

Figure 2 shows, in simplified form, the basic home equipment involved in a typical cable TV system. The first drawing shows a simple arrangement where the cable TV converter is built into the TV set; the second shows an arrangement where a cable TV converter is used to offer greater program selection. **Figure 3** shows an installation involving a VCR.

The cooperation of the TV owner is essential. First determine what ham band frequencies and TV channels are affected. Do not be fooled by interference on harmonically related TV channels. Normally, common mode TVI will affect all TV channels, whether harmonically related to the ham signal or not, but the number of disturbed channels depends on the strength of the parallel line currents and how well the manufacturer has designed the TV set. (Note that a vertical transmitting antenna will cause a stronger common mode signal than will a horizontal antenna. Common mode interference can also exist on 40, 80 and 160 meters — bands not usually subject to harmonically related interference.)

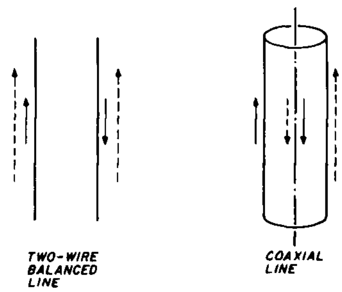

fig. 1. Common mode current (dashed line) is equal in each wire in balanced system but is unequal in coaxial system (right).

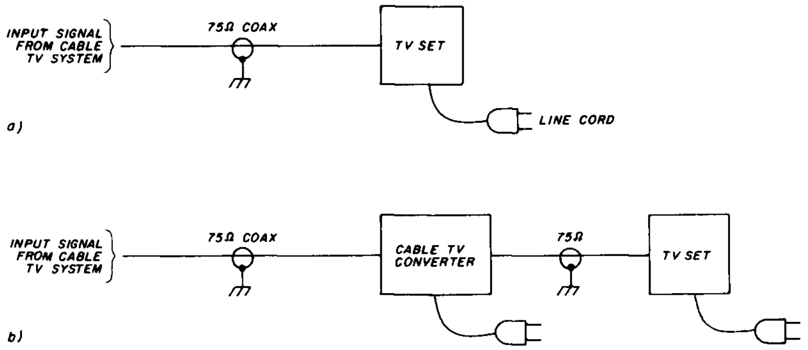

fig. 2. (A) Simple home cable TV setup with TV converter built into receiver. (B) Home cable TV setup with external converter. Some installations may have two or more additional TV sets installed. More complex installations involve FM, stereo systems, external speakers, etc. Do not forget these when investigating interference. All are suspect.

Once you've determined which radio frequencies are causing the TVI, note the affected channels. It may be all of them, or just one or two. Disconnect the TV receiver from the input signal lead to the antenna or cable system and recheck the channels where there was interference. Normally, the channels will be clear. If interference still exists, a power line filter for the TV receiver may be needed, or external speaker lines of the receiver must be filtered. Solve the interference problem first.*

Once the TV set and/or cable TV converter are free from interference with the TV signal input lead disconnected, place a balun/high-pass filter/balun arrangement in the signal lead (**fig. 4**). The interconnecting leads should be as short as possible. A parts list is given in the drawing. Radio Shack parts were selected because they are widely available. Parts specifications are listed in case you select components from other manufacturers.

If everything's been done correctly up to this point, there should be no interference on the TV set regardless of transmitter frequency and TV channel selected. If you're still experiencing interference, install a coaxial high-pass filter between the cable TV converter and the TV set, as shown.

when a VCR is involved

The procedures for eliminating TVI in a cable TV system apply equally well when a VCR is involved, but the final solution may be more complex. There are many makes of VCRs and many different ways of connecting them into the cable TV system. They can be in series with the cable TV converter or TV set, or split off the cable TV input lead. **Figure 5** shows some typical arrangements involving VCRs along with the correct method of eliminating common mode interference.

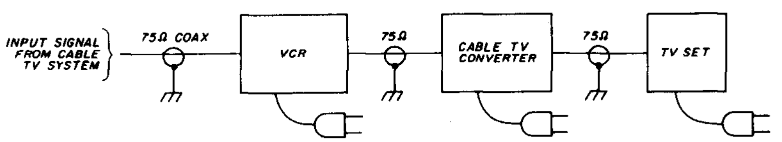

fig. 3. Home cable TV installation involving a VCR. Three power cables are involved, any one of which could pickup rf energy.

With the cooperation of the TV owner, first disconnect the cable TV

*For detailed information on all aspects of interference (including interference to Amateur operation) the *Interference Handbook* by William R. Nelson, WA6FQG, an RFI investigator with 33 years experience, is available from *ham radio* Bookstore for $11.95 plus $3.50 shipping and handling.

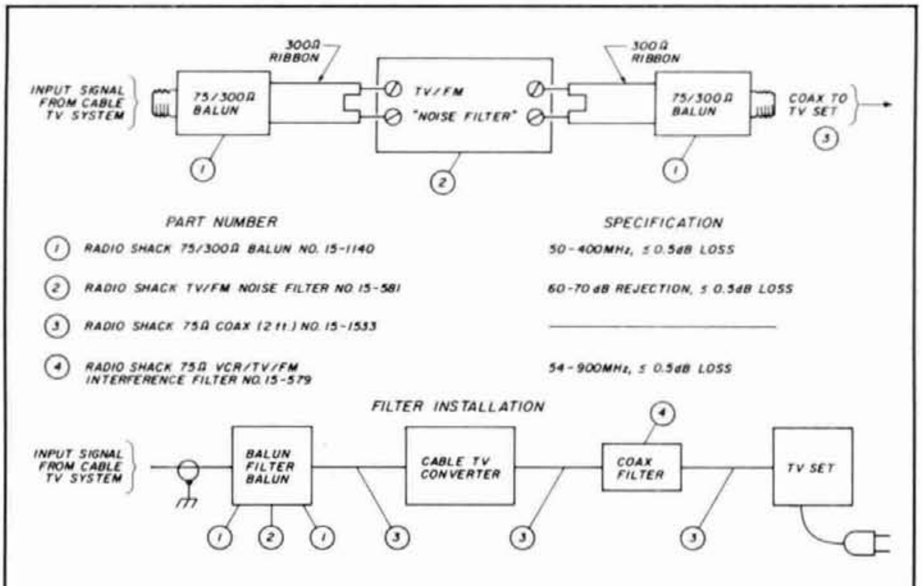

fig. 4. Filter arrangement for TV and cable TV converter.

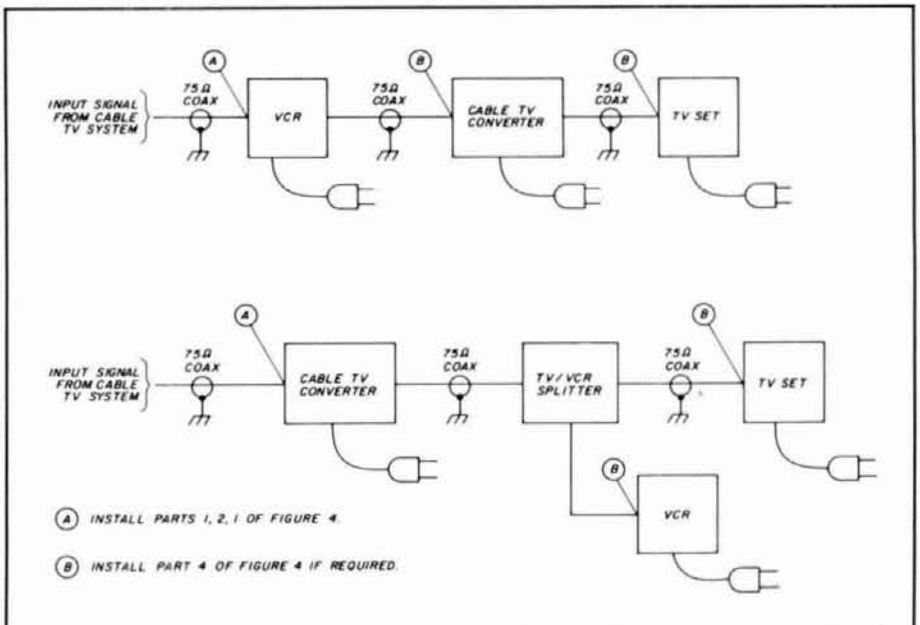

fig. 5. Filter arrangements for VCR installation. In case of severe interference install parts 1, 2, 1 of *fig. 4* here.

input signal lead from the circuit. Place a tape in the VCR and let it play, observing the picture on the TV set. Operate your transmitter on all hf bands, one at a time, and note any interference on the VCR picture. Also check all channels with the VCR inoperative but in the circuit. Identify any TV channels experiencing interference. If there is interference with the VCR operative, or unoperative but still in the circuit, install the balun/high-pass filter/balun arrangement discussed earlier between the cable TV signal input lead of the cable TV converter. If interference continues, disconnect the VCR from the circuit and repeat the tests with the TV converter in the circuit. You may need to insert a coaxial high-pass filter between the cable TV converter and the TV set.

