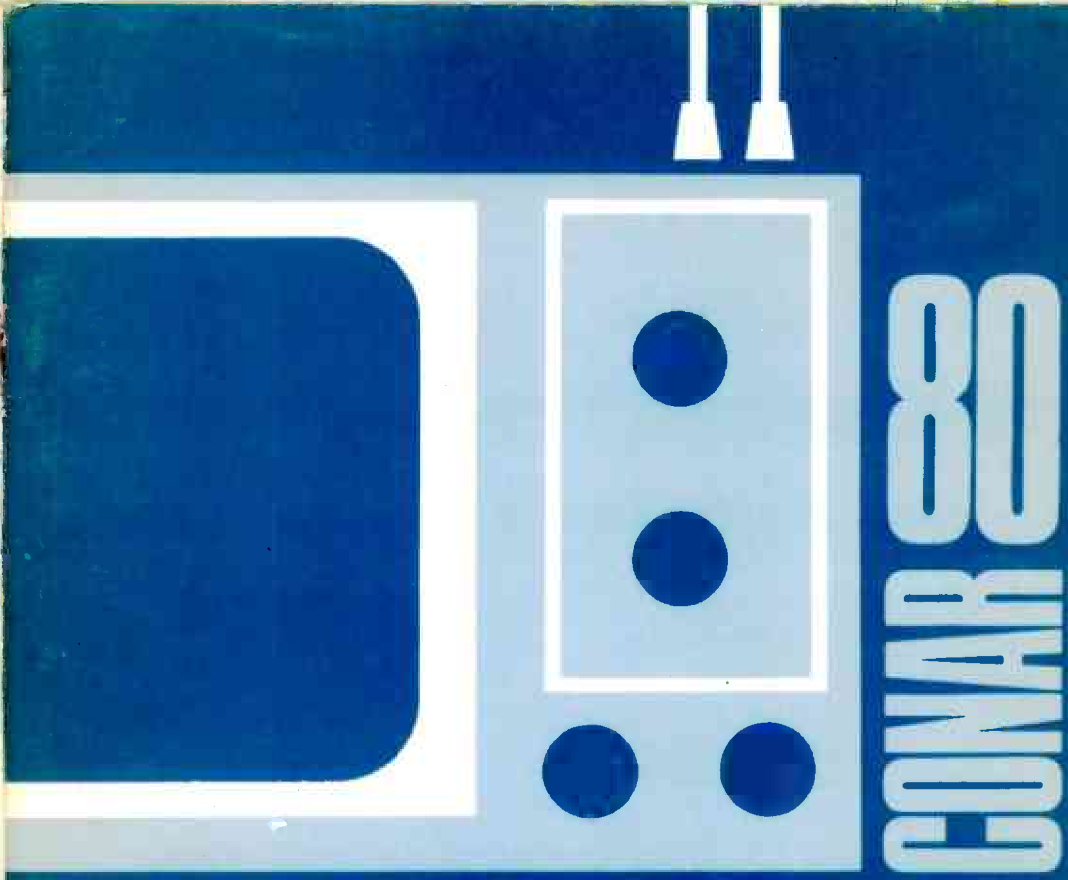



- CONAR presents the Model 80 TV Receiver
- A programmed introduction to the phase-locked loop and its applications

nri journal

May/June 1973

# SPECIAL REDUCED PRICE OFFER!

# *Custom 80*

# ALL SOLID-STATE BLACK-AND-WHITE TELEVISION KIT

Regular $139.95

## NOW ONLY $129.95

| |
|---|
| **This offer expires July 31, 1973. Orders must be postmarked on or before that date and must be on the Journal order blank.** |

Imagine the satisfaction and pride when someone asks where you got your portable TV and you answer, "I built it myself." All solid-state circuitry and printed circuit board construction combine to make building the Custom 80 a most rewarding weekend project.


**Stock No.80UK**
**Weight 32 pounds**
**Parcel Post Insured**

The convenient carrying handle makes this a "portable" portable—and the 75 square inches of viewing area is large enough so several can watch at once. Features include: Built-in vhf-uhf antenna, handsome vinyl-on-steel cabinet, ac or 12-volt operation (battery pack optional). Special reduced price expires July 31, 1973—so order now.

**Specifications**

| | |
|---|---|
| **Transistors:** | 22 |
| **Integrated circuits:** | 2 |
| **Picture size:** | 12-inch diagonal (75 square inches) |
| **Tuning range:** | VHF: 2 through 13. UHF: 14 through 83 |
| **Video response:** | 3.5 MHz |
| **Audio power output:** | 350 milliwatts |
| **Front panel controls:** | VHF coarse and fine tuning, UHF coarse and fine tuning, on/off/volume, brightness, vertical hold, contrast |
| **Rear chassis control:** | Height, linearity, AGC, low-voltage adjustment, horizontal hold |
| **Power requirements:** | 45 watts ac, 24 watts dc |
| **Overall size:** | 10 inches high by 17 inches wide by 9 inches deep |
| **Weight:** | 25 pounds |

**Stock No.80AC**
**Weight 13 pounds**
**Parcel Post Insured**

**Limited Time Offer**
**Regular $54.95**

## Only $49.95

# Custom 80 Battery Pack

Now! You can make your Custom 80 completely and personally portable—with this specially designed battery pack from Conar. You don't have to miss those important programs simply because you're camping, fishing, or vacationing in an "out-of-the way" place. You have up to three full hours of viewing on one charge. An overnight charge restores even completely discharged batteries to full charge. And up to 500 complete charge/discharge cycles are possible before the batteries have to be replaced.

Order both the Custom 80 and the battery pack on this special offer for maximum savings. If you already own the Custom 80, you can still get the battery pack on this money-saving introductory offer. Remember, this special price expires July 31, 1973, and your order must be on the Journal order blank. Order now!

nri journal
May/June 1973
Volume 31, No. 3



EDITOR AND PUBLISHER
*William F. Dunn*

MANAGING EDITORS
*Jane Wright*
*Judith Rhodes*

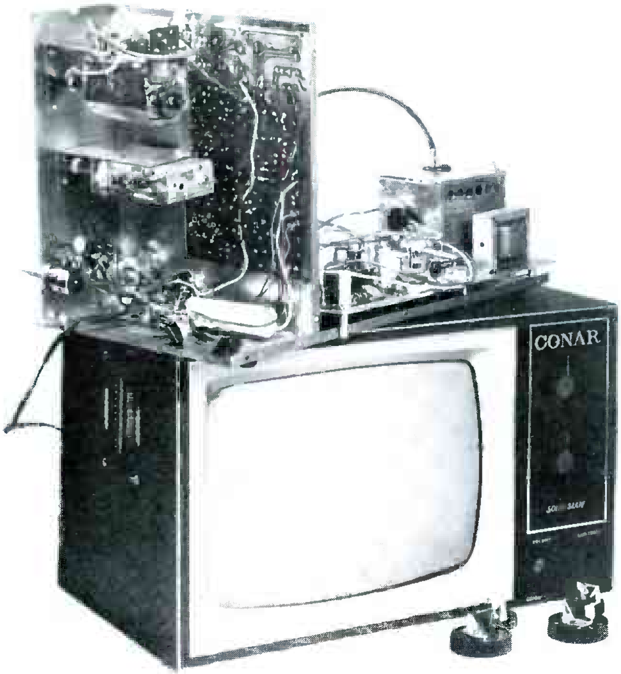
TECHNICAL EDITOR
*E.B. Beach*

EDITORIAL ASSISTANTS
*Mildred Duncan*
*Barbara Ramberg*

STAFF ARTISTS
*Thomas Beadling*
*Arthur Susser*

In this issue of the Journal, CONAR Instruments presents its new all solid-state portable TV receiver and battery pack. Don't miss the special offer to all students and alumni.

The NRI Journal is published bimonthly by the National Radio Institute, 3939 Wisconsin Avenue, Washington, D.C. 20016. Subscription price is two dollars yearly or 35 cents per single copy. Second-class postage is paid at Washington, D.C.




# CONAR presents the model 80 TV receiver

*by james m. lytle*

CONAR presents the Model 80, a brand new all solid-state portable TV set. The new set features a 12" diagonal screen, built-in vhf antenna (uhf antenna included), 117 VAC or battery operation, and state-of-the-art circuitry designed around 22 transistors and 2 integrated circuits.

The 12" diagonal screen provides 75 square inches of viewing area, big enough so that several can watch the action at once and yet compact enough to be "taken along" and used as a personal portable.

The owner of this set will also want to take along the Model 80-1 battery pack. With this accessory he won't have to miss that favorite program or ball game while at the beach next summer or on a hunting or camping trip.

The Model 80 TV set and battery pack are available from CONAR in kit form only. But you need no special skills, test equipment, or knowledge of electronics to assemble either. Printed circuit board construction and expertly written and illustrated assembly manuals make assembling the kits a relatively fool-proof weekend project. At the same time, the project offers you the opportunity of learning solid-state TV from inside out if you are so inclined.

For a short time only, active students and alumni may purchase the Model 80 portable TV and battery pack at a savings over their regular catalog prices of $139.95 and $54.95 respectively. On all orders received by CONAR before July 31 (only the order blank from this issue of the Journal will be accepted) the student/alumni price for the Model 80 is $129.95 and for the battery pack $49.95. If you already own a Model 80, you may still purchase the battery pack at the reduced price. Remember, you must use the order blank from this issue of the Journal to order yours. The stock number for the TV is 80 UK and the shipping weight is 32 lbs. The stock number for the battery pack is 80 AC and the shipping weight is 13 lbs. The remainder of this article is devoted to the construction and circuit features of the kit.

Nearly all of the components for the TV circuits are mounted on two circuit boards. The vertically mounted board contains the video i-f amplifier, keyed agc and inverted stages, video amplifier and sound circuits.

An integrated circuit performs the functions of sound i-f amplifier, sound detector, and audio preamplifier. Figure 1 is a simplified schematic diagram of the circuits within the sound IC. The recovered 4.5 MHz frequency modulated sound i-f signal is first applied to the i-f amplifier portion of the circuit. The signal is amplified and any amplitude variations which may be present are removed by the limiter circuits. The constant-amplitude output of the i-f amplifier and limiter circuit is then applied to the phase detector.

The phase detector produces an output voltage proportional to the phase difference between the two input signals applied to it. Obviously, then, if this circuit is to demodulate the FM sound signal, one of the inputs must somehow be shifted in

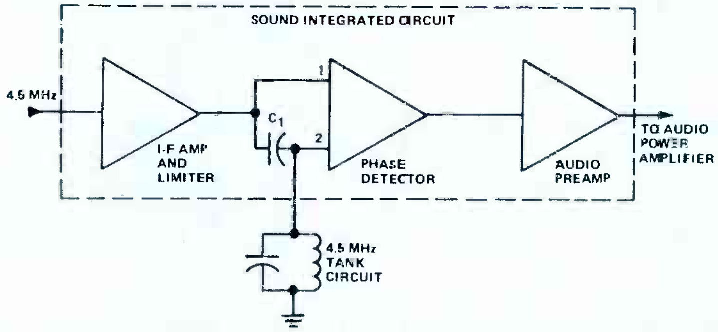



FIGURE 1. SIMPLIFIED SCHEMATIC OF THE MODEL 80 SOUND INTEGRATED CIRCUIT.

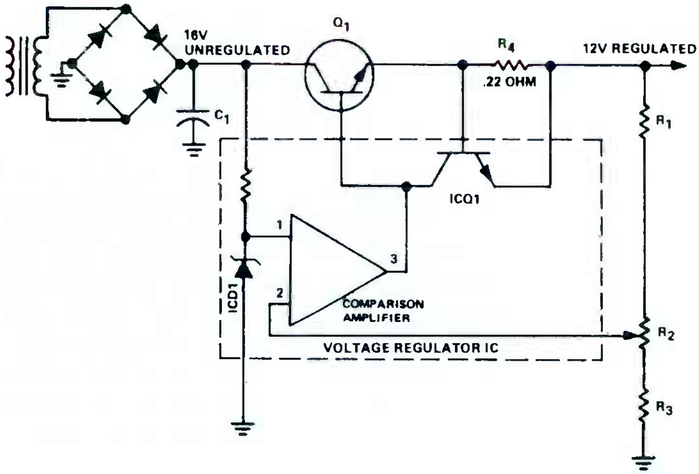



**FIGURE 2.** SIMPLIFIED SCHEMATIC OF THE VOLTAGE REGULATOR.

phase with respect to the other. Furthermore, the amount of phase shift must be proportional to the signal frequency at any instant. This task is accomplished by $C_1$ and the 4.5 MHz tank.

