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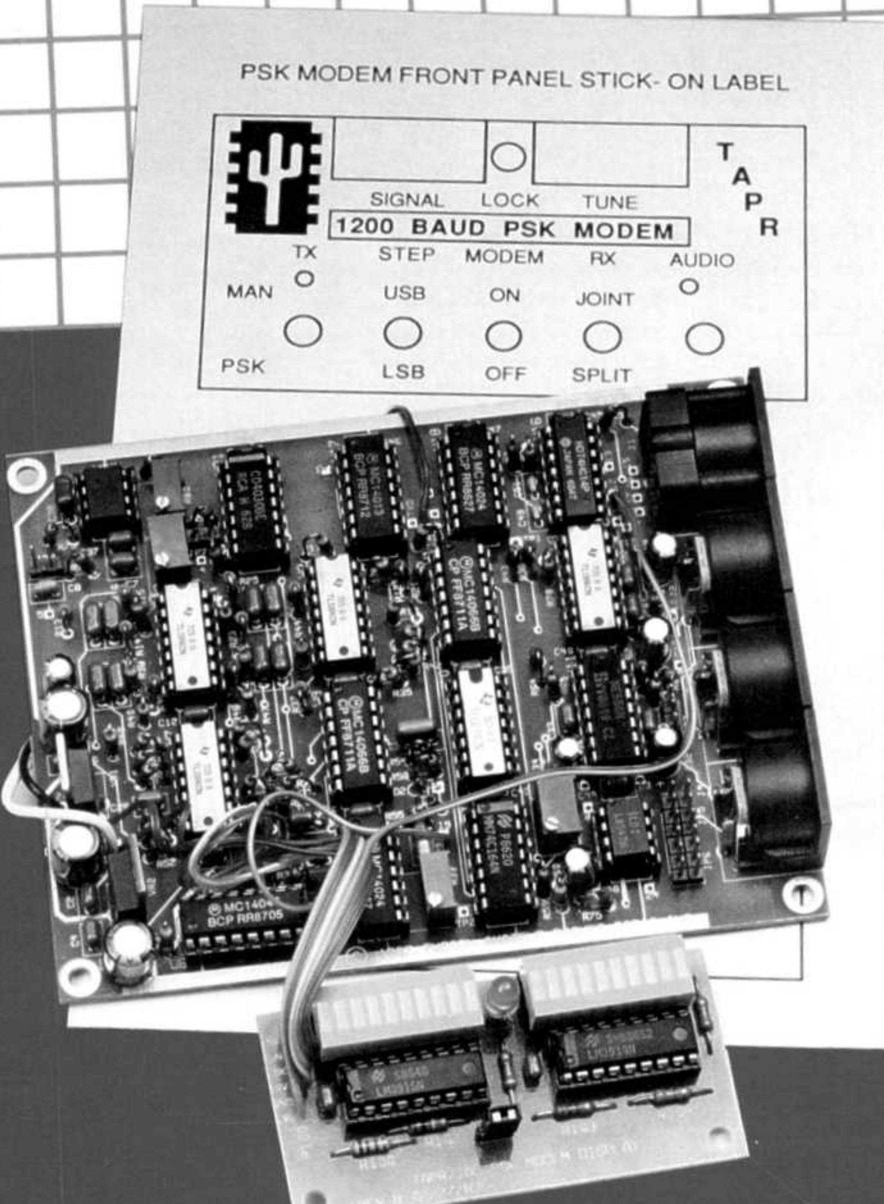

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COLUMNS

ABOUT THE COVER

The TAPR PSK modem decodes FO-12's packet signals. Features include a dual-mode modulator, bar-graph style LED indicators in the center-tune and signal-level circuits, and a low-overhead dc power supply. See page 3 for details.

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Purposes of *QEX*:

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

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

Both theoretical and practical technical articles are welcomed. Manuscripts should be typed and double spaced. Please use the standard ARRL abbreviations found in the 1985 and 1986 ARRL Handbooks and in the January 1984 issue of *QST*. Photos should be glossy, black-and-white positive prints of good definition and contrast, and should be the same size or larger than the size that is to appear in *QEX*.

Empirically Speaking. . .

The 13-cm Band

With the threats to other Amateur Radio frequencies, we should not be unaware that our microwave bands have become an ever more tempting takeover target for other services. Many covet those frequencies for terrestrial circuits and for communications to and from space. Now is the time for a coordinated effort to increase the development of the 13-cm band (2300-2310 & 2390-2450 MHz) to the same degree as the 23-cm band (1240-1300 MHz). That means hams actively using the band, and having a variety of production-model radio equipment available for both terrestrial and earth station communications systems. There are good reasons for achieving this goal by 1992.

It is in the best interest of Amateur Radio for us to encourage band occupancy and thus "stake our claim." The band for US hams is 70 MHz wide, giving room for all sorts of Amateur Radio communications. This includes the usual voice, image and data modes with high-speed digital communication for interconnects and networking.

As interest in high-speed communications increases, our need for this spectrum will grow rapidly. This is true for high-speed digital communications, and especially so for networks that will carry image information. There is only limited space available in the 33-cm (902-928 MHz) and 23-cm bands. Frequencies in those bands will be needed (and used) as networks are built, but those bands will not be enough. The 13-cm band will play an important role in developing a national high-speed digital network for Amateur Radio.

Phase-4 satellites are planned for launch in approximately five years, and will use frequencies in the 13-cm band for both high-speed digital communications and multichannel repeater linking. Current plans call for uplinking in the 23-cm band, and downlinking in the 13-cm band.

If the Phase-4 satellites are to be successful, the necessary equipment to communicate through the satellites must be available prior to (not later than) launch. A dedicated few will build their own equipment. However, most hams will want to purchase off-the-shelf equipment. Even if the Phase 4 Amateur Radio satellite program is less than a complete success, equipment can be used for terrestrial communications.

A most important step is to get amateurs on the band. It will require hams interested in the band, and willing to buy equipment for the 13-cm band, to achieve "critical mass" and thereby encourage manufacturers to build the equipment needed to realize development of the band.

Some Amateur Radio manufacturers are already marketing products for use in the 13-cm band. These products include transverters and antennas. These products should be advertised and featured in product announcements and reviews.

The challenge to Amateur Radio organizations, publishers and individuals is how to "activate" experimenters and—more importantly—operators. Those operators are people that must be encouraged and facilitated. They have to be convinced that there is a need to occupy and use the 13-cm band.

It will require broadly based and immediate action to succeed in developing the 13-cm band, and to have commercial equipment available in time for Phase-4 satellite launch. That action should include:
Studies of urban noise levels, particularly with regard to possible problems from microwave ovens. Investigation of circular polarization on terrestrial circuits. (Will be used in Phase 4 Satellites.) Club sponsored activities to increase awareness of and activity on the 13-cm band. Packet radio and repeater groups to consider the role of the band in networking and repeater linking plans. Conference organizers to solicit papers and plan to include forums on related subjects. We should explore areas of cooperation with the microwave communities in Europe, Japan, Australia and New Zealand. Feature articles and booklets should be published on equipment, operating, propagation, developments and achievements, etc. Importers should look for equipment to sell. Manufacturers should begin the planning and development necessary to have commercial equipment available by 1992.

It is no secret that we have been working on a book on UHF and microwaves here at ARRL HQ. That book will help in this effort. AMSAT President, Vern Riportella, WA2LQQ, has discussed this need in an editorial published in July 1987 *ham radio magazine*. Bill Olson, W3HQT, will lead the way in *QEX* with his new column. Watch *QEX* and *QST* for more articles on the subject.

It will take the combined efforts of organizations and individuals that are opinion leaders to develop the 13-cm band on this accelerated basis. It can, and should, be done. Will you help?—K8CH

The TAPR PSK Modem

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Background

In 1983, the Japan Amateur Radio Satellite Corp (JAMSAT) began to prepare for the launch of their first Amateur Radio satellite. One of their projects included a PSK demodulator to decode JAS-1 packet signals. Several months prior to the August 1986 launch of Fuji-OSCAR 12 (FO-12), JAMSAT and the Tucson Amateur Packet Radio Corp (TAPR) collaborated to make available a kit version of the JAMSAT design. The modem is now available to all amateurs through TAPR.[1]

Overview

The information presented here is not for construction purposes. Instead, it is meant to be a preview of the TAPR PSK modem kit. The TAPR PSK modem contains some refinements of the design published in *QEX*.[2] The modifications are the result of many hours of work by Tom Clark, W3IWI; Eric Gustafson, N7CL (who also did the PC board layout); Dan Morrison, KV7B; Mike Parker, KT7D; and myself. TAPR's version includes: a dual-mode modulator, bar-graph style LED indicators in the center-tune and signal-level circuits, a low-overhead dc power supply, a highly-configurable up/down tracking system, optimized PLL, and an interconnection system to allow for ease of switching between FSK and PSK operation.

The Modulator

The modulator circuit in Fig 1 generates edge-synchronized 1200 bps data in Manchester format per the requirements of FO-12's demodulators. This circuit consists of portions of U16, U17, U18 and U21.

The incoming Tx Clock signal (19,200 Hz for TNC 2s or 38,400 Hz for TNC 1s) is buffered and applied to divider U18. The 1200 Hz output of U18 (divide-by-16 for TNC 2s, or divide-by-32 for TNC 1s) is then routed to PSK modulator U21B, an XOR gate.

The other input to U21B is the buffered Tx Data signal. The buffered Tx Data signal is also applied to U17B, a D flip-flop. U21D (an XOR gate) generates an error signal between the D and Q nodes of the flip-flop if a data signal edge occurs that is not in perfect synchronization with the clock. This error signal is applied to divider U18, causing a reset. In this manner, the divided clock signal fed to U21B is in edge-synchronization with the data.

The square-wave output from U21B is fed through resistive divider R5-R6 and RC low-pass filter R7-C8 to the transmitter. Audio bandwidth shaping in the transmitter is required to produce reasonably clean modulation of the RF signal.

For work with FO-12, this modulator is entirely satisfactory. For other applications, however, the generated modulation spectrum may not be optimum. For this reason, an alternative, variable-frequency, non-edge-synchronized clock signal is available. Generated by U24, an LM555, this clock is divided by U17A to produce a square-wave signal that is variable from about 1000 to 2500 Hz. Use of this clock allows you to properly center the modulating audio spectrum for best match to the particular characteristics of the station transmitter. This is especially helpful when using an SSB transmitter, where the IF filters may have poor phase response or group-delay characteristics when driven by the JAS-compatible modulator.