These arrangements should solve

the interference problem with the VCR either on or off. If the problem continues, the interference may be in the VCR circuitry associated with the recording or playback heads, or it may be due to improper grounding or faulty connectons in the cable TV circuit. It's a good idea to contact the cable TV company involved and ask them to inspect their equipment for proper connections. Don't be surprised if the cable TV company inspects your station with a spectrum analyzer. If the cable company finds transmitter harmonics, you need to do more work on your installation, or you must investigate the possibility of external rectification. If the cable TV circuit is "clean", the problem lies in the VCR.

Because sensitive circuits of the VCR operate in the low-frequency portion of the 80-meter band, it is wise to restrict operation to the upper portion of the band until you solve the problem. Check with servicers of the VCR in question to see if any TVI corrective measures are available for that model. The VCR is a complicated electromechanical device and probing its "innards" is not recommended!

the Faraday solution

I received a note from Wayne Cooper, AG4R, outlining a system which "breaks" a TV coaxial line for protection against fundamental overload and common mode interference. The idea was sent to him by ZS6AUB, who got it from G3LLL. It consists of a 1:1 transformer in the antenna lead which will pass the VHF signal but will reject a lower frequency interfering signal. The idea is simple and inexpensive (**fig. 6**). The coax is cut about a foot from the TV receiver and two tightly coupled 2-inch diameter loops are formed. Each coax center conductor is soldered to the outer braid and cable ties or vinyl tape hold the loops together. This comprises an electrostatic shield. The coupling scheme has some loss and may make a weak channel more "fuzzy", but works okay when the picture is good to begin with.

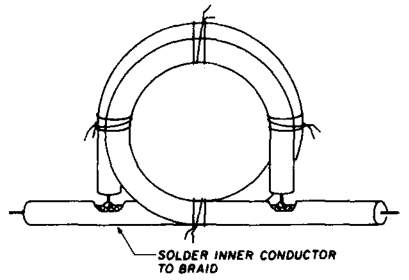

fig. 6. Tightly coupled loops break coax to cut fundamental overload and common mode currents.

another interesting quotation

Last month I intimated that radio hams are well-read, well-rounded individuals. As of this writing, the July column hasn't seen daylight, so I haven't received any response to my request for identification of a well-known quotation. Even so, I'm going to try again to see how alert my readers are. I suspect only the old-timers will identify the following; the book first came out in 1923. It created a sensation and is still a first-rate story (available in paperback). So, here's the quotation, which took the form of a telegram.

STORY TRUE. AWAIT ME ALGIERS. (signed) BURROUGHS

If you know the book and can identify the situation, drop me a note on your QSL to Box 7508, Menlo Park, California 94025 and I'll publish the calls of the erudite "winners" in this column!

ham radio

precision high-voltage dc regulator

Convert an unregulated high-voltage power supply into a regulated adjustable voltage source

I have built a short-circuit proof, RFI resistant, solid-state precision regulator that converts an unregulated, high-voltage power supply into a stable, adjustable voltage source.

There are three prerequisites this unregulated power supply must meet:

- The minimum, full-load, unregulated voltage (including ripple) must exceed the regulated output voltage by ≈45 volts*.
- The unregulated supply must be capable of providing the additional 2.2 mA consumed by sampling resistor R_2 (**fig. 1**).
- The voltage difference between the unregulated supply and the regulated output must not exceed the voltage capability of the pass element.

applications

- Adjustable screen supply for tetrode or pentode class AB-1 grid-driven linear amplifiers (using a suitable (−) screen current bleeder resistor).
- Klystron and traveling wave tube amplifier power supplies.
- Backward wave and klystron oscillator power supplies.
- Plate supply for a linear amplifier.
- Any requirement for a regulated voltage up to 6 kV. 1000 amperes or more is possible if enough pass FETs and heat sinks are available.

* May be altered by using different values of R_1,R_2,C_6, and R_{11}.

limitations and design considerations

The output voltage capability of the regulator is indirectly set by the maximum voltage dropping capability of the FET pass element. The voltage difference between the unregulated supply and the regulated output voltage is wasted as heat by the pass element. Since only a small part of the input voltage appears across the pass element, the maximum output voltage capability of the regulator is about five to six times the maximum output voltage rating for the pass element. The Motorola MTM6N6O is rated at 6 amperes, 600 volts, 150 watts maximum. The highest regulated voltage with this pass element is about 3 kV. Similar FETs with ratings up to 1 kV at 150 watts (before thermal derating) per device are available. A 1-kV pass element can be used to regulate 6 kV. Current capability may be increased by paralleling pass elements.

Paralleling FETs is somewhat easier than paralleling bipolar transistors because the FET's control element (gate) consumes no power. Since 0 + 0 = 0, two or three FETs use the same driving power as one — exclusive of the gate capacitance and charge bleeder resistors from the gates to the sources. Driving the gate capacitances is a problem. Each gate adds about 1800 pF. If more than two MTM6N60s are to be paralleled, use an NPN emitter follower driver to drive the bank of FETs in the pass element. The pass FET source leads should have current equalizing resistors as paralleled, bipolar transistor emitters do.

A common reason for paralleling FETs is to obtain increased power dissipation instead of more current. Although a dissipation rating of 150 watts may look good, it is only true at 25 degrees C case temperature. One way to keep the case ≤25 degrees C, while dissipating 150 watts would be to immerse it in circulating distilled ice water. Because this is impractical, the device is derated according to the manufacturer's data sheet. An educated guess would be about 50 percent,

By R.L. Measures, AG6K, phone: 805-482-3034

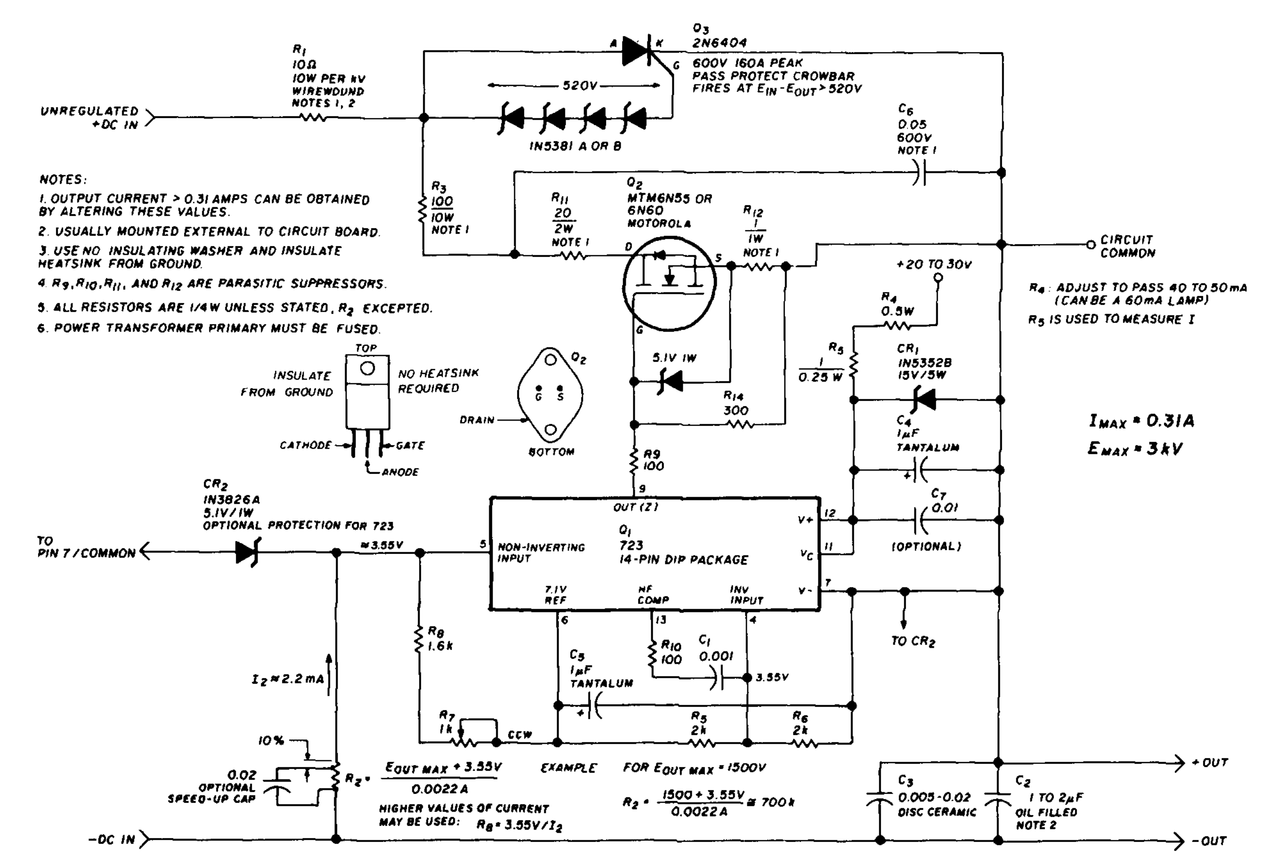

fig 1. Short-circuit proof, high-voltage regulator using a 723 IC and FET pass element.

or 75 watts per device with a heat sink that keeps the FET case below 85 degrees C in a worst-case situation.