The 4.5 MHz tank is a parallel resonant circuit tuned to 4.5 MHz, which appears as a pure resistance only when the signal at terminal 2 of the phase detector is at exactly 4.5 MHz. When the signal shifts above or below this frequency, as it does when frequency modulation is present, the tank appears as a complex impedance, which, in conjunction with $C_1$, shifts the phase of the terminal 2 input. Thus, our previously stated requirement (to shift the phase of one of the inputs an amount proportional to its frequency) has been met. The output of the phase detector, then, is a reproduction of the audio modulating signal. The recovered audio is amplified in the preamplifier stage before being applied to the audio power amplifier. The other circuit board used in the Model 80 is horizontally mounted and contains the horizontal and vertical oscillators, the sync separator, and the power supply regulator. The second of the two integrated circuits in the set is used as the regulator.

Figure 2 is a simplified schematic diagram of the power supply regulator IC and its associated circuitry. The 16-volt unregulated output of the rectifier is applied across filter capacitor $C_1$ to the collector of the series pass transistor $Q_1$. The conduction of $Q_1$, and therefore the voltage drop across it, is automatically adjusted by the control circuitry in the IC to keep the output voltage to the TV circuits at exactly 12 volts.

The heart of the control circuit is the comparison amplifier. The output current at terminal 3 of this amplifier is determined by the difference between the two input voltages at terminals 1 and 2. As you can see, the voltage at terminal 1 is held constant by the action of Zener diode ICD1. The voltage at terminal 2, however, is some fraction of the output voltage as determined by the setting of the voltage adjust pot $R_2$. Thus, a sample of the output voltage is constantly being compared in the comparison amplifier with a known reference voltage. If the power supply output voltage changes for any reason, the comparison amplifier senses the change as a difference between its two input voltages. The resulting change in output current at terminal 3 adjusts the conduction of $Q_1$ to bring the output voltage back to its original value.

An additional feature of the regulator is that it has built-in short circuit protection. This means that if the 12-volt regulated output is short-circuited to ground, or abnormally loaded for any reason, the current from the power supply will be automatically limited to a safe value.

Short circuit protection is provided by the action of the .22-ohm resistor, $R_4$, and transistor ICQ1. Since the .22-ohm resistor is connected in series with the power supply load, the voltage drop across this resistor is proportional to the load current. When the load current increases enough to drop about .6 volt across this resistor, transistor ICQ1 turns on and shunts current around the emitter-base junction of $Q_1$. This shunting action of ICQ1 prevents any further increase in the conduction of $Q_1$.

The Model 80-1 battery pack, shown in Figure 3, comes equipped with an ac line cord and a 12-volt battery cord. The ac line cord connects to a 117 VAC outlet when the batteries are being charged. The 12-volt battery cord connects to the TV when operating the set from the battery pack. Both cords store neatly inside the cabinet when not in use.

The 117 VAC line cord furnished with the TV set terminates in a 5-pin socket which mates with a 5-pin plug mounted on the back of the set. To operate the set from 117 VAC, you simply connect the ac line cord to the mating plug. Referring

**FIGURE 3.** THE MODEL 80-1 BATTERY PACK.

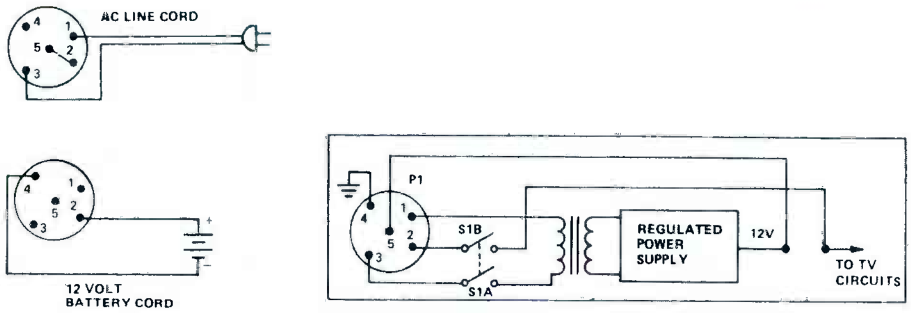



FIGURE 4. WIRING DIAGRAM SHOWING HOW SWITCHOVER FROM 117 VAC LINE TO BATTERY OPERATION IS ACCOMPLISHED.

to Figure 4, you can see that this connection applies 117 VAC to pins 1 and 3 of P1 and places a jumper across pins 5 and 2. When the set is turned on, ac power at pins 1 and 3 is supplied to the primary of the power transformer through S1A, half of the on/off switch. The 12-volt output of the regulated power supply is then routed to the TV circuits through jumpered pins 5 and 2 of P1 and S1B, the other half of the on/off switch.

To change over to battery operation, you replace the 5-pin socket from the ac line cord with an identical socket connected to the 12-volt cord from the battery pack. This 12-volt cord socket applies +12 volts to terminal 2 of P1, as shown in Figure 4. When the set is turned on, this +12 volts is applied directly to the TV circuits through S1B.

Built into the battery pack is a completely independent electronic charging circuit. This feature permits the batteries to be recharged directly from a 117 VAC source with no interconnections to the TV set. During the charge cycle, the circuit continuously monitors the state of charge of the batteries and regulates the charging current accordingly. When the battery becomes fully charged, the charge current is automatically turned off.

In order to understand the operation of the charger circuits, you must first know some basic facts about the batteries themselves. Two 6-volt batteries connected in series supply the 12 volts necessary to power the TV set. These batteries are similar in operation to the lead-acid batteries used in automobiles. They differ, however, in that they contain a gelled electrolyte, quite unlike the liquid electrolyte used in the automotive type battery. Internally, they are actually drier than the so-called "dry cell."

In order to charge the batteries, a voltage of the proper polarity is applied across the battery terminals. When this voltage exceeds the terminal voltage of the batteries, a charge current will flow. The magnitude of this charge current depends on two factors: (a) the amplitude of the applied voltage and (b) the amount of charge contained in the batteries. If the applied charging voltage is held constant,

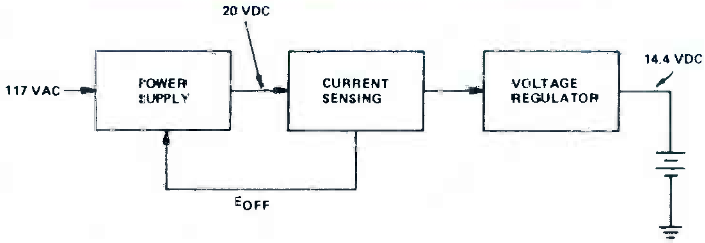



**FIGURE 5.** BLOCK DIAGRAM OF THE BATTERY CHARGER CIRCUIT.

the charging current will automatically decrease as the batteries approach a fully-charged condition. The batteries are considered to be fully charged when they accept approximately 150 milliamps at an applied voltage of 14.4 volts.

With these facts in mind, take a look at the block diagram of the charger circuit shown in Figure 5. The power supply converts the 117 VAC line voltage into about 20 VDC. This voltage is applied through the current sensing circuit to the voltage regulator which maintains an output of exactly 14.4 volts across the batteries. The charge current which flows is continuously monitored by the current sensing circuit. When this charge current drops to about 150 milliamps, the current sensing circuit generates the signal $E_{OFF}$, which shuts down the voltage regulator and terminates the charging operation.

Figure 6 shows a little more specifically how all this is brought about. The output of the full-wave bridge rectifier is filtered across $C_1$, and then applied through $R_1$

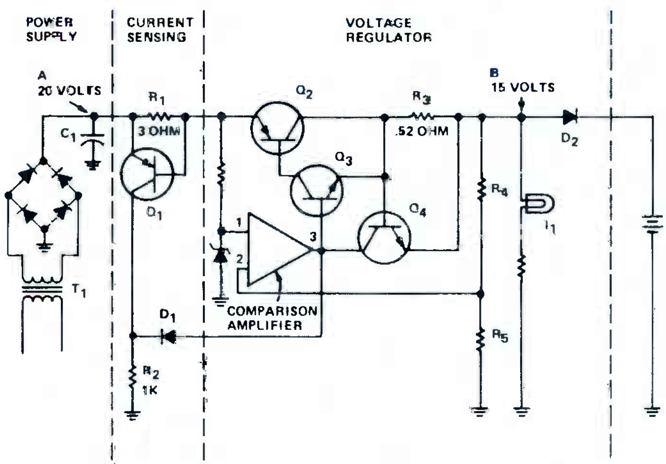



**FIGURE 6.** SIMPLIFIED SCHEMATIC DIAGRAM OF THE CHARGER CIRCUIT.

to the voltage regulator circuit. This regulator uses the same integrated circuit as the voltage regulator in the TV set and is similar in operation. It differs in that the pass transistor $Q_2$ is a PNP type rather than an NPN type.

Just as before, the comparison amplifier generates an output at terminal 3 proportional to the difference between the reference input at terminal 1 and a sample of the output voltage at terminal 2. The output of the comparison amplifier drives $Q_3$ which, in turn, drives $Q_2$ to maintain a constant output voltage. The values of $R_4$ and $R_5$ are chosen to produce a 15-volt output at point B in the circuit. With the normal diode drop of .6 volt across $D_2$, the voltage applied to the batteries then becomes 14.4 volts.

Notice that all the current supplied to the regulator (and therefore to the batteries) flows through $R_1$ in the current sensing circuit. Until the batteries are fully charged, this current will produce a voltage drop across $R_1$ sufficient to bias $Q_1$ heavily into conduction. With $Q_1$ conducting heavily, nearly the entire 20-volt output of the power supply appears at the collector of $Q_1$ and also at the cathode of $D_1$. This high positive voltage holds $D_1$ cut off.

As the batteries charge, they accept progressively less charge current until finally the voltage drop across $R_1$ can no longer keep $Q_1$ biased into conduction. When $Q_1$ finally does cut off, the high positive voltage that had been holding $D_1$ cut off is no longer present. Thus $D_1$ begins to conduct and current flows up through $R_2$ and into terminal 3 of the comparison amplifier. This current pulls the voltage at terminal 3 to a low value which, for all practical purposes, cuts off $Q_3$ and, in turn, $Q_2$. When $Q_2$ cuts off, the output of the regulator drops to zero and charging stops.

Lamp $I_1$ connected across the output of the regulator remains lighted while the batteries are being charged. When the regulator turns off, $I_1$ goes out, signaling that the batteries are fully charged and again ready for use. Diode $D_2$ prevents the batteries from discharging back into the regulator circuit.

Transistor $Q_4$, together with resistor $R_4$ in the voltage regulator circuit, limit the output current from the regulator to a maximum of about 1200 milliamps. This maximum charge current flows when the batteries are first placed on charge after a complete discharge. The operation of this circuit is similar to the current limiting circuit described for the TV power supply regulator.

Once the batteries have been fully charged, they will power the TV set for about three hours before charging is necessary. It will then take about 8 hours to fully recharge the batteries. Up to 500 complete charge/discharge cycles of this type are possible before the batteries have to be replaced.

It is not, however, necessary to completely discharge the batteries before they are recharged. If the set is not operated for the full three hours between charges, the batteries may never have to be replaced, as literally thousands of shallow charge/discharge cycles are possible with a single set of batteries. □

# NRI introduces its first computer course graduate

Congratulations to Mr. Elmer H. Blush, Jr.! Mr. Blush is the first graduate of NRI's Complete Computer Electronics Course. It took him less than two years to complete this program and he did it with an A average.