Bar-graph Displays

Adjusting the audio signal level applied to the modem and receiver tuning are aided by easily duplicable and inexpensive LED displays (Fig 2). The LEVEL indicator is a logarithmic display based on the LM3915. Extensive experimentation indicates that the linear-type LM3914 lacks sufficient dynamic range to work effectively with the PSK demodulator because it is limited to an 8-dB range. The LM3915 provides about 27 dB of indicating range; this roughly matches the useful signal amplitude range of the demodulator. In use, the average signal level is adjusted so that the 6th or 7th LED (Q6 or Q7 output) is lit and signal peaks generally do not illuminate the 10th LED. A bar- or moving-dot display is selected by means of jumper JP200 (open or default for dot, closed for graph).

The center-tune indicator takes information from the PLL control voltage and provides an intuitive display—simply tune the receiver to center the dot after first setting the audio drive level. A LOCK LED alerts the operator when the PLL is synchronized to an incoming signal.

Power Supply

The power supply of Fig 1 is simple. An LM7805 three-terminal regulator provides the required +5 V dc output.

A clean source of +12 V dc is not always easily obtainable, and the last thing we need in a modem is a dirty supply! Testing showed that +10 V dc is an adequate level for the most-positive power rail. Therefore, a low-forward-drop regulator, the LM2930T-5.0, is cascaded with the +5 V dc supply. This provides +10 V for the modem with only a 10.2 V input requirement.

Up/Down Tracking

Each manufacturer has their own way of adding features to a radio. The features include up/down tuning buttons found on the microphones of most microprocessor-controlled radios, both HF and VHF. Some manufacturers require that a ground be applied to a certain pin, others require that a positive voltage be applied. Some future twist might require a different input (how else can you capture the microphone accessory market for your particular radio?), so a generalized interface was sought.

Fig 3 shows the solution—a dual opto-coupler. A pair of timers (LM556, U11), when driven by comparators, check the VCO control voltage against preset limits (U10C and U10D), and drive the inputs of isolator U12. An RC network (R75/C48) controls the duration of applied pulses. High-efficiency couplers in U12 (ILD-2) ensure that the respective output transistor is driven well into saturation.

The floating transistor outputs are then applied to a pair of 6-pin headers (JP5 and JP6). Push-on jumpers allow selection of two common configurations (pulling an open collector to ground or an open emitter to +5 V dc). Almost any conceivable microphone wiring arrangement can be accommodated by hard wiring.

PLL Refinements

The PLL in the original Costas loop is considerably underdamped. This makes the circuit somewhat input signal level sensitive, as well as subject to overshoot.

[1]Notes appear on page 8.

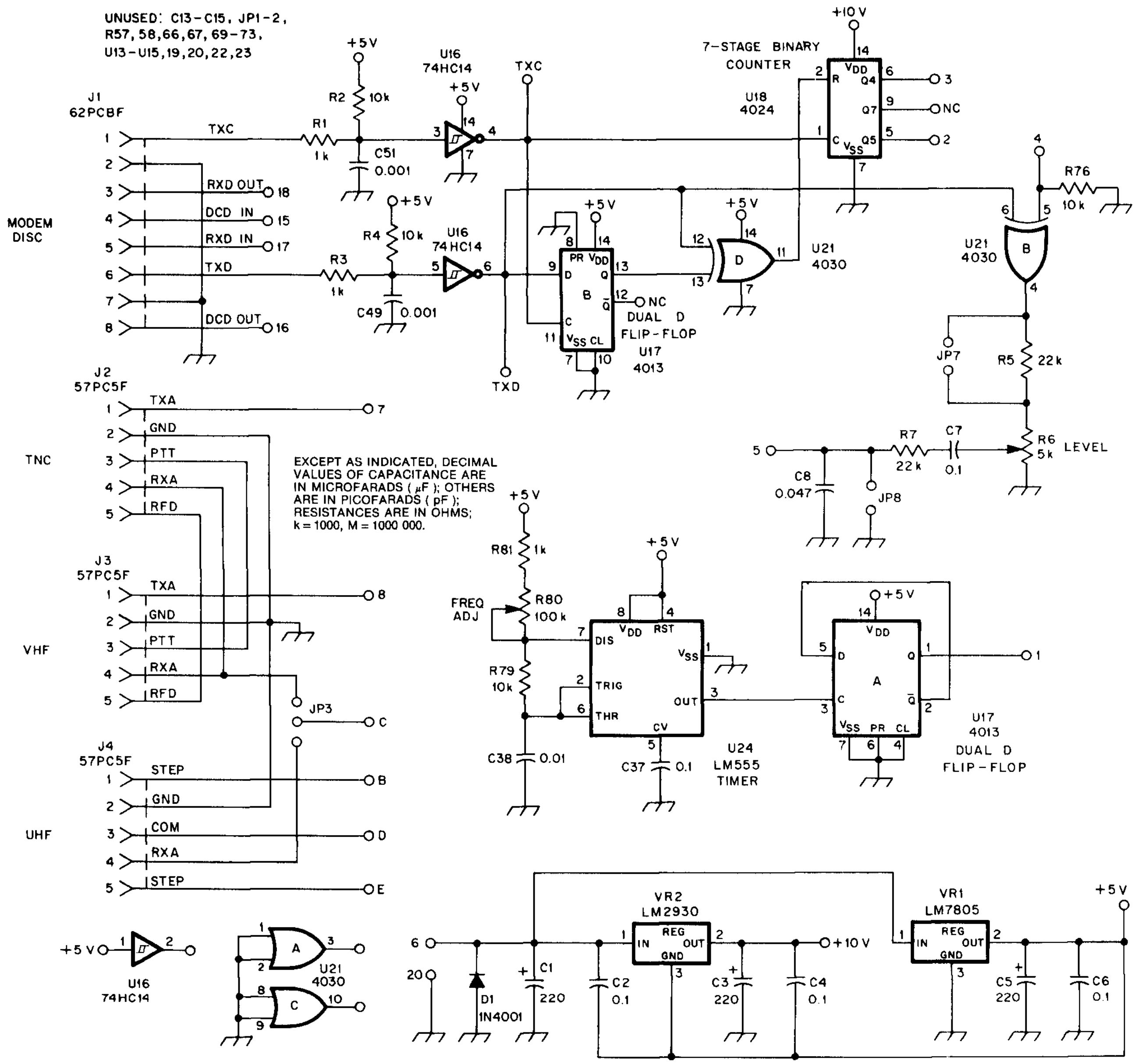

Table 1

Numbered Pad Functions For Figs 1 and 3

1—PSK 1600-Hz clock signal output (TTL)
2—JAS 1200-Hz clock signal output (TTL/TNC 1)
3—JAS 1200-Hz clock signal output (TTL/TNC 2)
4—PSK/JAS clock signal input (TTL)
5—XMIT audio signal from PSK modulator
6— + 1 X to 6 V dc power in
7—XMIT audio from TNC FSK modulator
8—XMIT audio signal to VHF radio
9—Audio signal out (to LEVEL potentiometer)
10—Audio signal in (from LEVEL potentiometer)
11—RX data (TTL) from PSK demodulator
12—DCD output to display board
13—DCD (TTL) from PSK demodulator
14—Tune signal to display board
15—DCD (TTL) to TNC HDLC controller
16—DCD (TTL) from TNC FSK modem
17—RX data (TTL) to TNC HDLC controller
18—RX data (TTL) from TNC FSK modem
19—LEVEL signal to display board
20—Power common in
21—AFC step-down pulse to switch
22—AFC step-down pulse from switch
23—AFC step-up pulse to switch
24—AFC step-up pulse from switch

Fig 1—Schematic of the 10.2-V driven dc power supply and dual-mode modulator. All TNC and radio interface connectors are shown. This circuit fits on the main PC board. (This schematic is not drawn to *QEX* style so that it remains consistent with the TAPR design.)