The greatest heat dissipation in the pass element usually occurs at about half the maximum current load. At full-load current the unregulated input voltage usually sags, and there is little remaining voltage drop in the pass element. So, even though the current is maximum, the pass voltage drop is minimum, and the heat dissipation is less than maximum.

circuit description

Series-pass regulators work on the principle that regulation will be achieved if they can be made to automatically waste the difference between the varying unregulated input and the desired regulated output voltages. The regulating process is a working example of Kirchoff's Law: The sum of all the voltage drops (the pass voltage plus the output voltage) are equal to the voltage source (the unregulated high-voltage power supply). If more voltage is dropped across the pass element, less voltage is left over for regulated output. If less is dropped across the pass element, the regulated output voltage increases. The missing piece is the brain that tells the pass element's gate what to do.

The circuit's brain is a 723 precision regulator integrated circuit in the upside-down and backward positive floating regulator configuration. In this regulator configuration, the positive output lead is the circuit common, or zero reference. The positive floating regulator uses its own power supply. In this circuit it furnishes about +20 volts at 0.05 A to a 15-volt zener to regulate the voltage that runs the 723 and the negative lead of the 723's supply is connected to (+) circuit common.

If the regulator is operated with the negative output terminal grounded, the 723 regulator, its power supply/transformer, voltage-adjust pot (R_7), and pass FET/heat sink will be elevated to the (+)output voltage. *All elements must be properly insulated from ground.* If the output is operated with the positive lead grounded, only the heat sink need be insulated. More on this later.

The 723 has a temperature compensated 7.1-volt reference, a differential error amplifier, and its own pass transistor. Access to the non-inverting and the inverting input of the differential error amplifier is provided. This gives the circuit designer freedom to create unconventional circuits like the positive floating regulator. 723s are sensitive amplifiers with a voltage gain of about 1000 and an open-loop current gain of about one million.

High gain is essential if a regulator is to accurately sense small deviations in the desired output voltage, make the necessary correction at the gate of the pass transistor, and maintain precise regulated output voltage. It is a problem to keep the regulator regulating and not deregulating by receiving radio signals at the same time. External rf energy allowed to enter a critical terminal on the 723. C_4, C_5, and C_7 are rf bypasses. C_1 and R_{10} reduce the rf gain of the differential amplifier. The input terminals of the differential amplifier are rf-isolated by the resistors that deliver the dc signals. Radio frequency has a hard time passing through high-value resistors.

Several commercial power supplies ignore the RFI problem and let the users figure it out. The 723 gained an undeserved bad reputation from those who did not understand the nature of rf and the amplifying ability of the 723.

current limiting

Most regulated supplies include some form of current limiting. I left it out of this design because the pass FET could not withstand the full, unregulated voltage during a short-circuit/zero voltage output condition. A type of current limiting practical here is a fuse, or circuit breaker, in the *primary* of the HV transformer. Ordinary 3AG fuses should *never* be used in the *secondary* circuit of a high-voltage supply if the fault voltage is above their 250-volt rating. A 3AG fuse acts like an arc lamp instead of a predictable current limiter above 250 volts during a fault, before it eventually explodes.

Fuses are cheap, power FETs are not and are very unforgiving of too much drain-to-source voltage. A crowbar thyristor circuit (Q_2) will automatically fire if the voltage across the FET is close to the breakdown voltage. This protects the FET(s) in this circuit from an unregulated voltage too high for a specific regulated output voltage. It takes about 1.5 μs for Q_2 to fire. During this time, the FET is protected by R_3/C_6, an R/C delay circuit.

If the pass-protect crowbar fires, the output voltage temporarily rises to the same level as that of the unregulated supply. The regulated voltage will return if the load is removed and excessive voltage is lowered. If there is a short across the output, the stored energy from the unregulated supply's filter capacitor is dumped into R_1 for a few milliseconds, until the primary fuse opens. R_1 must be a wire-wound power resistor because the peak dumping current is about 100 amperes.The value of R_1 is increased, as the voltage capability of the supply is increased, to keep the dumping current around 100 amperes. For a 3-kV power supply, R_1 should be a 30-ohm/30-watt unit.

polarity etiquette

Remember that *less positive and more negative* are interchangable terms, as are *less negative and more positive*. For example: +4 volts is more negative, and also less positive, than +5 volts. While −6 volts is more positive than −7 volts, neither voltage is positive with respect to circuit common. The reference "than" is the key.

N channel, enhancement mode, power FET rules

A more positive (than the source) gate voltage makes the FET conduct more heavily. If the gate voltage of the FET becomes less positive/more negative, the conductance of the FET will decrease (like a triode vacuum tube). The gate (control) of a FET resembles the grid in a triode vacuum tube, the source (of current carriers) is like a cathode, and the drain (of current carriers) is like a plate. The big difference between the vacuum tube and the FET is that the FET's control voltage is always positive (usually in the range of +2 to +4 volts) and the (+) gate draws no current — unlike a (+) grid in a vacuum tube.

the 723

The 723 differential error amplifier has two inputs. For the DIP package, Pin 5 is the noninverting input; pin 4 the inverting input. Pin 6, the internal 7.1-volt reference, is passed through a 2:1 voltage divider (R_5/R_6) and the resulting stable 3.55 volts are connected to pin 4, the inverting input. When the system is in balance, 3.5503 volts are applied to the noninverting input by an opposing-polarity voltage divider: R_7, R_8, and the output-voltage sampling resistor R_2. R_7/R_8 connects to the (+) 7.1 volt reference and R_2 connects to the (−) output terminal. If the output voltage is correct the differential error amplifier is balanced, as there is almost no voltage difference between the two input terminals. Therefore, the 723 output is steady and the regulator system is in a state of equilibrium.

Two situations could unbalance the system: too much or too little output voltage. Either situation will develop if the line voltage or the load current changes. A successful regulator must be able to restore balance.

if there is too much (−) output voltage with respect to the (+) common reference

It is safe to assume that the pass FET is conducting too much. The excessive, more negative/less positive output voltage causes more current to flow in R_2. This makes the voltage at the noninverting input more negative than the constant +3.55 volts on the other input. The difference voltage is amplified and the more negative output drives the gate of the pass FET more negative. This reduces the conductance of the FET, increasing the FET's voltage drop, leaving less voltage for the output and the output voltage decreases to the correct level.

if there is too little (−) output voltage with respect to the (+) common reference

It is safe to assume that the pass FET is not conducting as much as it should.

The insufficient, less negative/more positive voltage at the (−) output causes a decrease in current through R_2. This causes the voltage at the noninverting input to also become less negative/more positive than the constant +3.55 volts on the other input. The more positive signal is amplified by 723, driving the gate of the pass FET more positive. This increases the conductance of the FET and lowers the voltage drop across it. Consequently, more voltage is delivered to the output and the output voltage increases to the correct level.

performance

I built a 615 to 1000 volt, 0.31-ampere adjustable power supply observing the following performance parameters. Voltage regulation: ≤1 volt change, no load to full load. Ripple and noise: ≤ 150 peak-to-peak mV at 200 mA load, with a 0.02 μF speed-up capacitor across 90 percent of R_2. Without the speed-up capacitor on R_2 peak-to-peak ripple and noise were ≤ 500 mV. Line voltage regulation: ≤ 1 volt change for ± 10 percent line voltage change. These measurements were taken on a Fluke 8022 digital voltmeter and a Hewlet-Packard 1706A oscilloscope.