Mr. Blush and his wife, Olive, live in Arlington, Virginia. He is a professional TV service technician and is employed by Georgetown Electric in Washington, D. C.

Elmer said that he took the course not only to review his electronic fundamentals, but also to keep up to date technically, specifically to learn digital electronics and computer operation. Today, digital electronics is used extensively not only in computers but also in communications gear and is showing up more all the time in consumer electronic equipment (digital clocks, frequency synthesized tuning in FM/stereo receivers, and TV channel selection).

Elmer feels that a lucrative opportunity exists in the repair and maintenance of the many new electronic calculators on the market today. These machines are a sophisticated type of digital computer which are covered in the NRI Computer Course.

In return for his excellent performance in the course, Mr. Blush was awarded 11K, the new optional memory expansion kit for the Model 832 digital computer.

Other recent graduates of the NRI Computer Course are:

Mr. William Brady, Morningside, Maryland
Mr. Charles Dant, Pewaukee, Wisconsin
Mr. George Lange, Muskogee, Oklahoma
Mr. John Leininger, West Chester, Ohio
Mr. Willie Mathews, Huntsville, Alabama
Mr. Robert Reiner, Lexington Park, Maryland
Mr. Walter Schmitt, Atlanta, Georgia
Mr. Clement Simard, Ravenswood, West Virginia
Lt. Col. Robert Taylor, Alexandria, Virginia
Mr. Stephen Toczylowski, Erie, Pennsylvania

Congratulations go to all of these gentlemen who have completed NRI's most advanced technical program. Best wishes for your success from the NRI Staff.

SPECIAL NOTICE TO ALL COMPUTER COURSE STUDENTS AND GRADUATES

The optional memory expansion kit (11K) for the Model 832 Digital Computer will be available in late April, 1973. This optional kit consists of bipolar semiconductor, random access, read-write memory ICs that double the memory size of the Model 832 and greatly increase its computing power. Ten interesting programming experiments covering double precision and floating point arithmetic, address modification, square root algorithms and many others are included. A certificate of completion is awarded to those completing this comprehensive program of advanced programming experiments. The kit costs $47.50. Students can simply add it to their current accounts. Write for details.

*As an electronics technician or engineer, you cannot afford to overlook the phase-locked loop. You will no doubt encounter this technique sooner or later. Be ready for it!*

# a programmed introduction to the phase-locked loop and its applications

*by louis e. frenzel*

There are a lot of really good electronic circuits and techniques in existence that have never really been used or fully exploited. Because of their complexity and cost, such circuits and techniques have not found wide acceptance in practical, modern equipment. But now, integrated circuits have revived many of them. Integrated circuits permit us to take advantage of the many benefits offered by these sophisticated circuits and techniques.

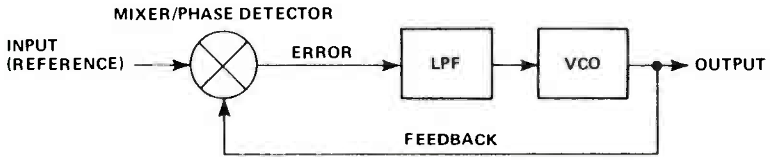
One of the most useful techniques made practical by the integrated circuit is the phase-locked loop. This technique has been known since the early 1930's, but it was used only in those applications requiring special and superior performance. The phase-locked loop, consequently, found many applications in military and space equipment where superior performance was essential and complexity and cost were not limiting factors.

Today as design engineers discover its many advantages, the phase-locked loop is being designed into more equipment. You will find it in AM and FM hi-fi/stereo equipment and color TV sets. In addition, the design of modern communications equipment—transmitters, receivers, and related equipment—has been greatly influenced by phase-locked loop techniques. Many industrial and computer applications have also been found.

The purpose of this article is to introduce you to the phase-locked loop using programmed instruction (PI). PI is a teaching technique that presents a subject to you in small steps called frames. In each instructional frame we give you some pertinent information, then test you on it immediately with a multiple-choice question. Selecting the correct or best answer leads you to another instructional frame of information that verifies your right answer and gives you additional information and another question.

If you select an incorrect answer, the program sends you to a frame that informs you of the incorrect answer, gives you remedial information, then sends you back to try again. The overall result is a quick, easy way to learn the key facts about a very pertinent subject. Start now with frame 1.

1 The phase-locked loop (PLL) is a frequency or phase sensitive feedback control circuit. It consists of three major parts: a mixer or phase detector, a low pass filter (LPF), and a voltage controlled oscillator (VCO), as shown.




The phase or frequency of a feedback signal from the VCO is compared to an input reference signal. If there is a frequency (or phase) difference, an error signal is generated. This error signal is filtered by the LPF into a dc level and is used to control the VCO frequency (or phase).

The PLL is unlike other more conventional feedback control circuits in that the important feedback signal characteristic is:

| | |
|---|---|
| amplitude | *go to frame 9* |
| frequency | *go to frame 18* |
| waveshape | *go to frame 24* |

2 Your choice is not correct. The output of the VCO will switch between two distinct frequencies, but in FM demodulation applications the PLL output is taken from the LPF. Consider the LPF output with an FSK input signal to the PLL, then return to frame 12 and select the right answer.

3 Your answer, $(f_r + f_o)$, is incorrect. You can't really say this until you know more about the LPF. Return to frame 18 and try again.

4 Incorrect. If the input reference frequency changes, then there will be two different frequencies applied to the phase detector. The phase detector will see this as a greater or lesser phase difference. This will change the control voltage applied to the VCO. You take it from there. Go back to frame 7 and select the right answer.

5 No, you are not right. Look again. There is a difference. Return to frame 32.

6

Correct. The dc input from the LPF controls the frequency of the VCO. Since the VCO output is the feedback signal and since the mixer/phase detector is sensitive to frequency and phase changes, naturally it is the VCO frequency that we want to control.

The VCO can be either a sine wave oscillator or a multivibrator of some kind, depending upon the desired waveshape of the output. In a sine wave oscillator using an inductor and capacitor to determine frequency, the frequency could be controlled by a voltage variable capacitor. In a multivibrator using a resistor-capacitor frequency determining network, the frequency could be controlled by varying the charging current to the capacitor. In either case, the VCO output frequency is made directly proportional to the dc control voltage. That is, the output frequency increases as the input control voltage becomes more positive.

An important characteristic for the VCO in a PLL is its linear voltage-to-frequency relationship. This means that:

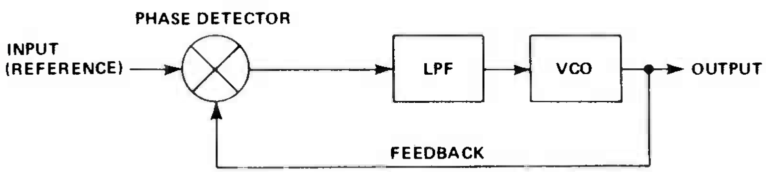
. . . the output signal will not be distorted if the VCO is linear. *go to frame 16*

. . . equal changes of input voltage produce proportional changes in output frequency. *go to frame 25*

. . . an increase in control voltage should produce an increase in output frequency. *go to frame 33*

7

Your answer, decrease, is correct. Since the VCO output frequency is directly proportional to the dc control voltage, a decrease in dc voltage will result in a frequency decrease. Increasing the control voltage, of course, will increase the VCO frequency.




Now, let's see how the PLL operates. If no input reference signal is applied, the output of the phase detector and the LPF is zero. The VCO then supplies an output signal whose frequency is strictly a function of the VCO circuitry. This is called the *free running* frequency. Now if an input

FRAME 7 CONT. ON NEXT PAGE

reference signal whose frequency is near that of the VCO is applied to the PLL, the phase detector will produce an output voltage proportional to the frequency difference. This signal is filtered and the resulting dc control voltage is applied to the VCO. The control voltage is such that it forces the VCO frequency to move in a direction that reduces the error signal. This means that the VCO frequency will change until it is *equal* to the input reference signal frequency. When this happens, the two signals are synchronized or "locked." At this time while the input reference and VCO output signals are equal in frequency, they are shifted in phase. It is this phase difference that causes the phase detector to produce the dc voltage at the VCO input to keep the PLL locked to the input signal.

Assuming that the PLL is locked, what do you think would happen if the input reference frequency changed?

The VCO output frequency would remain the same. *go to frame 4*

The VCO output frequency would be the free running frequency. *go to frame 13*

The VCO output frequency would change to the new input frequency. *go to frame 31*

---

**8**

You are right. If the input signal is outside of the lock range, the PLL will not lock on to it, so the VCO output will be the free running frequency. But as the input is varied into the lock range, the PLL will jump into a locked condition as soon as the input frequency gets close to the free running frequency. In other words, the PLL will "capture" the incoming signal if it is close enough to the free running frequency. Once the input signal is captured, the PLL is locked and will track further changes in the input signal frequency. If the input should vary outside the lock range, naturally the loop will go out of lock and the output will jump to the free running frequency.

The range of frequencies over which a PLL can capture a signal is known as the *capture range*. Like the lock range, it too is centered on the free running frequency. But the capture range is narrower than the lock range.

This frequency selective characteristic of the PLL seems to make it function like a:

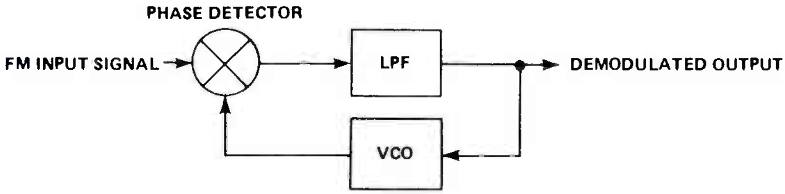
low pass filter *go to frame 10*
bandpass filter *go to frame 20*
high pass filter *go to frame 30*

9 Your answer, amplitude, is incorrect. Although the amplitude of the VCO is important to proper PLL operation, it is not the key characteristic. The phase detector senses frequency or phase changes, not amplitude changes. Return to frame 1 and select the correct answer.

10 Your answer, low pass filter, is not correct. A low pass filter passes only frequencies below a certain cutoff point. A bandpass filter passes a narrow range of frequencies between upper and lower cutoff points. Go back to frame 8 and try again.

11 Your answer, ($f_r - f_o$), is incorrect. How can you say this when you don't know the characteristics of the LPF? Go back to frame 18 and have another shot at it.

12 Correct. The PLL is widely used in FM applications because it can track a varying input frequency. If we apply a frequency modulated signal to the PLL input, the VCO output will track it if the frequency deviation of the input signal is within the lock range. The VCO follows the input signal because the error voltage produced by the phase detector and LPF forces the VCO to track. As it turns out, the VCO output must be identical to the input FM signal if the loop remains locked. The VCO generates the carrier that is frequency modulated by the error signal. For that reason, the error signal must be identical to the audio signal or other signal modulating the input. This then makes the PLL an FM detector or demodulator. The output taken from the LPF (as shown below) is the original modulating signal.




Since the VCO has a linear voltage-to-frequency relationship, the output is an undistorted representation of the information used to originally frequency modulate the carrier.

The PLL is without question the best FM demodulator available. Its frequency selectivity, linearity, and signal-to-noise ratio are far superior to the conventional discriminator and other forms of FM detectors.

FRAME 12 CONT. ON NEXT PAGE

The PLL FM demodulator is widely used in FM-FM telemetry systems for space applications. The new low cost IC PLLs are now showing up in FM stereo receivers, TV sets, and mobile communications equipment.

The PLL can also be used to demodulate frequency shift keying (FSK) signals. FSK is a form of modulation used to transmit binary (on-off, two level or 1 and 0) signals. The original digital binary pulses that switch between two distinct voltage levels are used to switch a sine wave oscillator between two distinct output frequencies. A series of pulses switching between two levels causes the oscillator output frequency to shift with a change in level.