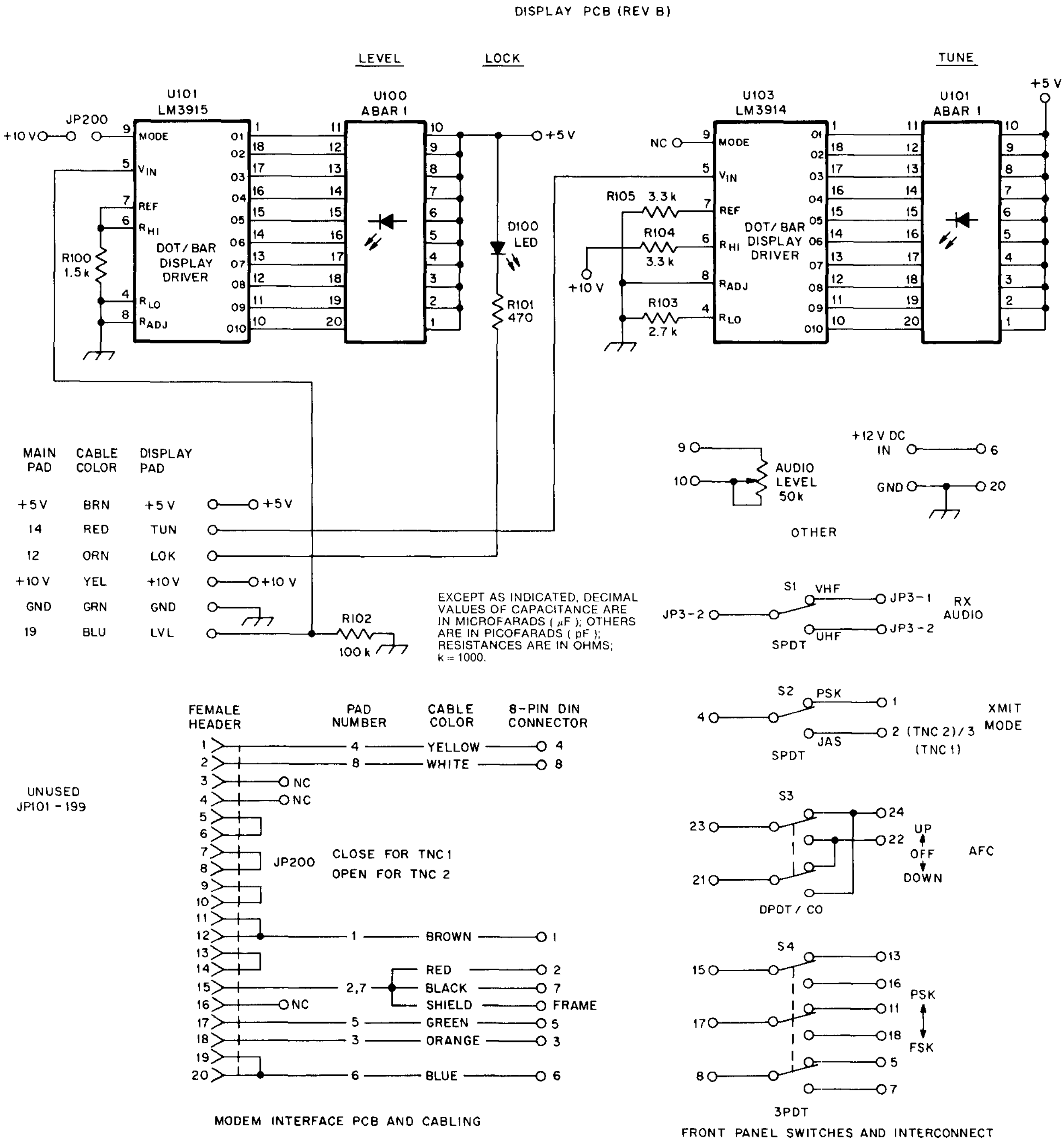

Fig 2—The top half of this schematic details the display circuits contained on the display PC board. Note that the jumper is labeled JP100. The lower left side of the circuit is the modem disconnect, a separate PC board, usable with both TNC 1 and TNC 2 style external modem interfaces. (This schematic is not drawn to *QEX* style so that it remains consistent with the TAPR design.)

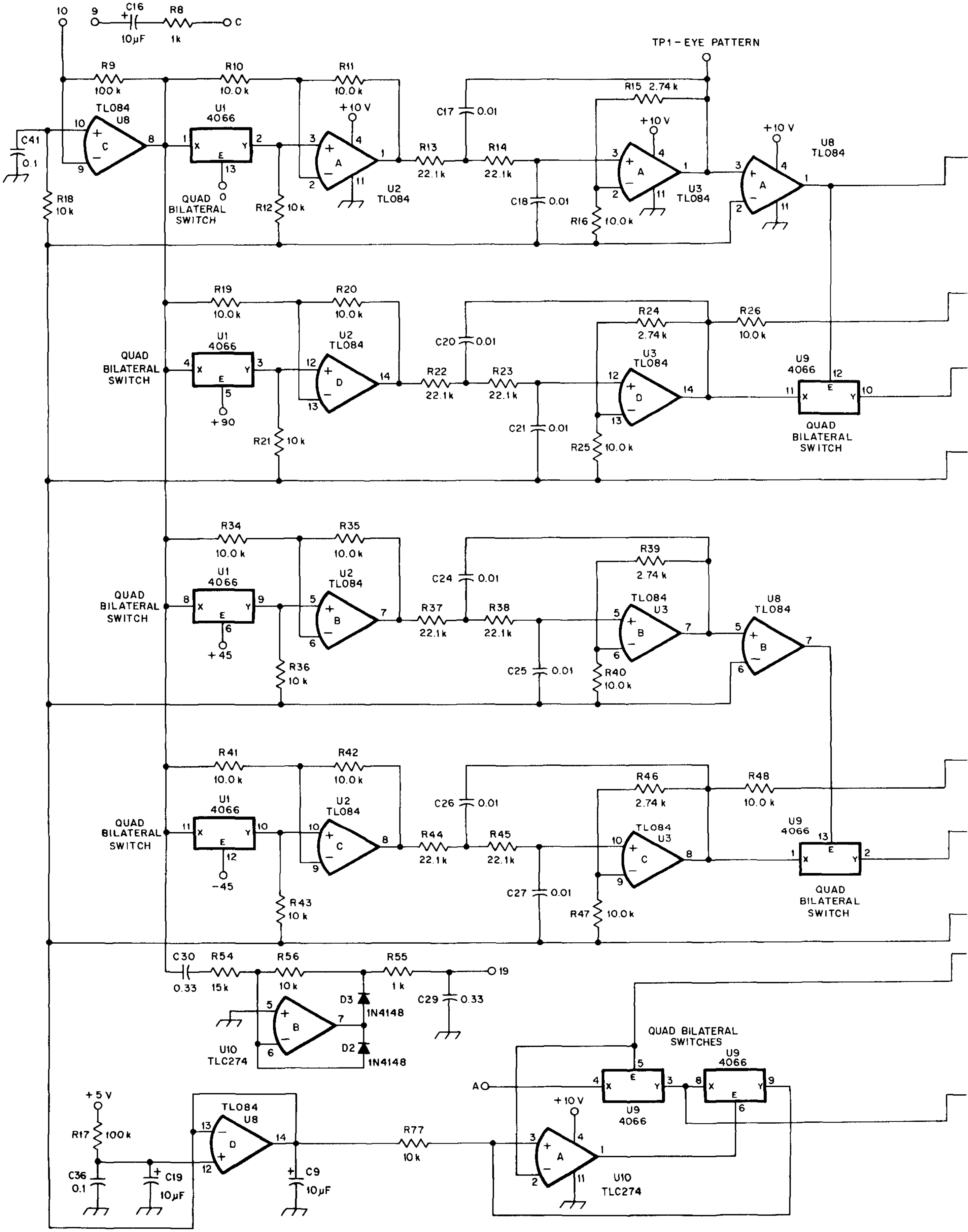
10
9
C16
10µF
R8
1k
C
TP1 - EYE PATTERN
R9
100 k
R10
10.0 k
R11
10.0 k
TL084
U8
U1
4066
+10 V
C17
0.01
R15 2.74 k
+10 V
+10 V
U8
TL084
C41
0.1
R13
22.1 k
R14
22.1 k
U2
TL084
U3
TL084
QUAD
BILATERAL
SWITCH
R18
10 k
R12
10 k
C18
0.01
R16
10.0 k
R19
10.0 k
R20
10.0 k
R24
2.74 k
R26
10.0 k
U1
4066
U2
TL084
C20
0.01
U3
TL084
U9
4066
QUAD
BILATERAL
SWITCH
R22
22.1 k
R23
22.1 k
+90
R21
10 k
C21
0.01
R25
10.0 k
QUAD
BILATERAL
SWITCH
R34
10.0 k
R35
10.0 k
R39
2.74 k
U1
4066
U2
TL084
C24
0.01
TL084
U3
U8
TL084
QUAD
BILATERAL
SWITCH
R37
22.1 k
R38
22.1 k
+45
R36
10 k
C25
0.01
R40
10.0 k
R41
10.0 k
R42
10.0 k
R46
2.74 k
R48
10.0 k
U1
4066
U2
TL084
C26
0.01
TL084
U3
U9
4066
QUAD
BILATERAL
SWITCH
R44
22.1 k
R45
22.1 k
-45
R43
10 k
C27
0.01
R47
10.0 k
QUAD
BILATERAL
SWITCH
C30
0.33
R54
15 k
R56
10 k
R55
1 k
19
D3
1N4148
C29
0.33
D2
1N4148
U10
TLC274
QUAD BILATERAL
SWITCHES
U9
4066
A
U9
4066
+5 V
R17
100 k
TL084
U8
+10 V
R77
10 k
C36
0.1
C19
10µF
C9
10µF
U10
TLC274

Fig 3—The PSK demodulator and the Costas loop. Comparing this circuit to that which appeared in *QEX*, the PLL, integrator, display driver, and AFC circuit changes are apparent. This circuit also mounts on the main PC board. (This schematic is not drawn to *QEX* style so that it remains consistent with the TAPR design.)

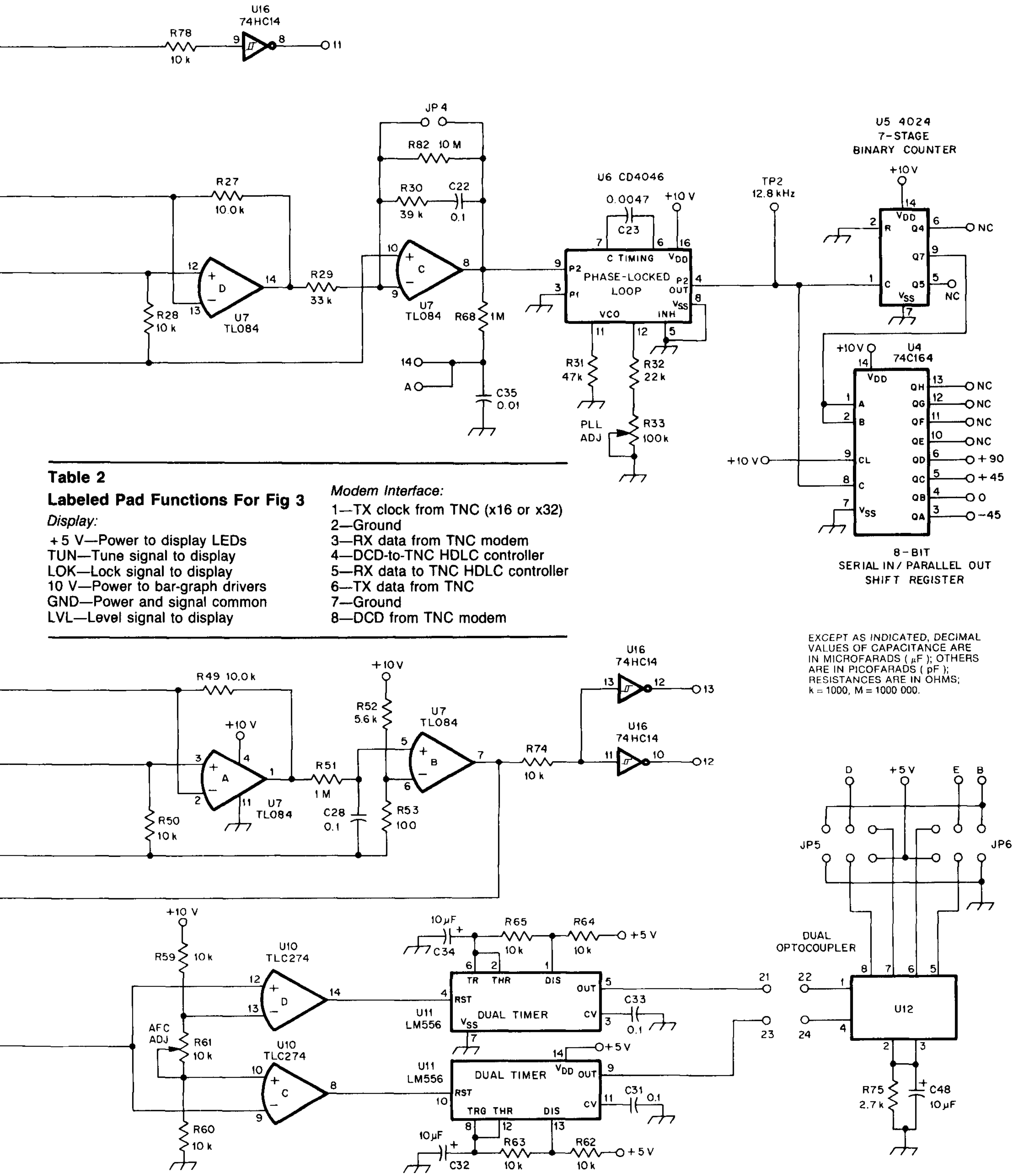

Table 2
Labeled Pad Functions For Fig 3

Display:
- +5 V—Power to display LEDs
- TUN—Tune signal to display
- LOK—Lock signal to display
- 10 V—Power to bar-graph drivers
- GND—Power and signal common
- LVL—Level signal to display