Changes were made to the regulator circuit and unregulated supply to increase the maximum output voltage to 1900 volts and, with more modifications, to 6100 volts. There was similar performance at the increased voltage levels.

In no case was I able to detect even a one-digit voltage change, from no load to full load, on my Fluke DVM, with its maximum count of 1999.

heat sink caveats

The FET's drain is connected to its case structure. If the case is insulated from the heat sink with a properly installed 1000-volt mica insulating washer, the thermal transfer between the FET and the heat sink will be compromised. It's better to fasten the FET case directly to the heat sink with a thin coating of thermal grease and then insulate it from ground with G10 Fiberglas™, acrylic, or some other nonhygroscopic material. **A high-voltage warning label should be placed on or near it. (We, at *ham radio*, do not recommend having a heat sink at high voltage. If you choose to use this method, provide an obvious label and accord the heat sink the same "respect" you would any other high-voltage component.)**

paralleling FETs

FETs are fast. They oscillate at VHF — just like triode vacuum tubes — unless parasitic suppressor resistors are used at the output and input terminals. Each FET in a bank of paralleled pass FETs should have it's own gate-to-source, charge bleeder resistor; a drain, parasitic suppressor resistor; a gate, parasitic suppressor resistor; and a source current equalizing resistor. Mount the suppressor resistors close to the FET(s). The resistor values can be juggled considerably to accommodate different current requirements.

FET selection

A wide range of power FETs are available from Motorola and other manufacturers. For Amateur Radio applications, the Motorola MTM3N95 and the MTM3N100 are probably the most versatile; a 6-kV regulator can be built with either. MTM means it has a standard TO-3 case (now called TO-204). The numeral 3 stands for 3 amperes; the N means that it has an N-type channel, and −) electrons carry the current. The letter P would indicate that it had a P-type channel and that the current carriers were (+) "holes," and all polarities are reversed. The number to the right of the N or P gives the source to drain, maximum voltage rating, less one zero. So, these two devices would handle 950 and 1000 volts, respectively. The rated dissipation on a good heat sink is 125 watts each during a blizzard, or roughly 70 watts indoors.

A good crowbar thyristor (SCR) for protecting a 1000-volt FET is the Motorola MCR225-12 rated at 1000 volts, 300 amperes peak, and ≤2μs turn-on time. The series zener trigger for this crowbar can be made from six 150-volt or 160-volt 5-watt zeners. The crowbar-thyristor does not need a heat sink.

resistor R_2 ratings

Resistors have maximum voltage ratings that take precedence over power ratings. Example: A 2-watt, 5.1-megohm composition resistor requires 3193 volts to reach the 2-watt dissipation level. So, although this may look like the right choice for a high-voltage sampling resistor, there is a 500-volt maximum rating that must be observed at all times. Using Ohm's law: $P = E^2/R$; at maximum rating, the "2-watt" resistor should only be used to dissipate 0.049 watts.

Special resistors are available for high voltages. They have a metal oxide, spiral deposited film, but are expensive and hard to find. The 0.5-watt 1 percent variety metal oxide film resistors are easier to locate and have a maximum voltage rating of 350 volts each. You can place as many as you need in series on a perfboard. I use 100 k, 0.5 watt, 1 percent resistors in series for R_2. They will stand 2.2 mA or 220 volts per unit at 0.5-watt dissipation and cost about eight cents apiece in quantities of 100.

modifications

If necessary, the regulator circuit can be modified to use a different sampling current. However, it probably should not be reduced below 1 mA.

construction

I built the circuit on a piece of perfboard, using a wire-wrap IC socket with the pins bent flat. You can also use a pc board if the traces used to carry the ≥ 100 ampere short-circuit current are made of sufficient cross section.

unregulated power supply *considerations*

Keep in mind that the unregulated voltage needs to be only slightly higher than the full-load, regulated voltage. Extra voltage will be wasted as heat, increasing the burden on the pass element. A wide range high-voltage supply should use a multi tapped power transformer.

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ELMER's NOTEBOOK

Tom McMullen, W1SL

propagation basics

One of the great mysteries to most Amateur Radio newcomers is how DX signals get from place to place around the globe. To a casual or uninformed listener, there is no apparent reason for some bands to be "dead" while others are booming with activity. And why does a band full of very strong signals fade out suddenly sometimes, but at other times slowly and incompletely?

There are reasons for this behavior, and an experienced Amateur soon learns to take advantage of the mechanism that provides a path to that distant station.

It all has to do with the ionosphere — that layer of gases that makes up the atmosphere we live, breathe, and fly in. Under the influence of radiation from the sun, this shell that protects life on earth takes on some strange properties that provide life on our Amateur bands.

layer after layer

Fortunately for us, the entire atmosphere does not react in the same way to solar radiation. There are "layers" of reaction at well-defined heights above ground; these layers change their characteristics daily and seasonally. Normal ultraviolet radiation from the sun causes most of the action, with help from periodic outbursts of radiation like Extreme Ultraviolet (EUV) and X-rays, and both high- and low-energy particles.

When ultraviolet and other solar radiation reaches the atmosphere, it reacts with the air molecules in such a way that they become "ionized". Some electrons are knocked loose from their parent atoms, and some molecules gain an extra electron or two. The result is a layer of particles that have an electrical charge, either positive or negative. Such a layer reacts with radio waves as they travel upward from the surface. Layers of different densities occur at different levels in the atmosphere. The lowest layer, approximately 45 to 55 miles above the surface, is called the "D" layer. There is also an "E" layer at about 65 to 75 miles high. It has a wandering cousin called "sporadic E" that creates some interesting conditions. (More about this one later.)

Things get more active at heights of 90 to 250 miles. There are two layers up there, called "F1" and "F2." These have an unusual property in that they are separate, distinct layers during the daylight hours, but combine after sunset to form just one "F" layer. **Figure 1** shows these layers as they might appear during a normal daylight period.

the D layer

This lowest layer is not really of much use to Amateurs. In fact, it usually works against our desire to QSO on the lower frequency bands (1.8, 3.5, and sometimes 7 MHz) by absorbing the waves as they travel outward from the

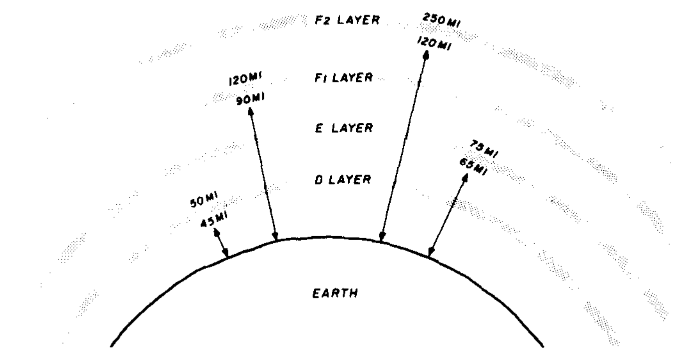


fig. 1. The atmosphere contains layers of ionized atoms at various heights above ground. These layers, D, E, F1, and F2 bend radio waves back to earth. The density of ionization determines the frequencies that are usable; the height determines the distance to the first (and subsequent) point of return to earth. At night the D layer disappears, and F1 and F2 combine to become one F layer.

antenna. The density of the D layer is such that wavelengths below a certain frequency (called the LUF, or Lowest Usable Frequency) are simply absorbed on the way through. Talk about a big dummy load! The D layer dissipates after sunset.

You can hear the effects of this dissipation on the AM broadcast band. Throughout the day, only nearby stations can be heard. But not long after sunset, DX starts to come in at ever increasing distances until you can often tune in stations half a continent away. That's why so many AM broadcast stations have to sign off at sunset — they would create unbelievable QRM when the D layer dissipates and allows better propagation. The same change takes place on the 1.8, 3.5, and 7 MHz bands; the distances that can be worked on 3.5 and 7 can span the globe. Of course, our high-flying friend, the F layer, is what provides all this DX on these lower bands at night.

the F layer(s)

No one is exactly sure why there are two F layers, but they definitely exist. Layer height and density are determined by sending a radio-frequency pulse straight up and recording the reflections as they return; the instrument used is called an *ionosonde*. Not only does this locate the height of the layers, but it can determine the point at which nothing is reflected when the radio frequency of the pulse is varied. This is the Maximum Usable Frequency (MUF). Frequencies higher than this will just keep going out into space, and those between the LUF and MUF will be bent (refracted) so that they return to earth.