When a PLL is used to demodulate such a signal, its LPF output will be which of the following?

| | |
|---|---|
| A sine wave that switches between two distinct frequencies. | *go to frame 2* |
| A sine wave that is switched off and on. | *go to frame 22* |
| A series of pulses that will switch between two distinct voltage levels. | *go to frame 32* |

## 13

No, your answer is not right. If the loop is locked, then the VCO output will not be at the free running frequency. Instead it will follow the input signal. Although the input signal could be at the free running frequency, it is not likely.

## 14

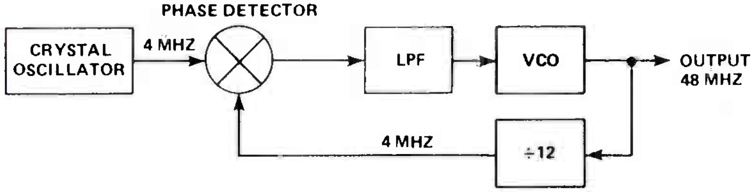
You are right. The LPF output really depends on where its cutoff frequency is with respect to the sum and difference frequencies. Both could be possibly passed or filtered out, depending on the cutoff frequency. However, in most PLLs, the LPF cutoff is set up so that the sum signal ($f_r + f_o$) is rejected and the difference signal ($f_r - f_o$) is passed. Under normal operating conditions in the PLL, $f_o = f_r$ so that the difference frequency ($f_o - f_r$) is zero. At this time, the LPF output is a dc voltage that is used to control the VCO. The magnitude of the dc voltage depends on the phase difference between $f_r$ and $f_o$. Even though $f_r$ and $f_o$ are normally equal, they are out of phase. It is this phase difference that the mixer/phase detector recognizes. The dc voltage from the LPF is proportional to the phase difference.

The dc control voltage out of the LPF is used to control what output characteristic of the VCO?

| | |
|---|---|
| frequency | *go to frame 6* |
| output voltage amplitude | *go to frame 21* |
| waveshape | *go to frame 27* |

15

Excellent. Your correct answer to this question clearly indicates your understanding of the PLL synthesizer. In the synthesizer below, the divide-by-12 circuit reduces the 48 MHz output to 4 MHz.




This is equal to the 4 MHz crystal reference oscillator so that the loop is locked. If the divide ratio is changed from 12 to 6, the output will go to 24 MHz. The reason for this is that the two inputs to the phase detector must always be equal if a locked condition is to be achieved. The reference is fixed so the only thing that can change is the VCO output if the divide ratio is altered. If the loop is locked, the output of the divider will be 4 MHz no matter what the divide ratio is. Therefore, with an output of 4 MHz, a ÷6 circuit must have a 24 MHz input. Since the VCO output is the divider input, the VCO and synthesizer output will be 24 MHz too.

As you can see, changing the divide ratio changes the output frequency. In this circuit, if the divide ratio is switched in increments between 6 and 12, the output frequencies will be as shown. With this setup, the output is switched in 4 MHz increments.

| Divide Ratio | VCO Output |
|---|---|
| ÷ 6 | 24 MHz |
| ÷ 7 | 28 MHz |
| ÷ 8 | 32 MHz |
| ÷ 9 | 36 MHz |
| ÷10 | 40 MHz |
| ÷11 | 44 MHz |
| ÷12 | 48 MHz |

What would you have to do to switch the output in 1 MHz increments?

Switch the divide ratio in increments of 4. *go to frame 23*

Use a 1 MHz reference. *go to frame 35*

Use a divide ratio that is equal to the output frequency in MHz. *go to frame 39*

16 Your answer is wrong. You may be confusing linear amplification with a linear frequency change if you selected this answer. Linear means a straight line relationship between voltage and frequency. Return to frame 6 and try again.

17 Your selection is incorrect. The output of the VCO will initially be at the free running frequency because the input signal is out of the lock range. When the input frequency gets close enough to the free running frequency within the lock range, how can the VCO output remain at the free running frequency? Return to frame 31 and try again.

18 Your answer, frequency, is correct. The important characteristic of the feedback signal in a PLL is frequency, not amplitude or waveshape. In more conventional feedback control systems, the amplitude of the feedback is the key factor. For example, in an agc system it is the amplitude of the feedback signal that controls the gain of the circuit.

In the PLL, if the VCO feedback frequency, $f_o$, differs from the input reference signal frequency, $f_r$, then the phase difference also exists. This causes the mixer or phase detector to produce an error signal. This error signal is a composite ac voltage made up of the sum and difference frequencies ($f_r - f_o$) and ($f_r + f_o$). This error signal is fed to the low pass filter (LPF) where it is filtered into a dc signal that is used to control the VCO.

Considering the fact that the LPF passes only those signals below its cutoff frequency, which signal would you expect to appear at the LPF output?

| | |
|---|---|
| ($f_r + f_o$) | *go to frame 3* |
| ($f_r - f_o$) | *go to frame 11* |
| Depends on LPF cutoff frequency | *go to frame 14* |

19 You are incorrect. The output frequency of the VCO is directly proportional not inversely proportional to the dc control input. Go back to frame 25 and try again.

20 Your answer, bandpass filter, is correct. Since the PLL will only capture and lock on to input signals within a certain narrow band, the PLL acts like a bandpass filter. For that reason, the PLL is an excellent signal conditioner. You can take a noisy input signal or one with undesirable interference on it and filter it with a PLL. The PLL will lock on to only the desired frequency component of the input. The VCO reproduces the input signal at the same frequency but with the noise and interference removed. The PLL not only cleans up a signal but also can track it if its frequency changes.

This is only one of many useful applications of the PLL. In the remainder of this program we will look at some of the major applications and advantages of the PLL.

One of the earliest practical uses of PLL techniques was in TV receivers to keep the horizontal sweep oscillator locked to the incoming sync pulses. It is still used in this way. But perhaps one of the broadest recent uses of the PLL has been in frequency modulation (FM) applications. Why do you think the PLL is widely used in FM?

| | |
|---|---|
| It can track a varying input frequency. | *go to frame 12* |
| Because of its filtering capability. | *go to frame 26* |
| It does not respond to AM. | *go to frame 36* |

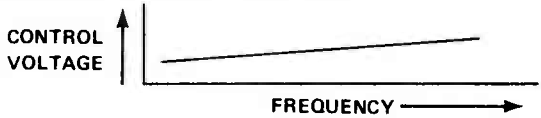
21 Your answer is incorrect. A VCO is an oscillator whose output frequency, not amplitude, is varied by a dc control input. Remember the phase detector senses frequency not amplitude changes. Return to frame 14 and select the right answer.

22 You have not selected the right answer. Keep the facts of the problem in mind. The PLL input is an FSK signal that switches between two distinct frequencies. The VCO tracks these frequencies. The PLL output for FM or FSK demodulation is from the LPF. Now go back to frame 12 and try again.

23 Incorrect. This choice is not at all logical. Go back to frame 15 and reread it. Note the relationship between the reference frequency and the output frequency increments.

24 Your answer, waveshape, is incorrect. The waveshape is irrelevant here. The important characteristic is frequency. The phase detector is sensitive to frequency changes, not waveshape. Return to frame 1 and select the correct answer.

25 Good work! You are correct. The linear voltage-to-frequency relationship of the VCO means that changing the control voltage produces a proportional change in output frequency. If we plotted a curve of output frequency versus control voltage and the result was a straight line like that shown, then the VCO is said to be linear.




Equal increments of control voltage produce proportional changes in output frequency. In the VCO of a PLL, the frequency change is directly (not inversely) proportional to a voltage change. If the voltage goes up, so does the frequency. To be useful in a wide variety of applications, the VCO in a PLL must be linear.

If the dc voltage out of the LPF should decrease, the VCO frequency will:

| | |
|---|---|
| decrease | *go to frame 7* |
| increase | *go to frame 19* |
| remain the same | *go to frame 37* |

26 Your answer is not right. Although the PLL does have filtering capability, this is not the reason for its use in FM applications. Remember, in FM the modulating signal varies the carrier frequency. Return to frame 20 and select the correct answer.

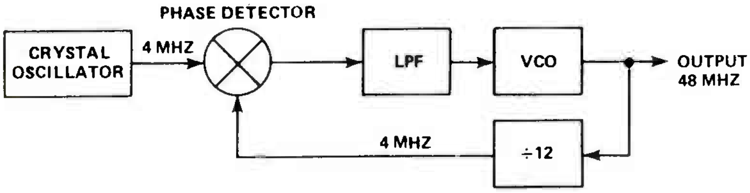
27 You are incorrect. The waveshape of the VCO is not affected by the dc control voltage from the LPF. Neither is the output amplitude. After all, the phase detector is not sensitive to these characteristics. Go back to frame 14 and choose the right answer.

28 Your answer is right. A glance at the circuit shows you that there is a circuit connected between the VCO output and the phase detector. This is a frequency divider whose output frequency is some submultiple of its input. The frequency divider divides its input by some whole number. For example, the output of a ÷12 divider whose input is 48 MHz would be 4 MHz.

The frequency synthesizer PLL also uses a stable, fixed reference input to the phase detector. When the PLL is locked, the stability and accuracy of the VCO output will be the same as that of the reference input. The

FRAME 28 CONT. ON NEXT PAGE

frequency divider, usually made up of digital flip-flops, is made switchable. That is, the frequency division ratio can be changed by setting a switch. Changing the division ratio changes the output frequency at which the loop will lock.




In the synthesizer shown, if the divide ratio is changed from 12 to 6, the output frequency will change from 48 MHz to:

| | |
|---|---|
| 24 MHz | *go to frame 15* |
| 72 MHz | *go to frame 34* |
| 96 MHz | *go to frame 40* |

29 Your choice is not right. The PLL will not lock on to a signal outside its lock range. Go back to frame 31 and reconsider the choices.

30 Your selection is wrong. A high pass filter passes all frequencies above a certain cutoff point. A PLL doesn't do this. Return to frame 8 and try again.

31 You are correct. If the input reference signal changes, then the phase detector will recognize a frequency (and phase) difference between the input and the VCO output. As a result, it and the LPF will produce a different dc control signal that will force the VCO to change such that it is equal to the new input frequency. As you can see then, the PLL will "track" an input signal frequency as it changes.

The range of frequencies over which the PLL will track an input signal and remain locked is known as the *lock range*. This is a range of frequencies above and below the VCO free running frequency. The PLL can track and "lock" to any input frequency in this range. If an input signal out of the lock range is applied, the PLL will not synchronize. The VCO output then jumps to the free running frequency.

FRAME 31 CONT. ON NEXT PAGE

What will the VCO do if the PLL input signal, which is initially outside of the lock range, is changed until it moves into the lock range near the free running frequency?

The VCO will lock on to the input as soon as it gets close enough to the free running frequency. *go to frame 8*

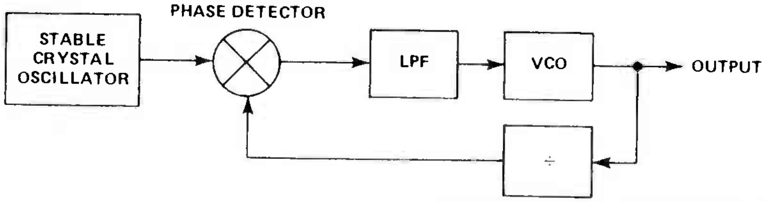
The VCO output will remain at the free running frequency. *go to frame 17*

The VCO will lock on to the initial input signal and track it into the lock range. *go to frame 29*

# 32

Your answer is right. The output of the PLL LPF will be a series of pulses that switches between two distinct voltage levels. When the PLL input is the 1 or "on" frequency, the LPF output will be some specific voltage level. The PLL will be in lock. When the 0 or "off" frequency is transmitted, the PLL will lock but at a different frequency. The LPF output will be another dc voltage level. The two dc levels define the original transmitted signal.