Modem Interface:
- 1—TX clock from TNC (x16 or x32)
- 2—Ground
- 3—RX data from TNC modem
- 4—DCD-to-TNC HDLC controller
- 5—RX data to TNC HDLC controller
- 6—TX data from TNC
- 7—Ground
- 8—DCD from TNC modem

This condition was experienced during early test stages by N7CL, KV7B and KT7D when they attempted to copy FO-12 on an ICOM R7000A receiver (which tunes in 100-Hz steps). Lock was lost on most steps unless the utmost care was exercised in tuning and audio level control.

The modified loop values shown in Fig 3 (see U6 and U7C) offer considerable tolerance to input signal level. These components also allow for frequency steps of about 200 Hz while remaining in lock, and provide perfect copy on FO-12 downlink signals. This was demonstrated by tracking the rapid Doppler-shifted downlink from FO-12 manually, rather than by using the AFC circuitry of the demodulator.

Finally, a high-value "bleed" resistor was inserted around the integrator (R82 at U7C) so that the resting dc level would be closer to ½ V_{dd}, rather than at one rail or the other. This aids in signal acquisition time for the PLL.

System Interconnection

The TAPR PC board set includes a display board for the bar-graph indicators, a modem interface board for use at the modem disconnect on TNC 1s and TNC 2s, and the main PSK board. The modem interface board solves a problem noted by W3IWI during testing, in which a TNC 2 connected to the prototype modem with a 20-conductor ribbon cable was susceptible to RFI on a regular basis. While Tom's RF environment is somewhat atypical (multiple high-power VHF, UHF and regular HF transmissions), RF susceptibility of a radio modem is not a desirable characteristic!

The interface board provides the necessary signals to the outboard (PSK) modem through an 8-conductor shielded cable. The main board has an 8-pin DIN receptacle for the TTL level signals from the TNC modem disconnect. In addition, three 5-pin DIN connectors are provided that closely follow the TNC 2 pinout.

In a station using a TNC 2, the DIN cable from the 2-m transceiver is plugged into the PSK modem at the VHF connector. The TNC radio connections are routed through a cable with 5-pin DIN connectors on each end to the connector marked TNC. The 70-cm radio is attached to the connector marked UHF.

When S4, the PSK modem switch, is in the OFF, or FSK, position, the PSK modem is bypassed and the TNC is connected to the 2-m radio. The packet station will function normally.

When S4 is in the PSK position, the PSK demodulator is connected to the TNC, bypassing the TNC's FSK demodulator. The audio source for the PSK demodulator is the radio connected at the VHF jack if S1 is in the VHF position, or the UHF jack if S1 is in the UHF position. This selection capability allows use of independent radios (the TS711/811 or IC271/471) or multiband radios (the FT726).

Transmit audio is generated in the PSK modulator and applied to the VHF radio. When S2 is in the JAS position, the transmit audio is generated in the Manchester format. Normal PSK is generated when S2 is in the PSK position. The AFC switch, S3, allows the demodulator's automatic tracking feature to be disabled, or enabled with selectable polarity. In this way, LSB or USB reception may be used.

Operation

Modem operation is straightforward. Simply tune in a PSK signal, such as FO-12's Mode JD downlink. Adjust the receive audio level until the 6th or 7th LED is lit, with peaks rarely illuminating the 10th LED in the LEVEL display. If the peak-to-average signal level is unusually high, decrease the audio level. The peak signal level requirement is more important than the average level.

Next, tune the receiver until the TUNE display is centered and the LOCK LED illuminates. At this point, the AFC may be enabled. To verify that the receiver tunes, track the downlink Doppler shift. If it does not track properly, reverse the switch setting.

The demodulator should now function. Operate your TNC normally, with the MONITOR on to check the data in the downlink, and operate through FO-12 following JAMSAT's instructions.

The modulator is even easier to use. Merely verify that you are not overdriving your transmitter in the JAS mode. For terrestrial point-to-point use with SSB radios, you may need to experiment with sideband selection, drive levels and center frequency of the modulator clock. This is best accomplished with the cooperation of another station. Once you know your proper transmitter settings, operation should be the same as FSK packet use.

Parts Selection

The group discovered that some modem functions are critical to overall performance and the use of better-than-average op amps is required. In particular, the integrator that drives the VCO should be a high-impedance device such as the TLC274 or TL084—the ubiquitous LM324 is not suitable in this position.

The LM556 up/down circuit requires op amps that can drive to the ground rail. Even the TL084 isn't always usable here, and the TLC274 is strongly recommended for use at U10.

Notes

[1]A complete parts kit with PC boards is available from TAPR. Current prices are $100 for the complete kit, and $30 for the PC board set and manual, plus shipping and handling charges. Please contact the TAPR office at the address given in the byline of this article before you order. The ARRL and *QEX* do not warrant this offer in any way.

[2]F. Yamashita, "A PSK Demodulator for the JAS-1 Satellite," *QEX*, Aug 1986, p 3.

Bits

Magazine Chooses a Winning Design

For the second consecutive year, *RF Design Magazine* has sponsored an RF Design Awards Contest (Feb 1987 *QEX*, p 10). The winning entry was recently chosen from 30 technical papers and focuses on an odd-order frequency multiplier. Charles Wenzel of Wenzel Associates, TX, was grand prize winner of a Hewlett-Packard 8590A Spectrum Analyzer.

The purpose of Wenzel's circuit is to take advantage of the superior noise and switching characteristics of Schottky barrier diodes to make a high performance odd-order frequency multiplier. The July 1987 issue of *RF Design Magazine* details the winning entry in one of its feature articles.

And while speaking of RF Design, it is never too early to publicize their RF Expo East '87. This event is scheduled for November 11-13, 1987 at Boston's World Trade Center. The technical program will consist of 40-45 original papers organized into 15 sessions. RF engineers who are also Amateur Radio operators are encouraged to bring their 2-m hand-held transceivers. A special calling frequency will be posted in the registration area. For further information about the RF Expo East, call 1-800-525-9154 or 303-220-0600.

Thoughts on Emergency Use of Phase IIIC and Phase IV

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If continuing progress is to be made in the Amateur Space Service towards a Phase IV series of spacecraft, a general expansion of the uses and users of such satellites needs to take place.—Synopsis of the Phase IV Study Team Proposal as prepared by Jan King, W3GEY, VP of Engineering, AMSAT

What activities, that are not now being used, can the Phase III and Phase IV satellites support? More importantly, what uses will recruit *new* users to help provide the needed support and *justification* for the existence of the Amateur Space Service?

Six new unexploited uses are:

1) Emergency communications
2) Packet radio communications
3) Maritime communications
4) Mobile communications
5) Repeater interlinks/teleconferences
6) Traffic handling

This article addresses the potential and limitations of amateur satellites in the emergency service.

Emergency Communications

How useful a satellite is in an emergency situation depends on two things—its *availability* and *accessibility*. Existing Amateur Radio satellites orbit the earth at regular intervals, but emergencies rarely occur at convenient times.

The geosynchronous Phase IV satellites, currently in the design stages, will have a 24-hour per day availability. The first in this series, however, will not be ready for launch until 1991. Meanwhile, Phase III birds (Phase IIIC is to be launched in 1988) are available for up to 10 hours per day.

How accessible is the satellite? The best antennas, equipment, and operating environment are often *not* available during most emergencies. In turn, many skillful operators are also either not present or are needed elsewhere. These factors must be taken into consideration when emergency use of an OSCAR satellite is contemplated.

What equipment is most likely to be on hand during the early stages of an emergency? The minimum building blocks for an emergency station could be a typical 10-W, 2-m and a 10-W, 70-cm multi-mode transceiver, and mobile antennas with about 3-dBi gain for each band.

Emergency Uplinks

While we do not know *precisely* how well the Phase IV satellites will operate, based on Phase IIIB (OSCAR 10) data, we can project their *likely* performance.

If a 2-m or 70-cm whip with 3-dB gain is placed in front of a properly aimed reflector (Fig 1), an additional 1.5-2.5 dB is obtained for a total of 4.5-5.5 dB. (Antenna gain varies depending on how sensitive the whip is to detuning by the reflector.) The reflector can be any metal surface spaced 1/16-1/8 λ away from the whip so that the combined array is broadside to the satellite.

Table 1 gives the resultant signal levels that arrive at the satellite when our considered equipment is used with either a 146- or 435-MHz uplink signal. We are able to supply the satellite with about 17-dB S/N (signal-to-noise) on a 2-m uplink or 8.5 dB at 70 cm. The path loss at 435 MHz produces a signal arriving at the input of the spacecraft's receiver to be about 9 dB weaker than at 146 MHz (L_{path} = 20 LOG (F1/F2)). On OSCAR 10, the spacecraft (S/C) antenna gain is somewhat higher at 435 MHz than on 2 m.

Both Phase IIIC and Phase IV satellites will have Mode JL transponders with simultaneous uplinks at 146 and 1269 MHz, and overlapping downlinks at 436 MHz. An uplink will be possible on either 2 m or 24 cm, and the downlink will be on 70 cm.

Mode B will also be available on Phase IIIC. Direct comparisons can be made between the strengths and weaknesses of 2-m versus 70-cm uplinks, and 2-m versus 70-cm downlinks.