The F1 layer seems to have very little to do — just a small amount of refracting except in times of very high solar activity. The F2 layer provides the bending that creates most of the DX openings during the day and most of the night. The density of the F2 layer is directly affected by the sun's activity, and can provide DX signals that vary from being just readable to pinning the S-meter. The higher the activity, the higher the MUF will be. This means that during periods of high solar activity the MUF will often climb up beyond 30 MHz, even reaching above 50 MHz in very good years. We are just starting a period of increasing activity, so get ready now for some spectacular openings on 28 MHz during the next 4 or 5 years. Peaks of activity can't be pinned down precisely, but the peak for this cycle should occur in the early 1990s. After that, there will be a gradual decline to the next minimum. The cycle from high to high (and low to low) runs approximately 11 years.

E and sporadic E

This layer was once called the "Kennely-Heaviside layer" after some early investigators who theorized about its properties. It provides relatively short-hop propagation by bending signals back to a point 600 to 1200 miles away.

Its cousin, "sporadic E" (E_S), is not consistent enough to provide much excitement on the Amateur bands below 21 MHz. Its effects would be masked by F-layer reflection and by noise levels. The E_S layer begins to be evident above 28 MHz when it is active; at 50 and 144 MHz the activity can provide amazingly strong signal paths. E_S signals have often been heard as high as 220 MHz, but it was not until early 1988 that two-way contact was made via this medium at 220 MHz.

The theory of E_S propagation that seems to fit is that it is a "cloud" or "patch" of ionization that wanders erratically about at heights of 65 to 75 miles. The most common locations for these clouds in the United States seem to be the southeastern part of the country. They often start near the Gulf coast in Louisiana or Mississippi, and travel northward toward Arkansas and Missouri. In some instances, a second cloud appears over the southwest. When this happens, VHF enthusiasts can experience the thrill of "double-hop" DX, with contacts possible out to 2,000 miles or more.

These E_S clouds have appeared farther east and north as well, and there are reports of European E_S propagation on 144 MHz. Signals can be very loud and stay with you for several minutes, or

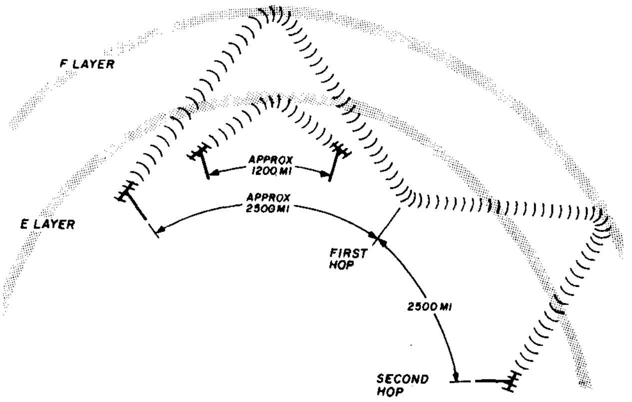


fig. 2. Ionized layers bend radio waves back to earth at distances depending on their height. Waves reflected from the ground can re-enter the atmosphere to be returned again for multiple-hop DX paths.

they can disappear in the middle of a QSO. In E_S QSOs it's wise to trade vital information first (QTH, signal strength, name, etc.), then chat about other things before the signal drops out. The points of reflection seem to move rapidly, and this creates somewhat of a contest atmosphere for the VHF enthusiast. The game is to see how many stations you can work before the cloud dissipates.

short path, long path

Another quirk of the F2 layer is its ability to fool us by not taking the shortest path between two points. Stations that are 6,000 miles apart, for instance, can sometimes work each other by pointing their antennas in the opposite direction for a path length of 18,000 miles. This happens because the amount of ionization can sometimes be greater in that direction than over the shorter path, or the short path may be noisy or have high absorption. Follow this procedure: if you feel that a path should be open but you're not hearing anything in that direction, turn your antenna around 180 degrees and try the other way. It often works surprisingly well.

multihop propagation

It doesn't take a great mathematician to figure out that a layer only 170 to 250 miles high can't reflect a radio wave to a point on the other side of the globe. In order to be line-of-sight at both ends of the path, the layer would have to be almost as high as the moon. As things work out, the radio energy returned to earth from the F2 (or other) layer strikes the ground and is reflected skyward again, to be bent back to reach the ground a second time or more (see **fig. 2**). Each time it does this, some signal strength is lost, but there's usually enough left for a solid QSO.

"Backscatter" is another interesting happening. In this mode, a signal strikes the ground at the end of the first hop, and enough of it is scattered back in the same direction to produce a signal near the starting point. On 28 MHz, for example, you might hear a station 100 or so miles away when you are both trying to work stations to the west, but if you turn your beam in his direction, you don't hear the signal. Backscatter signals are usually not very strong, but QSOs have been made this way. Sometimes this is the only way to get nearby contacts for a Worked All States (WAS) certificate.

the "greyline"

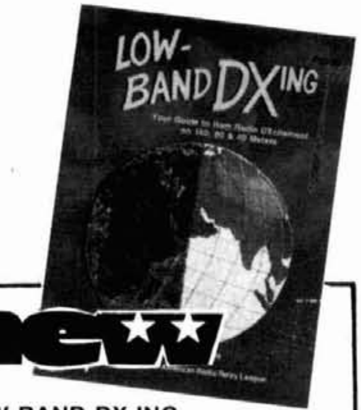
A mode that many Amateurs are learning to appreciate is the "greyline DX path." This is a band of good propagation that follows the twilight zone around the world. If you are in the twilight area just after sunset, chances are very good that you can work someone who is in a similar zone just before sunrise at his location. The opposite is also true — as long as both of you are in

this "edge-of-night" area, a good path can exist in between. At the spring and fall equinoxes the path will be directly over the poles; at other times the path will be off several degrees from north or south because of the earth's tilt. Propagation is possible because there is still enough F-layer activity to bend the signals, but the D layer has not built up enough to absorb them. There are computer programs that help find locations in the greyline at different times of year.

There are many other modes of propagation that help us make QSOs on various frequencies and at varying distances. Those I've outlined are responsible for 99 percent of all DX QSOs. Many articles and books have been written about the ionosphere and its effects on radio propagation, and some are fascinating reading. A serious DXer will learn all he can about this tool and use it for greater achievements. The rest of us can simply listen and learn to be at the right frequency at the right time by developing our own feel for openings. The column by Garth Stonehocker, KØRYW, in this magazine is a great help. Also, you can learn to eavesdrop on the sun's activity by tuning in WWV and using their sunspot and solar activity information.

However you go about it, DXing is great fun (and often contagious). Enjoy!

ham radio



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Garth Stonehocker, K0RYW

summer signal levels

With the summer sunshine and warmer weather comes the annual decrease in signals levels.

Signal strength is lost as its energy travels away from the transmitter. The largest loss is called free space loss, and it decreases all signals with distance. The amount of additional loss depends on the transmission mode and signal origin conditions. Examples of modes are: groundwave, line of sight, and skywave. Two originating conditions are launch angle and polarization of the launch from the antenna. For hf skywave propagation the losses of the ionospheric transit, its reflection, and the ground reflection in between hops must be included.

Most ionospheric loss comes from signal energy colliding with ions on its path through the D region, 60-80 miles (100-120 km) above the earth. The level of energy absorbed per transit of the D region depends on the location of the sun and is a function of cosine X, the zenith angle to the sun. Maximum absorption occurs at the subsolar point, directly under the sun; absorption decreases as the signal path moves away from the subsolar point in any direction. It is the next largest signal loss — 10 to 30 dB between night and day on midlatitude one-hop paths. Seasonal absorption in the D region increases as the sun's subsolar point moves to 23 degrees north for the United States' summer. This seasonal loss can amount to 18 dB more in summer than winter for midlatitude single hops. Absorption in the D region changes about 8 dB for a one-hop midlatitude path between sunspot numbers 20 and 120 during the 11-year sunspot cycle. It is rising fast this year.

The statistics above are given for the one-hop path as it is the easiest in which to see changes. When the signal travels three or more hops, the changes get blurred between them. There is more absorption with a larger number of hops, but the effect of absorption per hop is not linearly additive. Multiple hops cross into the night for the winter hemisphere, blurring additional losses. Ground reflections between hops are also lossy; loss varies with ground roughness and conductivity. On the average this loss is around 5 dB. All together, the losses amount to 120 dB of signal loss of transmitted power when received on summer days. Absorption is inversely proportional to frequency. However, this frequency dependency is hard to assess because as the frequency changes so does the extent of layer penetration. As a rough estimate, 10-MHz signals tend to incur twice as much signal absorption as 20-MHz signals.