One of the most popular uses of the PLL is in frequency synthesizers. A frequency synthesizer is a very stable signal source that can be varied over a specific range of frequencies usually in definite increments or steps. Frequency synthesizers are used as precision signal generators for test and measurement purposes and as primary signal sources in transmitters or receivers. The big advantage of a PLL synthesizer is its ability to generate a wide range of frequencies with great accuracy and stability by using only a single stable signal source. For example, a PLL synthesizer with a single crystal controlled reference input can readily generate 100 discrete frequencies that are as stable as the crystal reference. It takes the place of 100 individual crystal oscillators at a lower cost. By using a synthesizer for the local oscillator in a receiver or as the initial signal source in a transmitter, a wide range of channels can be obtained with a single crystal. When many channels must be used, a synthesizer greatly reduces the cost since crystals are expensive. The figure below shows a phase-locked loop frequency synthesizer.




FRAME 32 CONT. ON NEXT PAGE

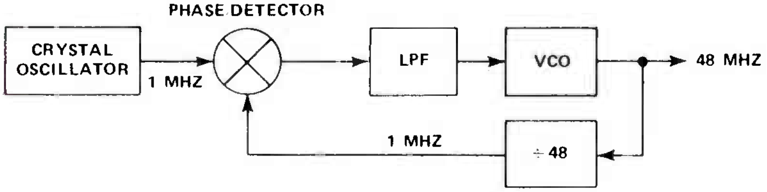
How is this circuit different from the PLLs we've looked at so far?

| | |
|---|---|
| There is no difference. | *go to frame 5* |
| There is a frequency divider between the VCO and phase detector. | *go to frame 28* |
| The LPF output is not used. | *go to frame 38* |

33 Your answer is not correct. It is true that an increase in control voltage will produce an increase in output frequency, but the change may not be linear. That is, equivalent increments of voltage change will not necessarily produce equivalent changes in frequency. Return to frame 6 and choose the right answer.

34 Your answer, 72 MHz, is not correct. How did you arrive at this? Remember that the two inputs to the phase detector must be the same if the PLL is to be locked. Keeping this in mind, consider the reference frequency, divide ratio, and the divider input frequency. Now, go back to frame 28 and make the correct selection.

35 Right! Good thinking. If the input reference is made 1 MHz, then when the divide ratio is switched, the output frequency will step in 1 MHz increments. The resulting PLL will look like that shown.




Note that the divide ratio is equal to the output frequency in megahertz in order to divide the output to 1 MHz so that it matches the input reference. By changing around the reference frequency and the divide ratio, it is possible to synthesize practically any range of frequencies from subaudio to microwave.

Note one final fact about the PLL circuit above. If the reference is considered the input, and the VCO is considered the output, then the PLL is acting as a frequency multiplier. Here the output is 48 times the input.

FRAME 35 CONT. ON NEXT PAGE

By setting the divide ratio properly, practically any multiplication ratio can be obtained. The PLL is often used as a frequency multiplier.

The PLL is a versatile circuit. You will begin to see it more often in modern electronic equipment. You will find it mainly in the popular applications described here, but in others as well.

**end**

---

**36** Your choice is not correct. Although it is true that the PLL does not respond to amplitude modulation (AM) as we have described it, this does not necessarily mean that that is the reason why we use the PLL for FM. Go back to frame 20 and consider the other choices.

---

**37** Your answer, remain the same, is not right. The dc voltage out of the LPF will vary the VCO frequency. The frequency change will be directly proportional to the voltage change. Now return to frame 25 and select the correct answer.

---

**38** Your selection is incorrect. True, the LPF output is not used here but that is not the main difference. Return to frame 32 and study the circuit again.

---

**39** Your choice is not the best answer. You may have to use a divider that divides by a ratio equal to the output frequency in megahertz but that alone won't do the job. Return to frame 15 and compare the reference frequency of the example with the VCO output frequency steps. Then answer correctly.

---

**40** Your choice, 96 MHz, is not right. Keep these key facts in mind. To remain locked, the two inputs to the phase detector must be equal in frequency. The reference frequency is fixed. Now consider what the divider input must be to achieve a locked condition. Return to frame 28 and answer correctly.

---

## Scholarship Award
# GERNSBACK

Once again NRI will cooperate with RADIO-ELECTRONICS Magazine in making an annual scholarship award of $125 to a deserving student currently enrolled in NRI. The Award will be applied toward furthering the selected student's education in electronics. NRI is one of eight home-study electronics schools chosen to perpetuate the scholarship established by RADIO-ELECTRONICS in memoriam to Hugo Gernsback, its founder and a notable pioneer in electronics.

If you wish to nominate a student for this award (and you may certainly nominate yourself), send a letter outlining the reasons for your choice to:

Gernsback Award
National Radio Institute
3939 Wisconsin Avenue, N. W.
Washington, D.C. 20016

Entries must be postmarked by May 31, 1973 to be considered. A panel of judges chosen by NRI will select the winner; their decision will be final. (Sorry, previous winners of the Gernsback Award do not qualify for the 1973 Awards.)

Written notification will be sent to the winner and announced in the September/October issue of the Journal.

## ham ads

**Wanted:** Information (schematic, etc.) for Philco Electronic Master, Model 7001. Howard Phillips, 4813 East King Street, Tulsa, OK 74115

**Wanted:** Hallicrafters SX199, Hammarlund HQ129 or old tube type Zenith Trans-oceanic receiver. Andrew Jobbagy, G-5507 South Saginaw, Flint, MI 48507

**Wanted:** Information (schematic or manual) for ITT/Kellogg Model K30H-A FM taxi transceiver. Charles Harrington, Western, NE 68464

# HAM NEWS

***By Ted Beach K4MKX***

Well, gang, it looks like a pretty short column this time. We haven't heard from too many of you since last time, and I've not had the time to work up anything interesting for general information. Just wait until next time, though – we'll really do it up fine for you.

Now, here are the NRI amateurs we've heard from since last time, with the Amateur Course students and grads listed first:

We are always glad to publish the calls of those of you who have recently upgraded your license class. WB8BMU is the only one so listed this time, and is also somewhat of a puzzlement. Since when is Texas in the eighth call district? Maybe Bill is in the service and stationed in Texas? Oh well!

We didn't leave WN8OUD's name and QTH out inadvertently – the call belongs to Sister Marjorie M. Kramer, SND de N

| | | | |
|---|---|---|---|
| John | WN2MVJ | N | East Patchogue NY |
| John | WN4BDN | N | Mobile AL |
| Phil | WB4CYG | T | Macon GA |
| Burton | WN5ILO | N | N. Little Rock AR |
| Bill | WB8BMU* | G | Copperas Cove TX |
| | WN8OUD | N | |
| Don | WA8UWG | T | East Lansing MI |
| J.M. | WN9LMW | N | Champaign IL |
| Allen | WP4DQC | N | Utuado PR |
| Ben | WP4DQP | N | Rio Piedras PR |
| Jorge | WP4DQS | N | Maunabo PR |
| G.E. | VE1IH | – | Summerside PEI Can. |
| *Just upgraded – congratulations! | | | |
| Chuck | W7GSV | – | Big Sandy MT |
| W.D. | WA7UNS | A | Annabella UT |
| Allen | K8AXW | E | Keyser WV |
| Bob | WB8IJF | G | Vermilion OH |
| Louis | WNØIYG | N | St. Paul MN |

and there just wasn't room for all of that. Also, the information that was given to me didn't include a QTH.

Not listed is John Wittenmeyer who is awaiting the papers from the FCC so that he can take his Novice test. He has already had his volunteer examiner, W8QBG, check out his transmitter, so John will be ready to go just as soon as he gets those papers from the Federal Can Company.

WA8UWG is taking the Amateur Course in order to find out the "why" of radio and says he is getting a lot out of the course. Don got his Tech back in '67 and just wants to know why this radio stuff works the way it does. Nice going, Don, and keep at it.

Did you notice the three Puerto Rico calls in the list? How about that! I wonder if Allen, Ben, and Jorge know one another? After all, that island isn't all that big. Maybe you guys could get together for an "eyeball QSO" one of these days. Incidentally, they got their tickets in September, October, and December respectively, making WP4DQC the old timer of the group.

That's about it for the Amateur Course group, so let's see what's up with our other Rogues.

Chuck, W7GSV, says he'll be 59 years young in May and enjoys operating all bands, 75 through 2 meters. On the dc bands, Chuck uses a Yaesu FTDX 560 to a long wire which is 3 wavelengths long on 20 and 6 wavelengths on 10 and runs southeast to northwest. That ought to do the job, Chuck. He didn't mention on his QSL what the vhf rig(s) was.

WA7UNS passed up the Novice stage entirely and started out as a General in October. The following January, W.D. got his Advanced. He says that he spent two hours a day for three months studying the code to get the magic 13 per for the test and found the theory easy, thanks to his NRI lessons. Presently, W.D. is working for the commercial First Phone, and if his efforts in that direction are anything like what he has put into amateur radio I'm sure he'll have that ticket in no time at all.

K8AXW sent me a very newsy two page letter which he said he had meant to write some time ago but just now got around to it. No wonder. From what he says, Allen is a "professional student" who is never satisfied. He has taken three courses from RCA Institutes, is presently taking the NRI Electronics course, has completed a three year program in electronics at a local vocational school, and plans to take the NRI Marine and Aircraft courses before his GI Bill runs out. Like Wow! Allen has had a Ham ticket for about 16 years, starting out as DL4TPO in Germany, then K3FKA in Maryland, and now K8AXW in West Virginia. He operates his SB102 mostly on 40 meters to a vertical antenna but is getting interested in 2 meters and SSTV as well. Best of luck, Allen, and maybe we'll hear you on 2 one of these days.

WB8IJF is a graduate of three NRI courses and says that in December he decided to get a Ham license. With all the theory from his NRI training, all Bob had to do was brush up on his code and study Part 97 a bit to breeze through the General Test. Nice going, Bob.

Although there is a Ham Ad on the following item, I thought I'd mention here also that Charles Harrington (no call given) needs some help. He has an ex-taxi transceiver which he wants to convert to 2 meters and cannot find any information on it. It is an ITT/Kellogg Model K3OH-A and he would like a schematic or operating manual for it. I asked people in our local area and came up with the same results that Charles did – no one ever heard of the rig. Anyone help? Write Charles at: Western, Nebraska 68464.

And that puts the ribbons on it for now, gang. Let's hear from you and I promise we'll have a more interesting column next time. Until then, very 73.