The Phase IV antenna gain may be limited to about 2-4 dBi because of physical constraints on the spacecraft. More optimistic models of Phase IV suggest as much as 8-10 dBi antenna gain is achievable on 2 m. This opens up new possibilities for direct satellite access by emergency or mobile stations.

Looking back at Fig 1, keep in mind that there is a 3-dB penalty if the emergency antenna is linearly polarized and not circular. Use of a linearly polarized antenna drops the calculated 17-dB S/N on 2 m to 14 dB, an acceptable signal if ACSSB techniques are used. Our already

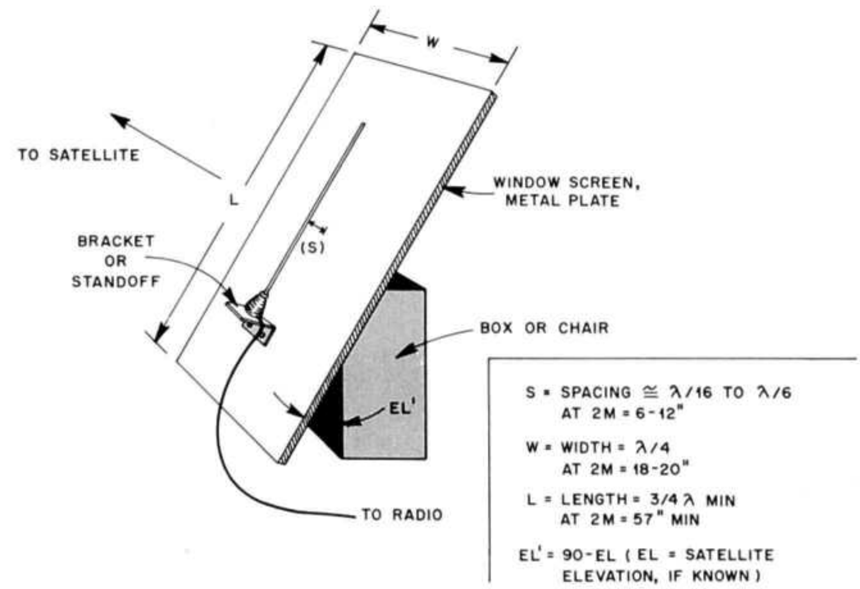

Fig 1—An emergency uplink antenna. By placing a mobile whip in front of a properly aimed reflector, an additional 1.5-2.5 dB gain is achievable.

Table 1

Emergency Uplink Signal Results

User Uplink:	*146 MHz*	*435 MHz*
P_o	10 W (+40 dBm)	10 W (+40 dBm)
L_{cable}	−1.0 dB	−2.0 dB
$G_{antenna}$	5.5 dBi	5.5 dBi
EIRP	40 − 1 + 5.5 = 44.5 dBm	40 − 2 + 5.5 = 43.5 dBm
Free Space Path Loss:		
L_{path}*	−169.0 dB	−178.5 dB
Spacecraft (S/C) Received Signal:		
S/C Antenna Gain	6.5 dBi	9.5 dBi
$L_{cable/relay}$	−1.0 dB	−2.0 dB
Signal at S/C RX	−120.0 dBm	−129.5 dBm
S/C Noise**	−137.0 dBm	−137.0 dBm
S/N at S/C***	17.0 dB	8.5 dB

* Based on 22,000 mile S/C to user distance. This distance varies depending on S/C location relative to a given user so that a few dB path loss variation will also be noticed.
** The Equivalent Noise Input of any receiver is:
N(eq) = −174 dBm + NF + 10 Log B(n)
where
NF = noise figure in dB
B(n) = noise bandwidth of the receiver (2400 Hz in this case)
This applies only when noise figure is 3 dB or greater.
*** This is the S/N ratio at the spacecraft's receiver output.

marginal 8.5-dB S/N on 70 cm drops to a very poor 5.5-dB S/N.

Several decibels of S/N level degradation also occurs on the satellite's downlink caused by transponder noise and intermodulation products. This could further reduce the 14 dB to 11 dB on 2 m, and place the 70-cm signal unacceptably close to the noise. The satellite will downlink an incoming signal with no better S/N than it receives.

If an emergency station has access to a 25-W PEP radio (4 dB more output than from a 10-W radio), the station may obtain an unprocessed (raw) uplink S/N of 15 dB at 2 m. With processing, that yields 28-dB *effective* S/N through the transponder using ACSSB techniques.[1] *Very* respectable uplink signals can be achieved if a 70- or 100-W, 145-MHz amplifier (and the dc power to use it) is available. The *average* power consumed on SSB or ACSSB is 1/4-1/10 that of full-carrier modes, and battery life is extended to several times that available when using FM equipment.

If a small 2-m beam is available for station use, it will have a 3-4 dB improvement over our previous figures. That provides the 10-W station with 14-16 dB raw S/N and the 25-W station with 18-19 dB. ACSSB techniques would improve the S/N to 27-28 dB and 34-35 dB, respectively—a moderate-to-good signal strength. A 100-W station would provide full-quieting signal levels to the satellite receiver.

[1]((S/N input + 3 dB) × 2) − 8 dB = S/N output (effective) using 2:1 ACSSB at S/N ≥ 13 dB.

We can conclude from this data that reasonable signal levels can be uplinked to the satellite using 2 m. Uplinking on 435 MHz without the use of high-gain antennas or a high-power output is less effective because of higher-path loss.

Downlink Performance

Our downlink signal is on 70 cm (Mode JL, 435-438 MHz), but it is unlikely that a makeshift 70-cm collinear whip, even against a ground plane, has sufficient gain to overcome the path loss on this band. A small 70-cm beam should be easily obtainable from an OSCAR station. Non-OSCAR stations are also a potential source of small 440-MHz antennas. A number of circularly polarized antennas are already in use for OSCAR 10 and are easily transportable because of their relatively small physical size.

A typical OSCAR-10 downlink signal generates about 4-5 W PEP. This is about 3-5 dB above the beacon's 2-W signal. Although these values represent uplinks in excess of the recommended power level, 5 W seems to be the level most operators instinctively feel provides them with a *reasonable* downlink level at 2 m. Presumably, then, the observed OSCAR 10 Mode-B S/N performance levels are indicative of what Mode JL users on Phase IIIC or Phase IV will expect to achieve on the 70-cm downlink (Table 2).

Using a VU (volume unit) meter, many Mode-B stations monitored on my Kenwood TR-9000 receiver are 13- to 15-dB S/N above the noise level. At similar downlink levels, ACSSB processing provides 29- to 33-dB S/N measured on the VU meter with the *subjective* S/N being about 21-27 dB—again, reasonable signals. About one third of the OSCAR 10 stations exceed this level with resulting downlinks in the S3-4 region. A smaller number are weaker, and are heard only at an S1 level. S/N for the stronger stations has been measured as high as 27 dB (unprocessed S/N), while the S1 signals are typically in the 7-10 dB category, depending on the external noise level.

OSCAR 10 telemetry indicates that the transponder often "sees" about 10 dB or more of AGC depression caused by the cumulative effects of about one third of the users who insist on running 110 W to a pair of 13-dB gain antennas. This yields close to 4-kW EIRP! AGC action as high as 20 dB has been observed on some East Coast/European passes! Mode JL could see higher AGC depression because of the lower path loss on the 2-m uplink frequency. While 10-25 W is sufficient for a 2-m uplink, it doesn't take many 200- or even 100-W power hogs to override weaker DX or emergency stations!

I conducted OSCAR 10 tests with a

Table 2

435-MHz Downlink Analysis

S/C Power Out per User:	*2 W*	*5 W*
	33 dBm	37 dBm
S/C Antenna Gain	9.5 dB	9.5 dB
S/C EIRP per User	42.5 dBm	46.5 dBm
Path Loss (435 MHz)*	−178.5 dB	−178.5 dB
User's Antenna Gain	13.0 dBic	13.0 dBic
Cable Loss	−2.5 dB	−2.5 dB
Signal at User's Rcvr**	−124.5 dBm	−120.5 dBm
Equivalent Noise	−137.0 dBm	−137.0 dBm
User's Receiver S/N***	12.5 dB	16.5 dB

* Assumes 22,000 mi S/C distance.
** Pr = S/C EIRP − Path Loss + User's Antenna Gain − Cable Loss.
*** S/N with linear antennas will have a −3 dB power penalty. Add this (if applicable), and any gain difference, to evaluate other antennas.

single 11-dB gain antenna. When AGC was depressed 10 dB, my downlink signal was only 5-6 dB above the noise. During times of heavier transponder loading, even 40 W provided less than 10-dB S/N! On rare occasions, I was able to access OSCAR 10 after a Mode-L period, when Mode-B activity tends to be low. I frequently achieved the more than expected 10- to 12-dB downlink S/N using only 10 W, and 14-16 dB with 40 W.

It's amazing what *not* having 10-15 dB of AGC depression can do for weaker DX, emergency, or portable/mobile stations! What this says about emergency operation, unfortunately, is that stations using the minimal equipment we have discussed will be unable to compete with overpowered stations and the usual AGC depression found in the general passband. A separate dedicated IF should be set aside for emergency use to overcome this problem.

Indirect Access

Why do we need direct access between an emergency station and the satellite? As a leading proponent for development of Community Access Systems (CAS or gateway stations), one might think that I would propose this as the answer to the problem.

I have been involved in several emergencies. Amateurs sometimes place *too much* faith in their mountaintop machines to pull them out during a crisis. During one situation in which I participated, the group was required to move off the repeater to simplex for a time because the machine started to malfunction. On another occasion, not one repeater had power in the affected area. Another machine fell victim to fire. Often, available repeaters are busy with local emergency communications and cannot be spared for gateway operations. Obviously, if a CAS system *is* available in an emergency, it should be used. A further argument *for* using Mode-L (1270/436 MHz) or Mode-S (2400/1270 MHz) equipment, *if available*, is to eliminate mutual interference between terrestrial 2-m or 70-cm communications and satellite communications—an important factor in most emergency work.

The foregoing statements could be interpreted as an argument for using Mode B. Transmit operations on 70 cm at 435-438 MHz should have less impact on local 440-MHz FM receive operations than 146-MHz transmit operations would have on local 2-m FM receive operations. Then, again, we *still* must resolve emergency problems such as the lack of 117-V ac mains and battery drain. Less transmitter power is needed to uplink on 2 m than on 70 cm. The receive antenna required for 2-m Mode-B operation is larger than that used on 70 cm. Admittedly, there are potential problems with Mode-B or Mode-JL operation if co-sited with other local activities. There is some question, however, as to whether regional or national/international operations, such as would be appropriate using a satellite linkup would, necessarily, need to be co-sited with other 2-m or 70-cm operations.