What can DXers do to enhance their effectiveness during summertime operations? Review the chart on the next page for the highest band available to the DX area you wish to contact. Operate during the evening, taking advantage of its lower absorption, but before the maximum usable frequency drops off. Make sure your antenna radiates substantial energy at that low TOA for the best chance of contacting the desired DX station. Keep up on current conditions (in terms of signal absorption and variability, QSB) by listening to radio station WWV on 5, 10, and 15 MHz at 18 minutes after the hour. If the solar flux has just increasd, absorption will be above normal. Absorption and fading conditions (QSB) are associated with an A figure of greater than 15 or a K figure greater than 4.

last-minute forecast

Higher frequency DX bands will have the most and longest long-skip openings in the first week or so of August (because of expected higher solar flux) and again the last week. Short-skip sporadic E openings will also be available, but spread out through the month and emphasizing different times of day between the higher and lower bands. The lower bands should be best the third week due to the expected lower solar flux; lower absorption during the day affects daytime short skip and creates better nighttime signals toward sunrise and sunset. Expect some disturbances 1 to 2 days long, 1 to 2 days after solar flares are announced over WWV. These disturbances will be more likely July 29th-August 1st, August 4-6th, and 24-27th. The VHF/UHF enthusiast will note that the moon's perigee and the full moon appears on the 27th. The Perseids meteor shower will occur from the 10th to the 14th, with a maximum rate of better than 50 meteors per hour expected on the 11th and 12th. This is an excellent shower to work with for meteor burst.

band-by-band summary

Six-meter paths will open for a half hour to a couple of hours some days around local noon. Sporadic E propagation will make this short-skip path possible out to nearly 1200 miles (2000 km) per hop.

Ten and 15 meters will have a few short-skip E_S openings and some long-skip openings to southern areas of the world during daylight. Some transequatorial (TE) openings associated with mildly disturbed geomagnetic-ionospheric conditions may occur in the evening hours toward the end of the month.

Twenty and 30 meters will support DX propagation from most areas of the world during daylight and into the evening, with a lengthened skip out to 2000 miles (3000 km) per hop. The amount of daylight is still near the maximum, providing many hours of good DXing.

Thirty, 40, 80, and 160 meters are the night DXer's bands. On many nights 30 or 40 meters will be the only usable bands because of thunderstorm QRN, but signal strengths via E_S short skip may overcome the static, when E_S is available. Try the predawn hours for less QRN.

ham radio

AUGUST

WESTERN USA

GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	
PDT	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	
ASIA FAR EAST	20	20	20	30	30	20	20	20	20	20	20	20	30	30	20	20	20	20	20	20	15	15	20	20	N
EUROPE	20	20	20	15	15	15*	15	15	15	20	20	20	20	20	30	30	20	20	20	30	30	30	30	20	NE
S. AFRICA	20	20	15	15	15	12	10	10	12	12	15	15	20	20	20	15	15	15	20	20	20	20	20	20	E
S. AMERICA	10	10	10	10	10	12	12	12	15	15	20	20	20	20	20	20	20	20	20	20*	15	15	12	12	SE
ANTARCTICA	15	15	15	20	20	20	20	30	30	30	30	30	30	30	30	30	30	30	30	20	20	20	20	15	S
NEW ZEALAND	12	12	12	12	15	15	20	20	20	20	20	20	20	20	15	15	15	12	12	12	10	10	10	12	SW
OCEANIA AUSTRALIA	10	12	12	12	15	15	30	30	30	30	20	20	20	20	15	15	15	12	12	12	10	10	10	10	W
JAPAN	15	20	20	20	20	30	30	30	30	20	20	20	20	20	20	20	15	15	15	15	12	15	15	15	NW

MID USA

MDT	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	
ASIA FAR EAST	20	20	30	30	30	20	20	20	20	20*	20*	20*	20	30	30	20	20	20	20	20*	20*	20*	20	20	N
EUROPE	20	20	20	20	20	15	15	15	15	15	15	20	20	20	20	20	30	20	30	30	30	30	20	20	NE
S. AFRICA	20	15	15	12	12	12	10	10	10	12	12	12	15	15	20	20	20	20	20	20	20	20	20	20	E
S. AMERICA	10	10	10	10	12	12	12	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	12	12	SE
ANTARCTICA	15	15	20	20	20	20	20	30	30	30	30	30	30	30	30	30	30	30	30	20	20	20	20	15	S
NEW ZEALAND	12	12	12	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	12	12	12	10	10	10	SW
OCEANIA AUSTRALIA	10	12	12	12	15	15	20	30	30	20	20	20	20	20	15	15	15	15	12	12	12	10	10	10	W
JAPAN	15	15	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	15	15	15	15	NW
CDT	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	

EASTERN USA

EDT	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	
ASIA FAR EAST	20	20	30	30	30	20	20	20	20	20*	20*	20*	20	20	20	30	30	20	20	20	20	20	20	20	N
EUROPE	20	20	20	20	20*	15	15	15	15	20*	20	20	20	20	20	20	30	30	30	30	30	20	20	20	NE
S. AFRICA	20	20	15	15	12	12	10	10	10	12	12	12	15	15	20	20	20	20	20	20	20	20	20	20	E
CARIBBEAN S. AMERICA	12	10	10	10	10	10	12	12	15	15	15	20	20	20	20	20	20	20	20	15	15	15	12	12	SE
ANTARCTICA	15	20	20	20	20	20	20	30	30	30	30	30	30	30	30	30	30	30	30	20	20	20	15	15	S
NEW ZEALAND	10	12	12	12	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	12	12	12	10	10	SW
OCEANIA AUSTRALIA	10	12	12	12	15	15	15	20	20	20	20	20	20	20	20	15	15	15	12	12	12	10	10	10	W
JAPAN	15	15	15	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	15	15	15	15	NW

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next **higher** band for possible openings.

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Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio England
c/o R.S.G.B.
Lambda House
Cranborne Road
Potters Bar
Herts EN6 3JW
England

Holland Radio
143 Greenway
Greenside, Johannesburg
Republic of South Africa

(continued from page 9)

cient associated with a teenager asking his parents to finance a new transceiver!

A comprehensive market survey would reveal that not all hams are affluent enough to afford such luxuries as $6,000 transceivers. The active-Amateur statistics clearly indicate that a large portion of the fraternity consists of retirees who must exist on fixed incomes. A properly equipped, modern Amateur station is frequently beyond their means. Although I am semi-retired, and am not by any means destitute, I rebel against the cost of the new Amateur equipment. I have countless associates who share this sentiment. This represents an untapped market. An astute manufacturer would recognize this vast potential.

What has been needed in the United States for a long time is a no-frills transceiver. It should have a quality design for CW and SSB operation. A maximum output power of 100 watts is adequate. It would not contain a speech processor, i-f shift or width circuit, nor would it need to have computer interface capability. A noise blanker is by no means a necessity, since most blankers are ineffective for the more common types of QRN, and they degrade the receiver dynamic range when activated. I also question whether or not a basic rig needs memory channels and two internal VFOs. Getting rid of the frills can bring the price of a good transceiver within the reach of those who can't, or don't, wish to invest several thousands of dollars in a hobby they use one or two days a week.

Joe nibbled at the edges of the problem in his HR editorial. I admire his tact and understand his limitations. But, someone needs to take the initiative toward encouraging the United States and foreign manufacturers to develop a *practical* transceiver that can serve our basic operating needs — especially those of the Novice and other new Amateurs. If a fancier rig is desired later on, rest assured they will buy it. But for now we need to get them started with the minimum of economic stress. What ever happened to the concept of high volumne and reduced per-unit-profit (shades of Henry Ford)? Small volume and high markup is not in the best interests of Amateur Radio.

Doug DeMaw, W1FB, Luther, Michigan 49656

generation gap in Amateur Radio

Dear HR:

Your editorial in the June issue reminded me of a similar request by Rich Rosen, regarding how to make Amateur Radio more accomodating and attractive. I remember some of the replies, both appropriate and absurd. At that time, the respondents felt that 1) it was up to the FCC to make it easier to obtain licenses, 2) the equipment manufacturers were not supplying sophisticated or inexpensive enough gear, 3) the technical challenges for Amateur Radio were diminishing, 4) there was an insufficient number of contests and prizes. The list went on.