Ted – K4MKX

# NRI HONORS PROGRAM AWARDS

*For outstanding grades throughout their NRI courses of study, the following January and February graduates were given Certificates of Distinction along with their NRI Electronics Diplomas.*

## WITH HIGHEST HONORS

Tommy Joe Ausbern, Seminole, TX
Roy A. Bagley, Suitland, MD
David E. Barber, APO New York
Elmer H. Blush, Jr., Arlington, VA
William L. Brady, Morningside, MD
James Steven Farnsworth, Sawyer AFB, MI
Richard L. Foster, Warminster, PA
Irving Givin, Medford, NJ
Glenn F. Golladay, Edinburg, VA
George A. Hackbardt, Tipp City, OH
Dale N. Klammer, Blaine, MN
Suzanne P. Lack, East Lansing, MI
Helmuth O. Loescher, Jr. APO San Francisco
Thomas E. Meyer, Saint Paul, MN
Nick F. Morrison, Virginia, MN
Karl M. Mraz, Baden, PA
Miles D. Ordinachev, Affton, MO
William R. Pritchard, Warner Robins, GA
Delbert E. Renaud, Enhaut Steelton, PA
Carlos A. Rosales M., New York, NY
Bobby L. Tapley, Dover, DE
Fr. Jesus Torregrosa, Quezon City, Philippines
Albert J. Vogl, Baltimore, MD

## WITH HIGH HONORS

Richard K. Aldrich, Kauai, HI
Donald P. Altringer, Westminster, CA
Julius Araluce, Goleta, CA
Ivan C. Beck, San Jose, CA
Bob Blackstock, Arlington, TX
Bruce Blechman, Far Rockaway, NY
Robert A. Boxell, Winter Park, FL
Roger W. Brace, Jr., San Antonio, TX
Chester Butterfield, Lexington, KY
Kenneth E. Campbell, Chico, CA
Gerald Clusen, FPO San Francisco
B. Cooper, Forked River, NJ
Donald A. Cote, Wahiawa, HI
James B. Cox, Greenville, SC
Raymond F. Culley, APO San Francisco
William M. Curren, Fullerton, CA
James S. Dorroh, Mathiston, MS
Howard L. Douthit, Punxsutawney, PA
Earl W. Ediger, Hutchinson, KS
Carl F. Eddy, Wilkes-Barre, PA
Paul Ehler, El Paso, TX
Ned C. Ferrali, Brooklyn, NY
James Leo Gagnon, Amarillo, TX
George Giannattasio, Upper Darby, PA
Leslie A. Gilhaus, San Angelo, TX
Benjamin R. Gilsdorf, Phoenix, AZ
Duard Greathouse, Washington, DC
Alfred E. Hales, Jr., Chalfont, PA
Delano H. Ham, Norwalk, CA
Charles E. Hanebuth, Saint Paul, MN
Charles E. Hummell, Albuquerque, NM
Donald O. Johnson, Matawan, NJ
William W. Johnson, Jr., Arlington, VA
LaVerne D. Koranda, Eatontown, NJ
William P. Krepczynski, Milwaukee, WI
Charles J. Law, Berrien Springs, MI
John A. Leininger, West Chester, OH
Myron A. Magdanz, San Diego, CA
George H. Mason, Pekin, IL
Herbert L. McKee, Hobart, IN
Harry B. Meek, Shelbyville, IN
Franklin D. Miller, McGuire AFB, NJ
Robert E. Pletcher, Bakersfield, CA
Kit C. Price, APO San Francisco
John G. Ridout, Portsmouth, OH
John W. Rippey, Jr., Roanoke, VA
Jerry L. Rochelle, Altus, OK
George C. Ryall, Brewster, NY
O. Wain Scholfield, Wichita, KS
Anthony V. Schroder, Des Plaines, IL
Ivan F. Smith, Port Huron, MI
Ned B. Smith, Holloman AFB, NM
Kenneth E. Snyder, Orlando, FL
Jerry W. Spencer, Long Branch, NJ
Mike M. Sperle, Napoleon, ND
Jeffrey Paul Steinhorn, College Park, MD

Thomas E. Stiles, Circleville, OH
Alan R. Towne, Concord, MA
Thomas L. View, Jr., Washington, DC
Albert Wentz, Minnewaukan, ND*
James D. Wheat, Pasadena, TX
D. Olney White, Prague, OK
Raymond D. Willard, Paterson, NJ
Gene F. Wilson, Saint Louis, MO

## WITH HONORS

Pablo Acevedo, Bronx, NY
Caiaphas Adamson, El Paso, TX
Pearley J. R. Angers, Chelmsford, MA
Max R. Bales, Guernsey, WY
Lewis A. Barnard, Marlboro, NJ
Marvin Barrow, Newport, AR
Bruce F. Beacher, Silver Spring, MD
Kenneth W. Bell, Manchester, TN
John J. Bentley, Jr., North Reading, MA
Richard Biskupiak, Forestville, CT
Brent Block, Gothenburg, NE
Shirley D. Brewer, Victorville, CA
Dale J. Broussard, Baton Rouge, LA
Austin W. Cannon, Rogers, AR
Kenneth J. Cayer, Dover, NH
Donald Lee Chant, Jr., St. Johns, MI
James C. Chase, Blossvale, NY
Donald S. Coates, Baton Rouge, LA
David A. Conrad, Bicknell, IN
Willard H. Cousins, Eureka, CA
Andrew N. Douglas, Portland, OR
Clayton R. Downs, Lebanon, TN
Clarence L. Dragon, Moosup, CT
Stephen W. Drobeck, Lorain, OH
Thomas M. Favalora, Jr., Cabot, AR
Carlos L. Garcia, Jacksonville, FL
Thomas A. Gertz, Ballwin, MO
Daniel F. Gloudemans, Milwaukee, WI
John C. Golden II, New Smyrna Beach, FL
Robert Guggenbuehl, Sr., La Crosse, WI
Jay W. Hedden, Kansas City, MO
Thomas A. Heim, Clarks Mills, PA
Lawrence M. Henry, Dickinson, TX
Eduardo Hernandez, El Paso, TX
Douglas Hicks, Hueysville, KY
Michael E. Hite, Lancaster, PA
Elvis G. Hoyle, Forest City, NC
Mark Alan Hughes, Waterloo, IA
Wilkins W. Hunt, Jr., Dixie, LA
Ronald E. Jackson, Lee's Summit, MO
Charles Jalbert, Conventry, RI

*Name was omitted from previous list.

Bart Johnson, Literberry, IL
Joseph G. Keithley, Jr., APO New York
Russell A. Kendrick, Mount Vernon, WA
J. L. Knotts, Coraopolis, PA
Gerald Ronald LaBrake, Malone, NY
Bruce R. Lake, McConnellsburg, PA
Martin J. Lamar, Boise, ID
Donald E. Lauts, Stapleton, NE
Merle Lawrence, Ann Arbor, MI
Maurice LeBlanc, Madawaska, ME
Richard Gene Lee, Bettendorf, IA
Raymond Lemieux, Vanier ON, Canada
Dean W. Lines, San Jose, CA
Gail A. Litten, Groton, CT
Larry T. Lucek, Rockford, IL
Charles E. Maina, Los Alamos, NM
Jimmy E. Mann, Jacksonville, FL
R. C. McAllister, Bellingham, WA
Allen W. Nelson, Hanahan, SC
Paul E. Norton, Travis AFB, CA
Charles E. Nunemacher, Lake Havasu City, AZ
Dave Allen O'Daniel, Pagedale, MO
Leonard S. Oleniak, Wilkes-Barre, PA
T. W. Pace, Greenbelt, MD
Karl Pazal, Brantford ON, Canada
Donald W. Peck, APO San Francisco
Paul A. Pena, Manassas, VA
Victor E. Peterson, Des Plaines, IL
Owen Portwood, Jr., Columbus, OH
Gaylord F. Redemer, Calumet, OK
Robert A. Reinen, Lexington Park, MD
Alan Saalfrank, Fort Wayne, IN
Donald L. Schellbach, Altus, OK
Walter H. Schmitt, Atlanta, GA
Horst M. Schulze, Dublin, CA
Clifton W. Sides, APO New York
Clement Simard, Ravenswood, WV
Joseph C. Snyder, Baltimore, MD
Gerald L. Spearman, Chicago, IL
William L. Swanger, Jr., Mountain View, CA
Robert P. Taylor, Alexandria, VA
Tom Teranishi, South San Gabriel, CA
Virgil W. Thulin, Manteca, CA
Thomas F. Tilley, Fort Rucker, AL
Lee Wayne Troupe, Zephyrhills, FL
Edwin Tucker, Lockport, NY
Richard N. Walsh, Port Deposit, MD
Howard E. White, Jr., McAlester, OK
Jimmy Whitson, Aqua Dulce, TX
Joe L. Williams, Marshville, NC
James L. Wilson, Sacramento, CA
Joseph F. Withers, Oceanside, CA
Owen H. Wood, Livingston, MT
Millard Young, Levelland, TX

## DIRECTORY OF ALUMNI CHAPTERS

CHAMBERSBURG (CUMBERLAND VALLEY) CHAPTER meets at 8 p.m., 2nd Tuesday of each month at Bob Erford's Radio-TV Service Shop, Chambersburg, Pa. Chairman: Gerald Strite, RR1, Chambersburg, Pa.

DETROIT CHAPTER meets 8 p.m., 2nd Friday of each month at St. Andrews Hall, 431 E. Congress St., Detroit. Chairman: James Kelley, 1140 Livernois, Detroit, Mich. 841-4972.

FLINT (SAGINAW VALLEY) CHAPTER meets 7:30 p.m., 2nd Wednesday of each month at Andy Jobaggy's shop, G-5507 S. Saginaw Rd., Flint, Mich. Chairman: Stephen Avetta, 239-0461.

LOS ANGELES CHAPTER Chairman: Graham D. Boyd, 3177 Virginia Ave., Santa Monica, Calif. 90404. (213) 828-8129.

NEW YORK CITY CHAPTER meets 8:30 p.m., 1st and 3rd Thursday of each month at 199 Lefferts Ave., Brooklyn, N.Y. Chairman: Samuel Antman, 1669 45th St., Brooklyn, N.Y.

NORTH JERSEY CHAPTER meets 8 p.m., 2nd Friday of each month at The Players Club, Washington Square, Chairman: George Stoll, 10 Jefferson Ave., Kearney, N.J.

PHILADELPHIA-CAMDEN CHAPTER meets 8 p.m., 4th Monday of each month at K of C Hall, Tulip and Tyson Sts., Philadelphia. Chairman: John Pirrung, 2923 Longshore, Philadelphia, Pa.

PITTSBURGH CHAPTER meets 8 p.m., 1st Thursday of each month in the basement of the U.P Church of Verona, Pa., corner of South Ave. & 2nd St. Chairman: Charles Kelly.

SAN ANTONIO (ALAMO) CHAPTER meets 7 p.m., 4th Thursday of each month at Alamo Heights Christian Church Scout House, 350 Primrose St., 6500 Block of N. New Braunfels St. (3 blocks north of Austin Hwy.), San Antonio. Chairman: Robert E. Bonge, 222 Amador Lane, Antonio, Tex. 78218, 655-3299

SOUTHEASTERN MASSACHUSETTS CHAPTER meets 8 p.m., last Wednesday of each month at the home of Chairman John Alves, 57 Allen Boulevard, Swansea, Massachusetts.

SPRINGFIELD (MASS.) CHAPTER meets 7 p.m., 2nd Saturday of each month at the shop of Chairman Norman Charest, 74 Redfern Dr., Springfield, Mass. 734-2609

TORONTO CHAPTER meets at McGraw-Hill Building, 330 Progress Ave., Scarborough, Ontario, Canada. Chairman: Branko Lebar. For information contact Stewart J. Kenmuir (416) 293-1911.


## NORTH JERSEY CHAPTER'S MEETING PLACE VANDALIZED

North Jersey's meeting place was broken into by vandals on January 29 and extensive damage was done to the chapter's metal locker. The doors were bent beyond repair and have since been replaced with new plywood doors and hardware. A bag containing a vtvm and small tool kit belonging to the chapter and a microphone belonging to the Player's Club public address system was recovered by police on a nearby school lawn.

As far as chapter business is concerned, work which was started last month is being continued on the color TV set. Many bad solder joints have been discovered, and consequently, much valuable time has been lost resoldering the set.

During the month of March, our National President and Chapter Chairman, George Stoll, enjoyed a well-deserved vacation in Arizona. Vice Chairman, Franklin Lucas, conducted the meeting and also gave a lecture and demonstration on low voltage systems and troubles. Old

# Alumni News

transformers and full wave rectifiers were discussed as well as the newer diode types.

The chapter members also discussed the problems Bob Kreger had been having with his radio and record player amplifier. Bob had replaced some parts but was still having trouble in the FM section. Unfortunately, Bob did not bring the set in since he lives too far from the meeting place.

The chapter was also pleased to welcome Emil Savino of Jersey City as its guest and new member. Emil is presently an NRI student.

Mr. Arthur Bryon gave a lecture on transistor checkers. The lecture was enjoyed by all.

The members also worked on two troublesome dogs. Norman had a Sylvania TV which had trouble in the color circuits. The trouble proved to have been caused by a bad capacitor. Frank Kowalski brought in a midget Singer TV Model TV6U which had trouble in the sync circuits.

The meeting adjourned at 10:30 with snack time afterward. The chapter wishes to thank Mr. Charest and his mother for the coffee and fine pastry.