The biggest argument *against* total reliance on Mode-L or Mode-S transponders is having the right equipment available at the right time, and in the right place. Some exploitation could be made of TVRO dishes for Mode-S communications. For example, the small town of Bartlett, NE, with a population of 150, has no fewer than 10 TVRO dishes.

The availability of transmit and receive equipment still raises its ugly head. Such equipment is less likely to be found in remote areas than in more-populated regions. Community Access Stations may alleviate this problem, but not to the point of "ready access" under emergency conditions, especially during the station's infancy.

Conclusion

Amateur satellites have great potential for use during regional emergencies if designed for this purpose. There are many counterbalancing factors to consider. Mode JL would have to be modified to include a special, high sensitivity 2-m uplink channel with a separate AGC from the general passband to help meet *all* possible emergency scenarios, including *direct access* by marginally-equipped ground stations.

Some of these concepts will be studied using the Phase IIIC satellite when it is launched in 1988. As part of the AMSAT Phase IV Study Team assigned to look into transponder design, I am interested in receiving responses to this article. Send your comments and an SASE to James Eagleson, WB6JNN, 15 Valdez Lane, Watsonville, CA 95076.

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OSCAR 10 Suffers Relapse

On August 11, 1987, OSCAR-10 command station operator Peter Guelzow, DB2OS, reported that the satellite had returned to ill health. For the next three months, OSCAR 10 should not be used for communication. Problems reoccurred because of the estimated angle of the sun—it is currently −40 degrees, and the illumination has decreased to under 75%. During the next several months, illumination will drop to nearly 0%.

DB2OS's report continued to say that the power budget is unbalanced, and the battery completely discharged. This was observed by FMing on the general beacon and from signals in the transponder's passband.

OSCAR 10 can no longer be automatically controlled by the on-board computer (IHU) because of the radiation damaged memory. To extend the satellite's life and to ensure maximum battery health, total abstinence is required until the sun's angle is able to charge the battery. The next period of communication begins around November 20, when illumination is better than 75%. Watch the *Amateur Satellite Report* for further information.—*Tnx Vern Riportella, WA2LQQ, PO Box 177, Warwick, NY 10990.*

California Eastern Laboratories Markets New Components

NEC introduces its UPG700 series—three GaAs digital ICs designed for high-speed digital signal processing. The UPG700B is a master-slave D-Type Flip-Flop with set/reset functions, the UPG701B is a master-slave T-Type Flip-Flop with set/reset functions, and the UPG702B is a three-input OR/NOR gate. Each chip can operate beyond a 2.4-Gbit/s data rate. The ICs are available in 16-pin ceramic packages and are highly reliable because of the stability of the WSi refractory gate metallization system. All the devices use ion-implantation, off-set 0.8-micron gate and air-bridge technology to provide the best high-frequency performance. Price is $197 each for quantities of 100; sample quantities are available.

Three new high-isolation IF amplifiers are designed specifically for use with video systems. Their high isolation prevents signal leakage during operation between 10-150 MHz at 10 V. The UPC1668, 69 and 70C are available in 8-pin DIP with a typical noise figure from 6.5-7.5 dB, and gain from 7.0-14.5 dB at 70 MHz.

New high-frequency silicon transistor arrays can be configured to provide a variety of functions ranging from double-balanced mixers to high-speed logic gates. Four microwave arrays are available—UPA101, 102, 103 and 104—and each has an outstanding H_{fe} linearity. They are available in either a 14-pin ceramic package with superior thermal dissipation, or in a 14-pin mini-flat pack with 35% size reduction.

For complete information on these new ICs, contact California Eastern Laboratories, 3260 Jay St, Santa Clara, CA 95054, tel 408-988-3500.

Circuit Designer's Interface for the IBM PC

By Larry Rockfield, W6UB
5370 Old School Rd
Pleasanton, CA 94566

The personal computer is popularly known for number crunching and word processing, but it can also be used for systems control, to record a voltage or current, or to display waveforms. I wanted to breadboard a circuit, check its preliminary performance with or without the use of my IBM® PC, then interface the circuit to the computer for analysis or control. How could I accomplish this?

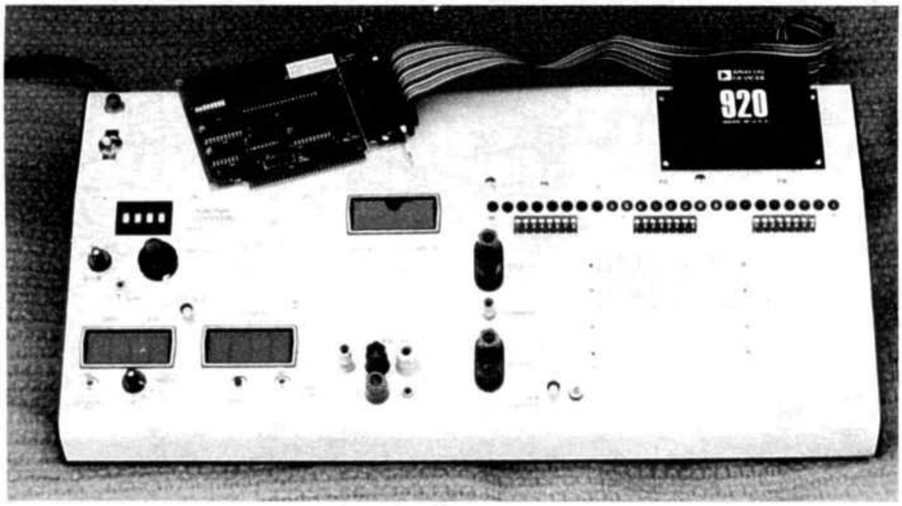

Fig 1—The MetraByte card's 24 I/O lines are terminated on three 8-bit terminal strips located above a solderless breadboard. Each I/O line is connected to CMOS-buffered color-coded LEDs mounted above the terminal strips. The LEDs provide instant visual feedback for breadboard input to the computer or computer output. Power supply voltage terminals, ±5 V and ±15 V, are to the left of the breadboard. Mounted further left is a 3½-digit voltmeter, a four-function decade timer, and a multi-function waveform generator. The frequency of the waveform generator is set by a bidirectional thumbwheel. The generator output is located near the bottom left of the breadboard with its output connected to a BNC and a quick-release post connector for convenient breadboard interface. The power switch and pilot light are mounted to the upper left of the case. An Analog Devices 920, ±15 V, 200 mA dc supply is shown in the upper right corner.[8]

Circuit Designer's Interface

To produce a test and measurements unit, I placed several small test instruments into one package with a direct computer link (Fig 1). The PC is tasked to check for proper operation of the interface unit and functions as a real-time oscilloscope. Intersil CMOS integrated component design is used in most interface sections to minimize discrete hardware, and parts of the unit are designed around Intersil data book circuits.[1] To link the computer's parallel bus to the circuit designer's interface, I purchased a programmable peripheral interface, the MetraByte PIO12.[2] The PIO12 board uses an 8255-5 chip with 24 programmable I/O lines that can be individually programmed in two groups of 12. The two groups control three ports: PA, PB, and PC. Three software-selected modes govern how the ports function.

Timer

An ICM7045 serves as a four-mode stopwatch/decade timer capable of driving eight 7-segment LED displays. Time display ranges from 0.01 seconds to 99 hours. The timer's standard mode operates like a stopwatch. Its sequential mode operates similar to the standard mode, but automatically resets on a second start/stop switch operation. In the split mode, time is cumulative. The rally mode is intended for timing events with interruptions.

A ICM7208 decade counter and scaler is housed in the same case as the timer. It measures frequency rather than time, and is a good choice for applications above a few Hz.

Digital Voltmeter

My circuit designer's interface uses an ICL7107 3½-digit A/D converter. The '7107 is a single-chip DVM designed to drive LED displays. The DVM project requires the 2-V full scale option with a voltage divider to provide 20 V full scale as a second range. If you do not already have these circuit components, you can use a commercial voltmeter.

Waveform Generator

The versatile Intersil ICL8038 generates sine, square and triangular waveforms. The advertised operating range of the generator is 0.001 Hz to 300 kHz.

Board Construction

Fig 2 shows the interface housed in a universal computer keyboard enclosure. Circuit layout is not critical, but it is a good idea to leave at least a ½-inch margin between the hardware extremities and the enclosure's edges. The 117-V ac input to the power supplies is confined to the opposite end of the case from where the computer I/O is mounted. Preassembled power supplies are available from Jameco Electronics.[3]

Behind the 37-pin D connector, a strip of PC board is mounted on one inch, no. 4-40 threaded spacers. The strip terminates the PC's power supply leads brought from the PIO12 card.

From the connector, the 24 I/O leads are routed to three TS-8 terminal strips.[4] The strips are intended to be mounted and soldered to PC board. In my design, the enclosure's front panel is sandwiched between the TS-8s and a strip of predrilled PC board (RS 276-162). Panel clearance holes are drilled for the TS-8 pins and insulating tubing to be placed over each pin.

The 24 LEDs are arranged single file in three groups of eight above the TS-8 terminal strips. Eight red LEDs (Port A) are mounted on the left, eight yellow LEDs (Port C) reside in the center, and eight green LEDs (Port B) are set to the right. The most significant digit of each port is located on the left side of each

[1]Notes appear on page 13.

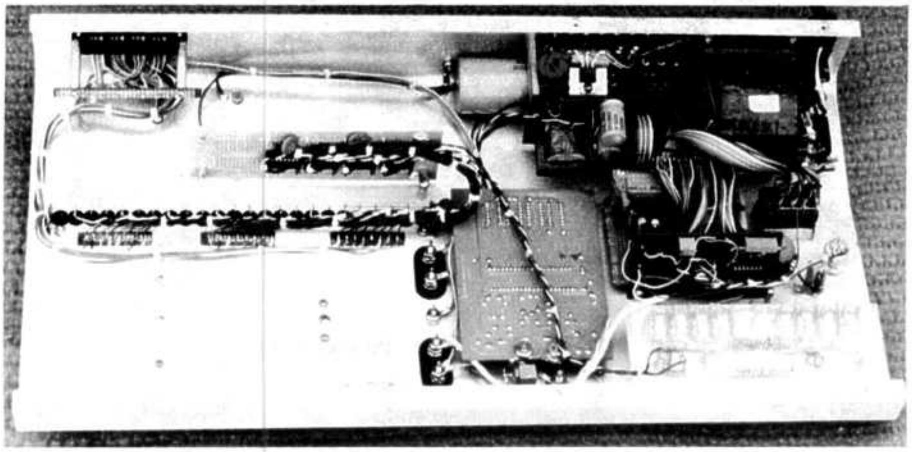

Fig 2—A ±5 V supply for the breadboard and LED circuits, and a separate ±5 V supply for the DVM resides inside the case. MetraByte provides access to the PC's ±5 and 12 V supplies at the 37-pin D connector, mounted on the rear of the card. Power supply connections are carried and terminated inside the circuit designer's interface case.

grouping. A bare +5 V bus mounted on stand-off insulators spans the row of LEDs, and the anode of each LED is connected to the bus.