I believe that Amateur Radio is experiencing the same phenomena that affects the entire country: a generation gap. Yes, I know that term is outdated but the application is here. The country has two (or more) generations of "wanna-bes" and "gimmes". Working couples spend more and more time away from home to provide more and more for their families. Their offspring are accustomed to essentially getting everything that they want.

Amateur Radio has and always will provide the kinds of challenges that people desire. I can't really fault anyone or anything for the decreasing number of ham operators. Society is changing rapidly. Societal expectations are changing just as quickly. Ham radio presents a kind of stable environment. I believe we are all caught up in changes, whether or not we like it or know it.

I would appreciate your printing this letter, and I encourage responses from the readers.

Larry Caracciolo, N3CCW

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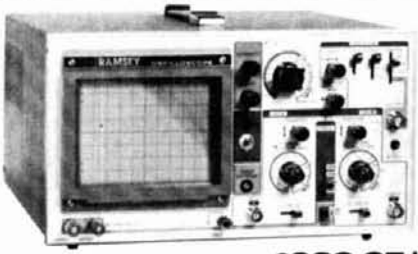

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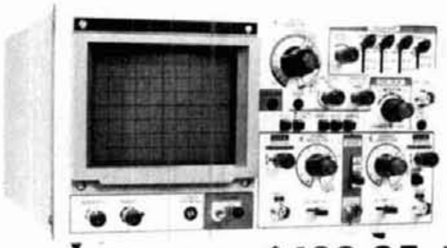

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CT-70	20 Hz-550 MHz	< 50mv To 150 MHz	1 PPM	7	1Hz, 10Hz, 100Hz	139.95
CT-90	10 Hz-600 MHz	< 10mv To 150 MHz < 150mv To 600 MHz	1 PPM	9	0.1Hz, 1Hz, 10Hz	169.95
CT-50	5 Hz-600 MHz	LESS THAN 25 mv	1 PPM	8	1Hz, 10Hz	189.95
CT-125	10 Hz-1.25 GHz	< 25mv @ 50 MHz < 15mv @ 500 MHz < 100 mv @ 800 MHz	1 PPM	9	0.1Hz, 1Hz, 10Hz	189.95
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A complete tone decoder on a single PC board. Features: 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts.
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Simple Class C power amp features 8 times power gain 1 W in for 8 out, 2 W in for 15 out, 5 W in for 40 W out. Max output of 50 W, incredible value, complete with all parts, less case and T-R relay.
PA-1, 40 W pwr amp kit **$22.95**
TR-1, RF sensed T-R relay kit **6.95**

COLOR ORGAN
See music come alive! 3 different lights flicker with music. One light each for, high, mid-range and lows. Each individually adjustable and drives up to 300 W, runs on 110VAC.
ML-1 Kit **$8.95**

VOICE ACTIVATED SWITCH
Voice activated switch kit provides switched output with current capability up to 100 mA. Can drive relays, lights, LED or even a tape recorder motor. Runs on 9 VDC
VS-1 KIT **$6.95**

VIDEO MODULATOR
Converts any TV to video monitor. Super stable, tunable over ch 4-6. Runs on 5-15V accepts std. video signal. Best unit on the market! Complete kit, VD-1 **$7.95**

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Produces LOUD ear shattering and attention getting siren like sound. Can supply up to 15 watts of obnoxious audio. Runs on 6-15 VDC
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UNIVERSAL TIMER
Provides the basic parts and PC board required to provide a source of precision timing and pulse generation. Uses 555 timer IC and includes a range of parts for most timing needs.
UT-5 Kit **$5.95**

WHISPER LIGHT
An interesting kit, small mike picks up sounds and converts them to light. The louder the sound, the brighter the light. Includes mike, controls up to 300 W, runs on 110 VAC
WL-1 Kit **$6.95**

FM WIRELESS MIKE
Transmits up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.
FM-1 Kit **$3.95**
FM-2 Kit **$4.95**

SIREN
Produces upward and downward wail. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.
Complete kit, SM-3 **$2.95**

SUPER SLEUTH
A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.
BN-9 Kit **$5.95**

60 Hz TIME BASE
Runs on 5-15 VDC
Low current (25ma)
1 min/month accuracy
TB-6 Kit **$5.50**
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NEW
TELEPHONE TRANSMITTER
Low cost with professional performance. Features include: self phone line powered, tunable from 76 to 100 MHz, polarity antisensitive, compact size (½" x 1¼"), easily installs anywhere on the phone line or inside the instrument itself.
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HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

HAM RADIO FREEBIE. On a space available basis, we are going to offer you, our subscriber, a chance to sell your old, used equipment. Please send us a short description of what you want to sell along with price, name, address and phone number. We will run it once in the next available issue of HR. Please limit your ad to 20 words or less.

SALE COLLINS. 75S-3B, 32S-3 rec, trans P/S $700. 30S-1, linear, $1500 mint. Z-100/PC, 768k $600. Swan 350 P/S $250. Rich (516) 957-6308 nights.

WANTED: Smith Chart transmission line calculator made and sold by Ham Radio. W8VLN, 1328 East Main, Eaton, OH 45320.

MACINTOSH SATELLITE Tracking and Propagation Software. MacTrak™ displays graphic maps (rectangular, polar, great circle), views from space, schedules, windows. Also tracks Sun and Moon. Compatible with KLM/MIRAGE rotor interface. Shows gray line, sunrise/sunset, bearing/distrnac,e mUF vs time, areas of world "open". SASE for info or $49.95 from R. Stegemeyer, PO Box 1590, Port Orchard, WA 98366.

TEKTRONIX 547 Oscilloscope, 50 MHz-BP $135, Tek-1A1 $60, Tek-1A4 $120, Tek-1L30 Spectrum Analyzer, 0.9-10.5 GHz $350, Hewlett-Packard 606A Signal Generator, 0.05-65 MHz, $100k, HP-8708A Synchronizer $150, HP-3300A Function Generator $95, HP-686C Sweep Generator, 8-12 GHz $95, HP-9865A Cassette Memory $95. Lambda LB-701-FMOV Variable Regulated Power Supply, 300 amps, new $295. A. Emerald, 8956 Swallow, Fountain Valley, CA 92708. (714) 962-5940.

HALL ELECTRONICS buys radio broadcast equipment for cash! Jon Hall, WB4MMV, PO Box 7732, Charlottesville, VA 22906. (804) 973-8697.

CUSTOM EMBROIDERED EMBLEMS, & Enameled Pins, your design, excellent quality, low prices, free booklet. A.T. PATCH CO, Box 682 Dept 19, Littleton, NH 03561. (603) 444-3423).

IBM-PC RTTY/CW. New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.

HAMLOG COMPUTER PROGRAMS. Full features. 17 modules, auto-logs, 7-band WAS/DXCC. Apple $19.95, IBM or CP/M, KAYPRO, Tandy, C128 $24.95. HR-KA1AWH, POB 2015, Peabody, MA 01960.

IAMBIC KEYER Low cost, low-current-drain. Designed by Paul Newland, AD7I. Features dot and dash memory, side tone generator and key circuit current amplifier. Although the sidetone generator and keyer amplifier were touted as options in the article, the kit includes both of these functions. For Kit, order # 151-KIT $19.95. For Assembled board order #151-ASY $29.95. Add $2.50 shipping per order. Calif. residents add 6⁄ sales tax. Visa & M/C accepted. A&A ENGINEERING, 2521 W. LaPalma #K, Anaheim, CA 92801 (714) 952-2114. For circuit details, see June 88 QST.

HARK-RADIO ARCHIVES Non-profit, low income newsletter for youth/elderly. $1 each. $6 bimonthly. 2308 Garfield *#304, Mpls, MN 55405.*

DIGITAL AUTOMATIC DISPLAYS. All Radios. GRAND SYSTEMS, POB 2171, Blaine, Washington 98230.

CHASSIS & CABINTS KITS. SASE. K3IWK, 5120 Harmony Grove Rd, Dover, PA 17315.

COMMODORE/AMIGA CUSTOM CHIPS very inexpensive. (eq. PLA/82S100-$13.25). Diagnostics and other hard to get items. New Heavy Duty Power Supply for the C64-$27.95 plus UPS. Send for complete catalog. KASARA, INC, 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-642-7634, 1-800-248-2983 (outside NY) or 914-356-3131.