**SPRINGFIELD CHAPTER CONTINUES TROUBLESHOOTING SESSIONS**

The Springfield Chapter's regular January meeting was held at the shop of Norman Charest with fourteen members present. The secretary reported that Mr. George Desnoyers was recuperating from a sick spell.

Al Dorman announced that he had a B & K transistor checker for sale at $45 which is really a $95 value. He also wishes to sell his CONAR scope for $35.

**SAN ANTONIO CHAPTER GIVEN SWEEP GENERATOR**

The San Antonio Chapter was given a post marker sweep generator by the Heath Company. Although its condition is doubtful, the chapter intends to make good use of it. The members wish to express their gratitude to the Heath Company.

At the February meeting, Mr. Sam Stinebaugh acted as chairman. The chapter discussed agc sections, TV tough dogs, and related subjects. The chapter also planned its get-together with the National Executive Secretary, Tom Nolan, and his wife Janet on April 18, 1973.

The new secretary, Mr. Harrison, has been prevented from taking over his new job because of ill health. The chapter's "old secretary" is hanging in there and Mr. Harrison expects to take over next month.

## DETROIT CHAPTER CONTINUES ITS COLOR DISCUSSION

Detroit's Chairman, Mr. Jim Kelley, has been lecturing to the chapter as he progresses in his NRI Color TV Course. He has presently been discussing the chassis that he is constructing. The entire chapter is benefiting from Jim's course.

The chapter was pleased to receive a Christmas card from Mr. Blan Straughn who has made many visits to the chapter in the past years. Everyone was glad to hear that Mr. Straughn is still in the electronics business.

## PITTSBURGH CHAPTER ENJOYS LECTURE BY MEMBER

Mr. John Benoit, an independent TV repairman, gave a lecture on the use of the oscilloscope. He gave a complete description of the waveforms, what they mean, and what they indicate. He had a TV set with him so he could show the waveforms and explain them.

At the March meeting, Mr. William Sinclair, the General Electric field representative, gave a talk on the Model JA series color TV receivers. Mr. Sinclair presented the talk using slides.

The chapter has also been compiling program schedules for the months ahead. The schedule includes a visit from the Executive Secretary of the Alumni Association in May; speakers from Motorola in June; Mr. John Gilbert in July; and the planning of the chapter's 25th anniversary coming up in 1978. With that kind of foresight and planning, the 25th anniversary celebration is bound to be a success.

## NEW YORK CHAPTER HOLDS TROUBLESHOOTING SESSION

At the January meeting, Willie Foggie, while pinch-hitting for Jim Eddy, talked about some of his experiences on B+ supplies. His talk was especially effective since he used a blackboard to draw his diagrams.

Brother Bernard Frey gave a talk on his amateur radio activity and told the chapter about the messages he had received from Nicaragua during the earthquake and how he relayed messages all over the United States. Needless to say, it was a very interesting talk.

At the January 18th meeting, Stephen Kross lectured on power supplies. He brought many different kinds of power supplies with him and described each one and showed how it worked.

Sam Antman read a card he had received from Blan Straughn. Sam also told about a letter he had written to Joe Bradley who is in Germany. Sam expects that Joe might be visiting the chapter sometime this coming summer.

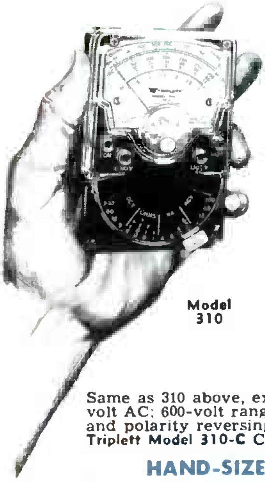
**Mr. John Benoit lectures on the use of the oscilloscope, giving a complete description of the waveforms, what they mean and what they indicate.**

# FROM CONAR . . .

## TRIPLETT Test Instruments

### for ACCURACY & RELIABILITY

### DIODE-PROTECTED, HAND-SIZE V-O-M'S



Model 310

1. Hand-size V-O-M with diode overload protection.
2. 20,000 ohms per volt DC and 5,000 ohms per volt. AC.
3. Single range switch; provision for clamp-on AC ammeter.

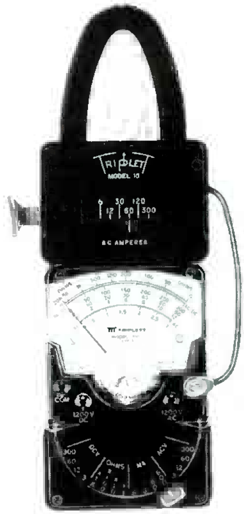
**RANGES**

**DC Volts:** 0-3-12-60-300-1,200 (20,000 ohms per volt).
**AC Volts:** 0-3-12-60-300-1,200 (5,000 ohms per volt).
**Ohms:** 0-20K-200K-2 Meg-20 Meg.
**DC Microamperes:** 0-600 at 250 mV.
**DC Milliamperes:** 0-6-60-600 at 250 mV.
**Accuracy:** ±3% DC; ±4% AC.
**Scale Length:** 2⅛". Self-shielded.
**Case:** Molded, black, 2¾" w. x 1-5/16" d. x 4¼" h.
**Batteries:** NEDA #910,220.
**Triplett Model 310**—Complete with 42" leads, batteries and instruction manual. Cat. No. 3018 ........ $46.00

### MODEL 310-C

Same as 310 above, except 20,000 ohms per volt DC and 15,000 ohms per volt AC; 600-volt ranges replace 1200-volt ranges; plus, suspension meter and polarity reversing switch for DC ranges.
**Triplett Model 310-C** Cat. No. 3022 ........ $59.00

### HAND-SIZE V-O-M CLAMP-ON AMMETERS



Model 100

1. Complete maintenance kit with V-O-M and clamp-on ammeter.
2. Diode overload protected; 20,000 ohms per volt on DC.
3. AC clamp-on will read up to 300 amps AC.

**Model 100**—Complete set includes Model 310, Model 10, Model 101, No. 311 lead and Model 379 case. Cat. No. 3014 ........ $82.00
**Model 100-C**—Complete set includes Model 310-C, Model 10-C, Model 101, No. 311 lead and Model 379 case. Cat. No. 3010 ........ $92.00

### MODEL 630-PLK V-O-M

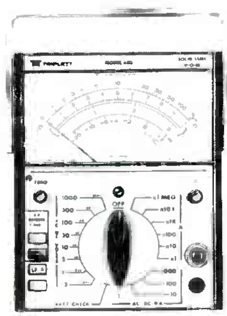
Model 630-PLK

1. Burnout-proof solid state overload protection; suspension movement.
2. Single range switch minimizes error; DC polarity-reversing switch.
3. 4 Ohmmeter ranges with 4.4 ohms center scale.

**RANGES**

**DC Volts:** 0-2.5-10-50-250-1,000-5,000 (20,000 ohms per volt); 0-0.25 at 100 μA.
**AC Volts:** 0-3-10-50-250-1,000-5,000 (5,000 ohms per volt).
**Ohms:** 0-1K-10K-1-Meg-100 Meg (4.4-ohm center scale on low range).
**DC Microamperes:** 0-100 at 250 mV.
**DC Milliamperes:** 0-10-100-1,000 at 250 mV.
**DC Amperes:** 0-10 at 250 mV.
**Decibels:** —20 to +49 ("0" dB at 1 mW on 600-ohm line).
**Output Volts (AC):** 0-3-10-50-250 (5,000 ohms per volt).
**Accuracy:** ±2% DC; ±3% AC. Diode protected suspension meter.
**Scale Length:** 4½". Transistorized electronic switching circuit protects tester against burn-out.
**Case:** Molded black, 5½" w. x 3-11/32" d. x 7½" h.
**Batteries:** NEDA #210, 13F.
**Triplett Model 630-PLK**—Complete with 48" leads, alligator clips, batteries and instruction manual. Cat. No. 3055 ........ $103.00
**Triplett Model 630-APLK**—Similar to 630-PLK with accuracy of ±1½% DC; ±3% AC. Cat. No. 3120 ........ $116.00

### MODEL 603 FET V-O-M



Model 603

1. Exclusive TRIPLETT MICRO POWER—TMP™ provides battery life in excess of a year for carbon batteries.
2. LOW-POWER OHMS—LPΩ™—6 ranges with 70 mV power source for in-circuit measurements without component damage.
3. FET V-O-M WITH AUTO-POLARITY—convenient and time saving, always reads up scale.

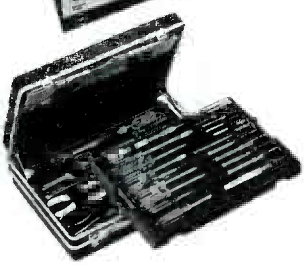
**RANGES**

**DC Volts:** 0-0.3-1-3-10-100-300-1,000. Input resistance 11.12 megohms with 1.12 Meg in Probe.
**AC Volts:** 0-0.3-1-3-10-100-300-1,000. Input impedance 10 megohms. Frequency range 20 Hz to 10 kHz.
**Ohms—Low Power:** 0-1k-10k-100k-1MΩ-10MΩ-1000MΩ. (70 mV open circuit voltage, 123 μW maximum power applied to device under test, 10 Ohm center scale on low range).
**Ohms—Conventional:** 0-1k-10k-100k-1MΩ-10MΩ-1000MΩ. (1.5 volt open circuit voltage, 56 mW maximum power applied to device under test, 10 Ohm center scale on low range).
**AC and DC Milliamperes:** 0-1-10-100-1000 at 316 mV.
**Decibels:** —30 to +62 ("0" dB is equal to .776V).
**Accuracy:** ±3% all Voltage and Ohms ranges, ±4% all Current ranges.
**Scale Length:** 4⅛".
**Case:** Shielded, molded, black, 5⅛" w X 3-3/16" d X 6½" h.
**Batteries:** NEDA 9V 1604 (2), 1½V 13F (1).
**Model 603** Complete with 48" leads, alligator clips, batteries and instruction manual. Cat. No. 3037 ........ $150.00

# 4 ways to buy Sams Photofact® at big savings!

Photofact sets give you all the facts needed to handle any TV, radio or record player service job correctly and without frustration.

Now, Sams makes Photofact an even better buy—with four special offers—four Easy Buy Time Payment plans that bring you the Photofact sets you need at a saving of 50¢ each, plus *free* file cabinets and *free* tool sets. And you pay for the Photofact sets on time, *with no carrying charge!*

## 1 Easy Buy Plan "A"

60 Photofact set library
$9.95 single drawer cabinet—free
Xcelite screwdriver/nut driver set—free
for $20 down and $133 balance
payable without carrying charge!

## 2 Easy Buy Plan "B"

180 Photofact set library
$38.95 four-drawer cabinet—free
Xcelite drive socket wrench set—free
for $20 down and $439 balance
payable without carrying charge!
A 49% bonus on investment!

## 3 Easy Buy Plan "C"

300 Photofact set library
$38.95 four-drawer cabinet—free
Two $9.95 single drawer cabinets—free
Xcelite service master tool set—free
for $20 down and $745 balance
payable without carrying charge!
A 50% bonus on investment!

## 4 Easy Buy Plan "D"

500 Photofact set library
Two $38.95 four-drawer cabinets—free
Two $9.95 single drawer cabinets—free
Vaco tools and luggage case—free
for $20 down and $1255 balance
payable without carrying charge!
A 55% bonus on investment!

Free Tool Offer
Expires July 31, 1973

**Clip and mail the coupon below for no-obligation information. No salesman will call.**

CONAR Instruments
3939 Wisconsin Avenue
Washington, D.C. 20016

I am interested in Easy Buy Plan _____. Please send me a Photofact purchase contract. I understand that this does not obligate me to buy.

Name ____________________

Company Name ____________________

Address ____________________

City ________ State ________ Zip Code ________

# CONAR

DIVISION OF NATIONAL RADIO INSTITUTE
3939 WISCONSIN AVENUE • WASHINGTON, D.C. 20016

CHECK ONE:
- ☐ Cash Order
- ☐ C.O.D. (20% deposit required)
- ☐ Select-A-Plan Order

CHECK ONE:
- ☐ New CONAR Account
- ☐ Add-on CONAR Account
- ☐ Re-open CONAR Account

PLEASE PRINT

NRI Student or Graduate No.