An experimenter's PC board (RS 276-170) is used to mount the LED drivers. Two H. H. Smith type 3024, no. 6-32 threaded swivel standoffs are used as the PC board mounting brackets.[5]

Conclusion

The circuit designer's interface is an open-ended tool. It combines several individual small test instruments, a breadboard, and terminals for a link between the amateur's station/test bench and the computer. The individual instruments are not controlled by the computer, but could easily be. Tasks such as checking for proper interface operation and calculating the frequency response of electromechanical control systems are performed by software. If you do not own an IBM PC, but are interested in learning more about the programmable peripheral interface components, two worthwhile articles include Bloom's discussion of the use of the Z80 for similar I/O work, and Ciarcia's tutorial on compatible peripheral interface chips.[6,7]

Notes

[1]"Hot Ideas in CMOS," is an Intersil data book available from Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002, tel 415-592-8097.

[2]MetraByte Corp, 440 Myles Standish Blvd, Taunton, MA 02780, tel 617-880-3000.

[3]Jameco Electronics, see note 1.

[4]OK Industries, Inc, 3455 Conner St, Bronx, NY 10475, tel 212-994-6600.

[5]Vector Electronics, Co, PO Box 4336, Sylmar, CA 91342-0336, tel 818-365-9661.

[6]J. Bloom, "The ARRL Microcontroller," *QST*, Jul 1986, p 14.

[7]S. Ciarcia, "Parallel Interfacing: A Tutorial Discussion," *Byte Magazine*, Part 1, Jul 1986, p 85, Part 2, Aug 1986, p 97.

[8]Analog Devices, Inc, PO Box 280, Norwood, MA 02062-0280, tel 617-329-4700.

Bits

FCC Experimental Actions

KB2XBR, AMTECH Corp, Mobile APL Terminal area, Oakland, CA. Granted CP and License for new experimental station to operate on 902- to 923-MHz band to test AVI system for purpose of total automation of management and tracking of equipment and cargo in the maritime industry.

KB2XBS, AMTECH Corp, NY, NY. Granted CP and License for new station to operate on 902- to 928-MHz band for testing performance of automatic vehicle identification system for use as toll booth collection unit.

KB2XBT, AMTECH Corp, Pueblo, CO. Granted CP and License for new station to operate on 902- to 928-MHz band for testing of performance and reliability of automatic vehicle identification system.

KB2XCT, Demming Mobile Robotics, Inc. Mobile within continental US. Granted CP and License for new experimental station to operate in 902- to 928-MHz band to develop low power video link for mobile security robots.

KB2XCQ, Robert Walter Stankus, Richmond, VA. Granted CP and License for new station to operate in 18.068- to 18.168-MHz band for research of HF during period of low sun spot activity.

The above information was excerpted from an FCC Public Notice, Report No. 227, June 15, 1987.

Zenith Introduces Flat-Tension Mask Technology

A new color video display based on patented technology offers a perfectly flat, virtually reflection-free faceplate with improved brightness, contrast, resolution and color fidelity. The flat-tension mask color display is a significant improvement in cathode ray tube (CRT) technology.

Both the flat-tension mask video display and conventional color CRTs use a shadow mask. This thin metal sheet, with hundreds of thousands of perforations, helps direct beams from the tube's electron gun to the screen, where they excite red, blue and green phosphors, creating the video image. In a conventional CRT, a curved shadow mask is supported by a frame and suspended by springs inside a tube. As electron beams strike the mask, it heats up and moves.

Zenith's new flat-tension mask's shadow mask is stretched flat and held under tension directly behind the tube's flat glass faceplate. The mask does not move under most display conditions. The result is increased brightness, increased contrast, better color fidelity, increased resolution and more ergonomic. For more information on Zenith's new flat-tension mask technology, write to Zenith Electronics Corp, 1000 Milwaukee Ave, Glenview, ILL 60025, tel 312-391-8181.

>50

Focus on technology above 50 MHz

By Bill Olson, W3HQT
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Coaxial Cable: Applications and Recommendations

This month, I will outline various uses of coaxial cable and attempt to make some recommendations based on my own experience. Tables of attenuation and power rating for popular cables at amateur VHF/UHF/SHF bands are included here to help you select a cable for your particular application.

Table 1

Attenuation (in dB/100 Feet) of Popular Coaxial Cables

Cable Type	*Frequency (MHz)* 50	144	220	432	902	1296	2304	3456	5760
0.085-in semi-rigid	4.0	6.8	8.6	12.1	18.0	22.0	30.0	38.0	50.0
RG-58	3.6	6.5	8.5	12.0	17.8	21.0	32.0	41.0	57.0
0.141-in semi-rigid	2.4	4.1	5.1	7.4	11.0	13.0	18.0	22.0	30.0
RG-8, RG-213, RG-214	1.5	2.4	3.4	5.0	8.0	10.7	15.9	22.0	31.0
Belden 9913	0.9	1.5	2.0	2.9	4.2	5.1	7.3	9.8	15.0
½-in foam flex	0.6	0.9	1.3	1.9	2.9	3.7	5.4	7.1	9.9
RG-17	0.6	1.2	1.7	2.4	4.0	4.9	8.0	12.0	**
½-in foam Heliax (LDF)	0.5	0.8	1.1	1.5	2.2	2.6	3.8	4.8	6.5
7/8-in foam Heliax (LDF)	0.3	0.5	0.6	0.8	1.2	1.5	2.0	2.6	3.2
7/8-in air Heliax	0.3	0.5	0.6	0.8	1.1	1.4	2.0	2.6	*
1-in 75-ohm Hardline	0.3	0.5	0.6	0.9	1.3	1.6	**	**	**
1-5/8-in foam Heliax	0.2	0.3	0.4	0.5	0.8	1.0	1.4	*	*

* above cutoff
** unknown

Note: The figures in this chart were interpolated from graphs and tables in various manufacturers' catalogs.

Table 2

Average Power Rating (in Watts) of Popular Coaxial Cables

Cable Type	*Frequency (MHz)* 50	144	220	432	902	1296	2304	3456	5760
0.085-in semi-rigid	470	270	220	150	105	85	64	47	38
RG-58	250	145	120	80	55	45	32	22	**
0.141-in semi-rigid	1700	1000	800	540	380	320	260	180	130
RG-8, RG-213, RG-214	1400	780	620	420	280	230	160	120	65
Belden 9913	2800	1600	1300	820	550	440	320	**	**
½-in foam flex	2400	1900	1600	1000	660	530	390	**	**
RG-17	3200	2400	1700	1200	680	500	340	240	*
½-in foam Heliax (LDF)	2800	1600	1300	820	550	440	320	250	160
7/8-in foam Heliax (LDF)	6500	3800	2900	2000	1300	1050	750	580	430
7/8-in air Heliax	8000	5000	4000	2700	2000	1600	1200	950	*
1-in 75-ohm Hardline	6500	3800	2900	2000	1300	1050	**	**	*
1-5/8-in foam Heliax	18000	14000	11000	7400	5500	4400	3300	*	*

* above cutoff
** unknown

Note: The figures in this chart were interpolated from graphs and tables in various manufacturers' catalogs.

Point-to-Point Wiring

When building UHF and microwave gear, the modular approach is often used so that blocks can be replaced or improved without rebuilding the whole rig. Sometimes, separate PC boards must be interconnected with coaxial cable. To save money on connectors, interconnections are often made by soldering the cable directly to the boards. This job is most easily accomplished by using small diameter, flexible Teflon® dielectric cable such as RG-316. With this cable, it's easy to make connections without an appreciable impedance bump, and the small cable is easy to route through equipment. Teflon dielectric makes it possible to solder (and resolder) connections without melting the thin dielectric. Semi-rigid Teflon cables of 0.141 and 0.085 inch diameters are useful here with a little more work.

Interconnecting Equipment

When connecting equipment in the station or joining modules with connectors, short lengths of medium diameter cable are most often used. These patch cables are often lengths of RG-58 fitted with BNC connectors. For applications requiring lower loss or higher power handling, use one of the Teflon equivalents to RG-58; RG-141, RG-142 or RG-303 are good choices.

At microwave frequencies, SMA connectors are a better bet and can be used with flexible cables or with semi-rigid types. For connections between high-power amplifiers and antenna relays, a wattmeter or a feed line, use a low-loss cable that will handle the power. See Tables 1 and 2. In all cases, be aware of a cable's loss and power rating when selecting an interconnecting cable.

Main Feed Line

The general rule at VHF and above is to use the biggest cable you can afford. At 50 MHz, you can get away with RG-8 if the run is not too long. At 2304 MHz, however, even ½-inch Andrew Heliax® has close to 4 dB loss for a 100-foot run. Belden 9913 is popular for short runs at the VHF and low UHF frequencies, but must be used carefully and within its ratings.

In my installation, I use lengths of 7/8-inch foam-dielectric, corrugated-jacketed Hardline on all frequencies from 144 to 2304 MHz. Don't ignore the possibility of using one high-quality feed line on all bands and switching it at the top of the tower with a multiple-pole coaxial switch. Good-quality Hardline is an excellent investment. Although the initial cost may seem high, the cable will provide many years of service if the connectors are installed properly.

Some of us still have some RG-17 cable around. (This is a 7/8-inch-diameter cable that resembles *big* RG-8.) If you want to use RG-17 (now designated RG-218) to go up the tower, put a tight loop in the top end before dragging it up. This will prevent the heavy copper center conductor from falling down and pulling out of the top connector.