WANTED military surplus radio equipment, we need, ARC-164, ARC-114, ARCj-115, ARC-159, ARC-186, ARN-118, RTj-1159A, Collins 718U-5, 719A, top dollar paid or trade for new Amateur gear. Write or phone Bill Slep (704) 524-7519. SLEP ELECTRONICS COMPANY, Highway 441, Otto, NC 28763.

HAMS-HELP. Handicapped Ham needs working HF rig with 10 meters, reasonably priced. Please help. Clem, KA3OUE. Call any time (412) 531-7443 EST.

CLOSED CIRCUIT TELEVISION EQUIPMENT. Discount pricing on cameras, monitors, sequential switches, pan tilt units, etc. Expert design assistance available. Dan Marshall, DETECTION DYNAMICS, 4700 Loyola Lane, #119, Austin, Texas 78723. (512) 345-8401.

WANTED: Operating and/or Maintenance Manual for the Gonset Model G-66B receiver. WE6N, 644 11th Avenue, Coos Bay, OR 97420-4405.

AN-PRC-64 *military radio wanted. Will pay top dollar for a unit* in very good condition. KC1EZ, Tim McInerney, 316 West 75th Street, New York, NY 10023 (212) 874-3333.

HRs 1970-79, plus 6 early issues, $170 plus shipping. Ned, W1RAN (203) 447-1255 after 5 PM.

SELL: Drake TR-3 HF Xcvr, AC-4 Pwr supply, mic, spkr, swr. Mint condition with manuals. $250. Will ship. Rob, KE8JH, evenings (616) 327-2142.

WANT COLLINS KWM 2/A and accessories. Also looking for other Collins gear. Call after 4 PM EDST (201) 728-7938.

CALL SIGN BADGES: Custom license plate holders. Personal, distinctive. Club discounts. SASE. WB3GND, Box 750, Clinton, MD 20735. (301) 248-7302.

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RTTY JOURNAL—Now in our 36th year. Read about RTTY, AMTOR, PACKET, MSO'S, RTTY CONTESTING, RTTY DX and much more. Year's subscription to RTTY JOURNAL $10.00, foreign slightly higher. Order from: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1-3 PM Eastern. Nine hundred Amateurs in 40 countries. Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

MARCO: Medical Amateur Radio Council, Ltd, operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

RUBBER STAMPS: 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224. (213) 774-1255.

DIGITAL AUTOMATIC DISPLAYS. All Radios. GRAND SYSTEMS, POB 2171, Blaine, Washington 98230.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

COMING EVENTS

Activities — "Places to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC, ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

VIRGINIA: August 7. The 38th annual Winchester Hamfest, sponsored by the Shenandoah Valley ARC, Clarke County Ruritan Fairgrounds, Rt 7, 2 miles west of Berryville. 7 AM—3 PM. Admission $4. Children under 12 and wives free. Tailgaters and tables $5. License exams. Talk in on 146.22/.82 and .52. For information Joanne Blaker, WB2CMV (703) 869-4878 or write SVARC, POB 139, Winchester, VA 22601.

PENNSYLVANIA: August 7. The 51st Hamfest of the South Hills Brass Pounders and Modulators ARC of Pittsburgh, south campus of Community College of Allegheny County, West Mifflin. Outdoor/indoor flea market, forums. Talk in on 146.13/73 and 146.52. For information Doug Wilson, WA3ZNP, 185 Orchard Avenue, Emsworth, PA 15202.

NEW YORK: August 20. 7th annual Finger Lakes Hamfest. Sponsored by the Tompkins County ARC. New Location—4-H Acres of Rt 13 NE of Ithaca. Donation $3. Flea market space $1. Wheelchair accessible. Free overnight camping. Talk in on 37/97 or 52. For information contact the Kings, N2GFW or N2GFX, Box 227, Etna, NY 13062. (607) 347-4313.

INDIANA: August 7. The Porter County ARC's annual Northwest Indiana Hamfest & Computer Fair, Porter County Fairgrounds & Expo Center, Rt 49, east of Valparaiso. 7 AM. 6 AM vendors. General admission $3.50, under 12 free. Walk-in license exams 8 -10 AM all classes. Talk in on 146.775/175 or 146.52. For information Jamie Veiner, NS9A, POB 1782, Valparaiso, IN 48384.

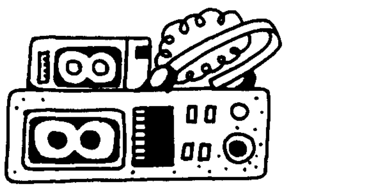
INDIANA: August 7. Angola Hamfest and FM Picnic, Steuben County 4-H Park on Crooked Lake. Gates open 7 AM. Indoor/outdoor spaces. Talk in on 147.21. For information Steuben County Radio Amateurs, POB 252, Angola, IN 46703.

MINNESOTA: August 14. The St. Cloud ARC's Hamfest, Whitney Senior Center in St. Cloud. Ticket donation $3.00. Extra ticket $2.00. Talk in on 34/94 primary, 615-015 sec. Contact: SCARC, Box 141, St. Cloud, MN 56302.

NEVADA: August 20. The combined radio clubs of Reno are sponsoring Reno Hamfest '88, California Building, Idlewild Park. 9 AM to 5 PM. Admission $3. Swap tables $7. License exams, Ham swap, refreshments. Talk in on 146.61 and 147.30+. For information, registration and VE exam SASE to Curley Silva, K7HRW, 3780 Hummingbird Drive, Reno, NV 89506.

TENNESSEE: August 28. The Lebanon Hamfest sponsored by the Short Mountain Repeater Club, Cedars of Lebanon State Park, US 231, 7 miles south of Lebanon. Outdoors only. Bring own tables. Talk in on 146.31-146.91. For information MaryAlice Fanning, KA4GSB, 4936 Danby Drive, Nashville, TN 37211.

MISSOURI: August 28. The St. Charles ARC will sponsor Hamfest 88, Blanchette Park, St. Charles. 6:30 AM-2:30 PM. Free admission and parking. License exams. Handicapped parking. Tailgating $2/space. Talk in on 146.07/67 rep and 146.52. Contact Eric Koch, NF0Q, 2805 Westminister, St. Charles, MO 63301. (314) 946-0948.



OPERATING EVENTS

"Things to do . . ."

Littleton, Colorado: August 21. The Arapahoe Radio Club's annual "Fourteener"s expedition operating from 14,000-ft mountain peaks in the Colorado Rockies. Listen for CQ 14. For certificate send QSL and legal SASE to K9AY, 7277 S. Clermont Drive, Littleton, CO 80122.

HAM RADIO TODAY has joined the programming lineup from the Voice of the Andes, HCJB Radio, an international broadcasting station that has been operating from Quito, Ecuador since 1931. Programming includes news from all over the world, construction hints, propagation news, equipment reviews and much more. For more information contact John E. Beck, Producer, HAM RADIO TODAY, c/o HCJB Radio, Box 691, Quito, Ecuador, SA.

Uncle Bill's Commodore C-64 Computer Software

by Bill Clarke WA4BLC

CODE COURSE

This computer program is broken into three user friendly parts. Part one introduces to the beginner the different morse characters. The student simply presses a key and the character is sent and displayed on the screen. Part two generates the morse character and the student is required to press the correct key on the computer. If the student answers incorrectly, the character is automatically resent. Part three sends morse characters in random groups of five. The student can tailor what is sent to their particular needs; numbers only, letters only or a combination of both. Speeds are from 5 to 20 groups per minute. The computer can also be configured to send the Farnsworth method (high speed/slow spacing code.) V 2.2

☐ **UB-CC (For C-64) $9.95**

KODE MASTER (for Novice, General or Extra Class students)

Prepare for your next code exam using computer generated QSOs. Each QSO contains callsigns, names, QTH's equipment info plus many of the other exchanges commonly found in Ham QSO's. QSO's can be displayed on the screen by one character at a time, by each sentence or after the completion of the QSO for checking. With a printer you can print out a hard copy. Available in 5 wpm for Novices, 13 wpm for Generals and 20 wpm for Extra class students.

☐ **UB-KN Novice Class (for C-64) $14.95**
☐ **UB-KG (for C-64) $14.95**
☐ **UB-KE Extra Class (for C-64) $14.95**

ANTENNA SYSTEM

This nifty antenna modeling and development program will help you get the most from your antenna projects while eliminating much of the drudgery of antenna calculations. Part one covers standard design antennas—dipoles, verticals and Yagi designs. Part two designs shortened dipole antennas for space limited hams. Great for shortened 160/80 meter antennas. All dimensions are listed. At this price it's not an engineering program but a neat program to have around.

☐ **UB-AS (for C-64) $9.95**

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