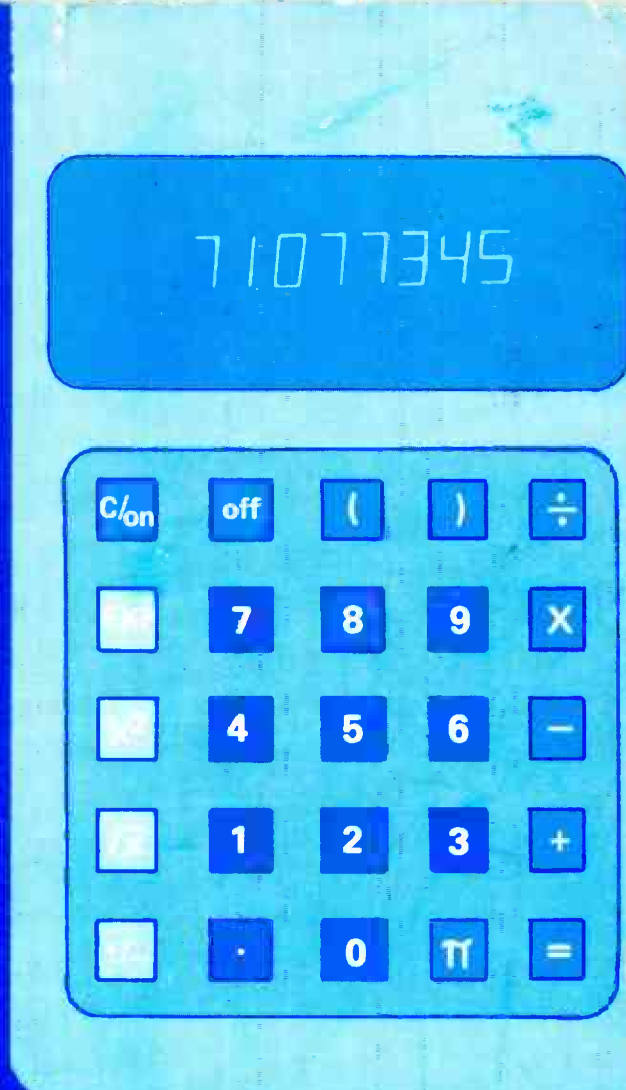

- Painless Math
- Switching Regulators
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nri journal

July/August 1975

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IMPORTANT: With so many calculators on the market, it's pretty hard for a student in electronics or a technician to pick the one best suited to his needs. After an exhaustive study of available machines, H. J. (Joe) Turner, Jr., NRI development engineer, prolific NRI Journal author, and avowed calculator nut, has found the Litronix 2260 to be by far the best calculator buy for use in electronics. Read his article in this issue of the Journal.

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painless math

Harold J. Turner, Jr.

Everyone has to handle numbers as a part of everyday life, and most people regard math problems as bothersome chores. This no doubt accounts for the current popularity of hand-held electronic calculators. These tiny "brains" are used by millions of people in dealing with the numbers that they encounter at school, at work, and even at play.

One has only to pick up a newspaper or walk through a department store to be assured that there is no shortage of different calculator models. Most of the machines you see advertised are of the "four-banger" variety. That is, they perform the four basic operations: add, subtract, multiply, and divide. A high-school student, a businessman, or a housewife would probably be quite pleased with a calculator of this type, and millions of them are sold every year.

As a student of electronics, however, you are in a much different position. For one thing, you encounter a larger amount of math in your studies than the average person does in dealing with the day-to-day problems of life. And, many of the mathematical operations that you must perform in order to develop a good knowledge of electronics fundamentals are beyond the capabilities of the simple four-function machine.

Until very recently, a calculator suitable for use in electronics had been financially out of the reach of most students. Now, however, as calculator prices continue to fall as a result of advancing technology and increasing mass production, a scientific calculator can no longer be considered a luxury for someone in your position, but rather, a reasonably-priced investment toward your education. By enrolling with NRI and pursuing your course of studies, you have demonstrated your interest in your future. And the right electronic calculator could be just what you need as an aid to mastering basic electronics.

As a design engineer, I have been watching the calculator market with very great interest for several years. I have watched prices plummet and operating features become more attractive, and I am sure that many of you have as well. Now, I will be the first to admit that the advice that I am about to give you will probably be obsolete a year from now. But that year could be most crucial to you; there are some things that just cannot be put off, and your electronics education is probably one of them. Here's my advice: *At the present time, and for the foreseeable future, by far the best buy in electronic calculators for use by students of electronics is the Litronix Model 2260.* As a service to NRI students, our CONAR Division is making this calculator available on a mail-order basis. The 2260 is of high-quality construction, and is covered by an unconditional one-year warranty. If anything happens to the machine within the first year, you may return it to Litronix for a replacement calculator at no charge, and with no questions asked. But even without consideration of the high quality of construction and the unusually liberal warranty, the 2260 is the least expensive calculator of its type available anywhere today. Let's look at some of its capabilities.