Surplus 75-ohm cable-television (CATV) Hardline is cheap (sometimes free) and has very low loss. It makes an

(continued on page 16)

13 Centimeters

By Bill Olson, W3HQT
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Burnham, ME 04922

We all need something new to do, right? This new column, which will appear every other month in *QEX*, is dedicated entirely to operation, techniques and equipment for the 13 cm (2300 MHz) band. With any luck, you'll all run out and get on the band or build new equipment to upgrade your present system. I will try to cover operating and technical developments in all aspects of 13-cm operation: weak signal terrestrial work, wideband modes, repeaters, beacons, EME and OSCAR Mode S. To make the picture as complete as possible, I will need input from you, the reader. Get the hint?

The 13 cm band runs from 2300 MHz to 2450 MHz with chunks missing in various parts of the world. In the United States, 2310 to 2390 MHz has been removed. In various European countries, the bottom 10 or 20 MHz is gone. This band is also known as S band, the old frequency designation for the 2 to 4 GHz range.

History

There has been a big jump in activity on 13 cm in the past four or five years. This is mostly because of the availability of inexpensive components such as GaAsFETs and MMICs that are usable at this frequency. In addition, some commercial equipment has become available for the band. Contests and VUCC operating awards have spurred activity, and talk of satellites with Mode S transponders (70 cm uplink, 13 cm downlink) has certainly helped.

Until a few years ago, 13-cm stations were scarce. Most were located in highly populated areas. It was difficult just finding equipment that would generate any kind of signal on the band. Very early work was done with wideband modes, using reflex klystrons as free-running oscillators in polaplexer-type configurations. Most contacts took place over line-of-sight paths. Some of the more ambitious stations tried weak-signal modes—mostly CW—using modified 2.2 to 2.3 GHz telemetry equipment. Other stations used homemade transmitters that were crystal controlled and multiplied all the way up to 13 cm. Dish antennas with the ever-popular 1-pound coffee-can feed were used most often.

The biggest problem with the early systems was that they did not hear! Diode mixer front ends were common, and occasionally there would be a preamp that oscillated most of the time. Parametric amplifiers were around but rather tricky for the ham to get working. Exotic devices like tunnel diode amplifiers with so-so noise figures could sometimes be borrowed from someone who borrowed them from work. The VHF and microwave clubs helped get people on the air and made it possible to talk to someone locally, but we really never thought about talking to each other over long distances (outside of our local activity center). That is all changing now.

Records

So what can we work on the 13-cm band? The DX records are as follows:

Stations	*Date*	*Distance*	*Propagation Mode*
PAØSSB-W6YFK	5 Apr 81	5491 mi	EME
VK5QR-VK6WG/P	17 Feb 78	1170 mi	Ducting
KD5RO W8YIO	29 Nov 86	940 mi	Tropo

These records were all established within the last 10 years. The most recent record, between KD5RO and W8YIO, was established with relatively low power and simple antennas, all over land and from permanent home stations. KD5RO was only running a half watt! In addition, the European terrestrial DX record appears to be around 800 miles (The February 1987 *DUBUS* "World Wide SHF Top List for 2320 MHz" shows OK1AIY, GW4FRE and SM6HYG all with best DX over 1290 km (802 miles). There are undoubtedly others with better DX.

North American Activity

In the United States, activity is not just confined to the highly populated areas near the big cities. My latest tally shows activity in at least 30 states and 3 Canadian provinces. The "hot beds" are Texas/Oklahoma, Pennsylvania/New Jersey, California, Ohio/Michigan, Illinois/Indiana, Florida/Georgia, Kansas(!), Colorado and Washington/Oregon. There are certainly other areas of activity, but I won't know how hot your area is until you write me and tell me!

Many US stations have best DX contacts in the 400-500 mile range; 200 miles is fairly commonplace. There are now 18 stations with VUCC on 13 cm, and WB5LUA has 26 grids worked on the band. During the VHF contests, 4 to 6 grid squares and 10 QSOs is not uncommon. The big mountaintop multioperator stations can work 20 to 30 QSOs in 10 to 12 grids, no doubt helped by grid-square expeditions.

European Activity

DUBUS shows PAØEZ with 57 squares worked, 25 stations with 30 or more worked, and 69 stations with 10 or more as of February 1987. A review of the log of G4CDA multioperator effort in the October 1986 RSGB contest for the bands at 432 MHz and higher shows conditions on 2320 MHz quite good (to say the least). They worked 70 stations in 24 grids with a maximum DX of 1227 km. Clearly, activity is greater in Europe than it is here!

Equipment

I surveyed active 13 cm operators at the 1987 Central States VHF Society Conference in Dallas, Texas, last July. About 40 of the hams present were active on 13 cm. At least 20 use commercial equipment. Seven use homemade equipment, and the rest I didn't write down. The appliances have hit 13 cm!

While at least 50% of the active stations are running 3 watts or less, many use homemade or converted surplus tube amplifiers at 30 to 50 watts output. A few (5 to be exact) have glommed Varian VA802 klystron amplifiers that run around 300 watts output. Remember that you don't always need high power . . .

A list of commercial equipment sources follows. If you know of equipment that I don't, please drop me a line. One of the goals of this column is to report on sources of 13 cm equipment and antennas.

Transverters

- SSB Electronics Microline 13—½ watt with GaAsFET front end and optional 4-watt solid-state linear amp, available through Transverters Unlimited.
- LMW Electronics 2304TRV2—1.5 watts with optional GaAsFET front end, available through Down East Microwave.
- Maki Denki—these used to be available; anyone have current information?

Preamps

- Angle Linear
- LMW Electronics
- SSB Electronics

Amplifiers

- EME Electronics—1 tube (7289 type)
- LMW Electronics—1 tube (7289 type)
- Frontier Microwave (WA3JUF)—class-C solid-state types

• WA2FGK—class-C solid-state types.
• surplus—TRC29 (nice unit if you can find one!)

Antennas

• Down East Microwave—45 and 55 element loop Yagis
• Parabolic—dish antenna kits and feeds. These used to be available from The VHF Shop. Anyone have current info?

Space Communications

The OSCAR Phase 3C launch keeps being moved back, but eventually it will go. This satellite features a Mode S transponder with the uplink on 436 MHz and the downlink on 2401 MHz. A few stations have already assembled receiving systems for 2401 MHz by putting new local oscillator crystals in the receiving sections of some of the popular transverters. The antenna requirements for Mode S appear to be in the 3- to 4-foot dish or 4-loop-Yagi category for receiving FM, less for narrow band modes. Launch time looks like mid 1988. Future plans for a Phase 4 geosynchronous satellite call for additional use of the 13 cm band.

What else can you do if you want to point your 13 cm antenna up in the air? W4HHK and WB5LUA have both copied telemetry signals from Russian satellites in the 2303.990 to 2304.015 MHz range—sort of like flying beacons. And of course for the ambitious, there is EME. Active stateside EME stations include W4HHK, WB5LUA, W6YFK and K2UYH (WA2WEB). Many EME stations are active from Europe, and a few others in this country working to get on. I will have a future column dedicated to 13 cm EME operation.

More to Come

Upcoming columns will cover technical topics like low-noise preamps, antennas, transverters, satellite receiving systems, solid-state linear amps, propagation and tube amplifiers. I'll keep you current on the operating side as well, with the latest information on new records, band openings and new stations. I need input from you, too, so let me know if you get on the band (or are even thinking about it). Tell me about a good band opening or an unusual contact. It's not that hard to get on 13 cm, and once you're on, you'll find it to be a great band. Let's see what can really be done up there!

>50

(continued from page 14)

excellent feed line at VHF and the low UHF frequencies, provided you can make connectors to fit it. If you're worried about the mismatch when using this cable in a 50-ohm system, you'll need to make matching sections (usually quarter-wave transformers) for each end. At 902 MHz and above, this cable is well above its characterized frequency, so you're on your own. Reports indicate that 1-inch and ¾-inch CATV Hardline work well at 1296 MHz. In any case, test it before dragging it up the tower!

Phasing Lines

When combining several antennas, matched lengths of coaxial cable are often used to properly phase the antennas. Phasing lines should be made from the lowest loss cable that the mechanical configuration (and budget) will allow. Phasing lines are much like main feed lines except that they are often where you cannot get at them without taking down the whole array. Also, they must be matched in length. My experience is that cutting phasing lines from the same roll of coaxial cable to the same physical lengths (within 1/8 inch) is acceptable through 2304 MHz.

Connectors

I'm saving a discussion of RF connectors for a future column, but there are a few points I will touch on here.

1) Use constant-impedance connectors such as type N, BNC, TNC or SMA. UHF connectors are not 50-ohm devices, but can be used at 220 MHz and below without introducing much of a mismatch. Use type N, SMA or TNC for work at 902 MHz and above.

2) Use weatherproof connectors outdoors. This pretty much means type N, a connector with a gasket for weatherproofing. Various sealing compounds are available to waterproof other types of connectors. Of course, enough layers of plastic electrical tape will waterproof a cable-to-cable connection—for a while anyway.

3) Use the connector designed for the cable! There are a few cable types that really don't have a connector designed for them. Belden 8214 and 9913 are examples that come to mind. The best connector for 9913 I have found is a Kings UG-21B. This is a male type-N connector with a long body and a wide reusable clamping washer that grips the cable really well. The shorter connectors that rely on clamping to the shield (of which there is precious little on 9913) are next to useless. Since the center conductor on 9913 is larger than standard RG-8, the center pin must be drilled out, or the center conductor must be filed down. Oversize pins are also available to match the conductor. All of the special "made for 9913" type-N connectors that I have seen are the short-body UG-21D types with fitted center pins. These work, but the mechanical strength of the connector is very poor.

Conclusions

It's been said many times that one of the best ways to improve your station is to improve the feed line. This is certainly true, since it benefits both the transmit and receive functions and takes very little time and effort to accomplish. See you all at the next flea market pawing through those big black rolls of "garden hose"!

Bits

Fast Fourier Transform Tutorial

Fast Fourier Transform Tutorial is a menu driven, graphics oriented education program designed for both classroom use and self instruction. The program presumes the user has no knowledge of the mathematics associated with Fourier Transforms. Rather, it permits hands-on experience showing (in high resolution) what the spectra of various waveforms look like. Examine the spectra of mixed sinusoidal, rectangular, saw tooth, triangular and random inputs under a variety of conditions. Observe the spectra of several window functions and digital transmission formats; even input your own signal. This program is available for the Apple, Kaypro and IBM computers. For more information about the tutorial, contact Dynacomp, Inc, 1064 Gravel Rd, Webster, NY 14580, tel 716-671-6160. Price: $39.95.