Name

Address

City State Zip Code

Ship to another address? Give Directions here

Name

Address

City State Zip Code

Moved since last order?

Previous Address City State

| 1. NAME OF ITEM | 2. STOCK # | 3. HOW MANY? | 4. PRICE EACH | 5. TOTAL | WEIGHT |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**IMPORTANT**

To speed handling, any correspondence should be on separate paper.

All prices are net F.O.B., Wash., D.C.

Please include postage for weight shown and insurance on Parcel Post orders.

Express Orders should not include shipping charges.

A 20% deposit is required on C.O.D. orders. SELECT-A-PLAN ORDERS: Please complete and sign reverse side.

Thank you for your order.

Prices in the CONAR catalog and Select-A-Plan time payment privileges apply only to residents of the United States and Canada. Residents of other countries and territories may obtain CONAR products, through SIGMA INTERNATIONAL CORPORATION, our Export Representatives. Address inquires and send orders to: Sigma International Corporation, 13 East 40th Street, New York, N.Y. 10016.

| | | |
|---|---|---|
| 6. Total Cash Price For Merchandise | | |
| (Do not remit for items shipped Express Collect) 7. Parcel Post and Insurance | | |
| 8. 10% Cash Down Payment and Parcel Post Costs Required on New CONAR Accounts | | |
| 9. Unpaid Balance of Cash Price (Items 6 & 7 less item 8) | | |
| 10. Sales Tax (Washington, D.C. Residents Only) | | |
| 11. Unpaid Balance (Amount to be financed) (Item 9 plus item 10) | | |
| 12. Finance Charge (See schedule on back) | | |
| 13. Total of Payments (Item 11 plus item 12) | | |
| 14. Deferred Payment Price (Items 6, 10 and 12) | | |

Please do not write in this space

# RETAIL INSTALLMENT CONTRACT & SECURITY AGREEMENT

# CONAR SELECT-A-PLAN

## SELECT YOUR TERMS TO FIT YOUR BUDGET

### CONAR FINANCIAL RATES:

**STANDARD PLAN**—The ANNUAL PERCENTAGE RATE is 17.75%

**EXTENDED PLAN**—The ANNUAL PERCENTAGE RATE is 15.50%

### TO SPEED SHIPMENT

1. Complete other side of this sheet.
2. Use Select-A-Plan Schedule on the right to find your Finance Charge and your Monthly Payment.
3. Insert amount of down payment (at least 10% of total order) and other information in Payment Agreement below.
4. Sign Payment Agreement and fill in Credit Application.

IMPORTANT: When you have made three monthly payments, you can "add-on" purchases with no down payment. If you are under 21, please have the Payment Agreement and credit application filled out and signed by a person over 21. He can make the purchase for you and will be responsible for payment. If you have a CONAR account open or recently paid-in-full, just sign the Payment Agreement.

NOTICE TO THE BUYER: (1.) Do not sign this agreement before you read it or if it contains any blank space. (2.) You are entitled to a copy of this signed agreement. (3.) The Finance Charge will be waived if the unpaid balance is paid within 30 days. If paid within 60 days, the Finance Charge will be reduced by 2/3; if paid within 90 days, the Finance Charge will be reduced by 1/3. Accounts extending beyond 30 days will pay up to $3 in Credit Service Charges before the above reductions are made.

### SELECT-A-PLAN SCHEDULE

PLEASE CHECK ONE: ☐ STANDARD PLAN ☐ EXTENDED PLAN

| IF UNPAID BALANCE IS | STANDARD PLAN | | EXTENDED PLAN | |
|---|---|---|---|---|
| | Financial Charge | Monthly Payments | Financial Charge | Monthly Payments |
| 20.01- 25.00 | 1.05 | 3.50 | | |
| 25.01- 30.00 | 1.50 | 4,00 | | |
| 30.01- 35.00 | 2.05 | 4.50 | | |
| 35.01- 40.00 | 2.65 | 4.75 | | |
| 40.01- 50.00 | 3.00 | 5.00 | | |
| 50.01- 60.00 | 4.15 | 5.50 | | |
| 60.01- 70.00 | 5.50 | 6 00 | 6.40 | 4.50 |
| 70.01- 80.00 | 7.00 | 6.50 | 8.00 | 5.00 |
| 80.01- 90.00 | 8.00 | 7.75 | 10.10 | 5.00 |
| 90 01-100.00 | 9.00 | 8.75 | 12.60 | 5.25 |
| 100.01-110.00 | 10 00 | 9.75 | 14.80 | 5.50 |
| 110 01-120.00 | 11.00 | 10.75 | 16.20 | 6.00 |
| 120.01-130.00 | 12.00 | 11.75 | 17.60 | 6.50 |
| 130.01-140.00 | 13.00 | 12.75 | 19.40 | 7.00 |
| 140.01-150.00 | 14.00 | 13.75 | 21.60 | 7.50 |
| 150 01-160.00 | 15.00 | 14.75 | 23.20 | 8.00 |
| 160.01-170.00 | 16 00 | 15.75 | 24.80 | 8 50 |
| 170.01-180.00 | 17.00 | 16.75 | 26.20 | 9.00 |
| 180.01-200.00 | 18.00 | 17.00 | 27.90 | 10.00 |
| 200.01-220.00 | 20.00 | 18.50 | 29.80 | 11.00 |
| 220.01-240.00 | 22 00 | 20.00 | 32.40 | 12.00 |
| 240 01-260.00 | 24.00 | 22.00 | 35.20 | 13.00 |
| 260.01-280.00 | 26 00 | 24.00 | 38.20 | 14.50 |
| 280.01-300.00 | 30.00 | 24.50 | 41.20 | 15.50 |
| 300.01-320.00 | 32.00 | 25.50 | 44.20 | 17.00 |
| 320.01-340.00 | 35.00 | 27.00 | 47.80 | 18.00 |
| 340.01-370.00 | 38.00 | 28.00 | 52.40 | 18.50 |
| 370.01-400 00 | 42.00 | 29.50 | 57.20 | 20.00 |
| 400.01-430.00 | 46 00 | 31.50 | 62.20 | 21.00 |
| 430 01-460 00 | 49.50 | 34.00 | 69.00 | 22.00 |

ON ORDERS OVER $460.00 THE FINANCIAL CHARGE ON THE EXTENDED PLAN WILL BE 15% AND PAYMENTS WILL BE IN PROPORTION TO AMOUNTS SHOWN ON ABOVE SCHEDULE

### HOW TO DETERMINE THE NUMBER AND AMOUNT OF MONTHLY PAYMENTS TO REPAY THE "TOTAL OF PAYMENTS"

Use the Select-A-Plan Schedule to find out what your monthly payment is. Then divide your monthly payment into your "Total of Payments" to find out how many monthly payments you must make. The amount which is left over is your final payment. FOR EXAMPLE, if your unpaid balance is $95, then your monthly payment is $8.75 (using the Standard Plan). If your "Total of Payments" is $104, then your monthly payment of $8.75 divides into that number 11 times with $7.75 left over. This means you make 11 payments of $8.75 each, plus a final payment of $7.75.

### PAYMENT AGREEMENT

Enclosed is a down payment of $.................. on the merchandise I have listed on the reverse side. Beginning 30 days from date of shipment, I will pay CONAR $.................. each month for .............. months, plus a final monthly payment of $.................. Title to and right of possession of the merchanidse shall remain in you until all payments have been made. If I do not make the payments as agreed, you may declare the entire balance immediately due and payable. In satisfaction of the balance, you may at your option, take back the merchandise, which I agree to return at your request. I understand that a 1% accounting charge will be added to my unpaid balance if my payments become 60 days or more in arrears. I agree that the above conditions shall apply to any add-on purchases to my Select-A-Plan account. The statements below are true and are made for the purpose of receiving credit.

DATE .................................................. BUYER SIGN HERE ..................................................

## IT'S AS EASY AS A - B - C TO OPEN A CONAR ACCOUNT

PLEASE ALLOW ADEQUATE TIME FOR NORMAL ROUTINE CREDIT CHECK. ONCE YOUR CREDIT IS ESTABLISHED, ONLY YOUR SIGNATURE IS NEEDED TO ADD ON PURCHASES

### A → WHERE DO YOU LIVE?

PRINT FULL NAME .................................................. Age ..........

HOME ADDRESS .................................................. CITY .................. STATE .................. ZIP CODE ..........

HOME PHONE .................................................. HOW LONG AT THIS ADDRESS ..................

( ) OWN HOME ( ) RENT .................. RENT OR MORTGAGE PAYMENTS $ .................. PER. MO.

WIFE'S NAME .................................................. MARITAL STATUS ( ) MARRIED ( ) SINGLE

NUMBER OF DEPENDENT CHILDREN ..................

PREVIOUS ADDRESS .................................................. HOW LONG? ..................

### B → WHERE DO YOU WORK?

YOUR EMPLOYER .................................................. POSITION .................. MONTHLY INCOME $ ..................

EMPLOYER'S ADDRESS .................. Street .................. City .................. State .................. HOW MANY YEARS ON PRESENT JOB? ..................

PREVIOUS EMPLOYER .................. Name .................. Address .................. HOW LONG? ..................

WIFE'S EMPLOYER .................. Name .................. Address .................. MONTHLY INCOME $ ..................

### C → WHERE DO YOU TRADE?

BANK ACCOUNT WITH .................. Street .................. City .................. State .................. ( ) CHECKING ( ) SAVINGS ( ) LOAN

CREDIT ACCOUNT WITH .................. Street .................. City .................. State ..................

CREDIT ACCOUNT WITH .................. Street .................. City .................. State .................. TOTAL OF ALL MONTHLY PAYMENTS INCLUDING CAR $ ..................

SPECIAL PURCHASE BY CONAR MEANS YOU CAN MOVE UP TO FOUR-CHANNEL SOUND AT A TWO-CHANNEL PRICE!

# Save $50

## EVR 4x4 Four-Channel Receiver

- Built-in Matrix Decoder Circuit
- Four-Channel 70-watt IHF Amplifier
- Full Two- and Four-Channel Inputs/Outputs

Dual front and rear bass, treble, and balance controls—tape monitor—two headphone jacks—FET/IC tuner—power bandwidth: 20-20,000 Hz. Dimensions: 4-3/4 by 16-3/8 by 11-1/2. 117 volts ac.

Regular $249.95

Stock No.44RT
Weight 40 pounds

**Only $199.95**

SELECT A MATCHED SET OF SPEAKERS FOR TRUE FOUR-CHANNEL ENJOYMENT

## ROYAL Speaker Systems

SPECIAL LIMITED-TIME FOUR-FOR PRICES.
OFFER EXPIRES JUNE 30, 1973.

All speakers in walnut-grain vinyl cabinets.

**Royal 6A** — Twelve-inch. Three-way air suspension. Response 30-20 kHz. 70 watts maximum. Weight 40 pounds.

CONAR's Regular Price
$79 each
NOW! FOUR FOR $300

**Royal 5A** — Ten-inch. Two-way air suspension. Response 35-20 kHz. 70 watts maximum. Weight 33 pounds.

CONAR's Regular Price
$64 each
NOW! FOUR FOR $250

**Royal 2B** — Dual six-inch. Two-way coaxial system. Response 45-18 kHz. 25 watts maximum. Weight 17 pounds.

CONAR's Regular Price
$32 each
NOW! FOUR FOR $120

All speakers on this page are shipped via United Parcel Service or best alternate method. Shipping charges are approximately $1.00 per 10 pounds.

NRI JOURNAL
3939 Wisconsin Avenue
Washington, D.C. 20016



Second-class postage paid at Washington, D.C. and additional entry


MR WILLARD F VELLINE 25923 G
1322 S 14 1-2 ST
FARGO ND 58102