Of course, the Litronix 2260 performs the standard add, subtract, multiply, and divide operations in the twinkling of an eye. But this is where the similarity between this machine and the typical four-banger ends. In addition, the 2260 also performs instantaneous squaring and square root operations, recalls the value of π at a single key stroke, offers true algebraic operation with parentheses for handling involved equations, and, perhaps most importantly, operates either in standard floating decimal point or *scientific notation* modes.

This is the system that scientists and engineers use to handle very large or very small numbers, such as those you run into in electronics problems every day. As you know, most electronics formulas are set up to operate in "basic units": ohms, farads, henrys, hertz, and so on. Unfortunately, many of the values that we must "plug in" to these formulas are very small fractions or numbers up in the millions. A good example of a very small number would be the capacitance of a common .05 microfarad disc capacitor. Since a microfarad is one millionth of a farad, to express this number in ordinary notation you would have to write .00000005 farad, and that's a lot of zeros to count when you are writing them down or entering them on a calculator keyboard. Even if the calculator could handle such a small number in this form, the chance of an error would be high. With scientific notation, the problem vanishes. This value would be entered into the 2260 as "$.05 \times 10^{-6}$" farad, with the "10^{-6}" indicating that .05 is to be multiplied by one millionth. Similarly, 22 megohms would be written in scientific notation as 22×10^{6}. Notice that here the exponent of 10 is positive, and indicates that the number 22 is to be multiplied by one million.

When you enter a number in scientific notation on the 2260, the multiplier, or *mantissa*, as it is called, will be seen on the left-hand part of the display screen, while the exponent of 10 will be seen on the right-hand side of the display. The "10" itself does not appear in the display; its presence is assumed whenever you see the one- or two-digit exponent on the right-hand side of the display.

Let's go through a typical problem using scientific notation to show how easily the 2260 can solve common electronics problems. Suppose you need to know the reactance in ohms of a .1 microfarad capacitor at a frequency of 440 hertz. As you have learned or will learn in Lesson B107, the formula to be used here is

$$X_C = \frac{1}{2\pi fC}$$

or, capacitive reactance in ohms equals 1 divided by the quantity 2 X π X frequency in hertz X capacitance in farads.

This problem would be performed on the 2260 as follows: First, enter the capacitance in farads. Since a .1 microfarad capacitor is .1 $\times 10^{-6}$ farad, clear the calculator and push the keys .1 EXP +/− 6. This enters the size of the capacitor into the calculator. Now multiply by 2 by pushing the X and 2 keys. This calculation is not actually performed until you push the X key again for the next multiplication: push X π, then X 440. If you now push the equals key, you will see displayed the value of $2\pi fC$. Since you need the reciprocal of this number, calculate it by pushing ÷ = =, and see the answer 3617.1578 (ohms) in the display. The sequence "÷ = =" is the standard procedure for finding a reciprocal on the 2260, as this method uses the automatic constant feature of the machine, and eliminates the need for a separate 1/X (reciprocal) key found on some calculators.

Let's try another example, this time using yet another feature of the 2260: automatic square root. The formula for resonant frequency in a tuned circuit is

$$F = \frac{1}{2\pi\sqrt{LC}}$$

or frequency in hertz equals 1 divided by the quantity 2 X π X the square root of the quantity inductance in henrys X capacitance in farads. Now, this may seem a fairly complicated formula, but is one that is encountered in electronics work fairly often, and it is one that the 2260 can handle with ease.

Let's assume that the inductor in our tuned circuit has a value of 1 millihenry, and the capacitor is rated at .01 microfarad. On the 2260, the resonant frequency is calculated as follows: First, enter the inductance as EXP +/− 3, since one millihenry equals 10^{-3} (if no multiplier is entered, the machine assumes that the mantissa is 1). Now push the X key, then .01 EXP +/−6 to enter the capacitance in farads. Now push the = key to complete the multiplication. The intermediate answer shown in the display is 1 X 10^{-11}. Push the square root key, and in an instant you will see the square root of the previous intermediate answer. Now push X π and X 2, then = and you have the value of 2 π times the square root of L times C. All that remains to be done now is to calculate the reciprocal of this value, and you will have the frequency in hertz. Do so by pushing ÷ = =. The resonant frequency 50329.223 (hertz) is now seen in the display.

I could go on for several more pages showing you how to adapt the 2260 to electronics problems, but I think that you must have the idea by now. Most of the math problems in your NRI program are concentrated in the first dozen lessons, and the importance of these lessons cannot be overemphasized, as the material you learn here is the foundation for all your later knowledge of more complex electronic circuits and systems. If you use a sufficiently powerful calculator, your progress through these lessons will be made smoother because you will be able to handle the math problems with greater ease than you can with pencil and paper.

I am sure that some of you graduates and more advanced students will take me to task for recommending a calculator which does not have the ability to directly compute logarithms and trigonometric functions. Believe me, I did not make this decision lightly. There is no doubt that such a calculator would be even more useful for handling electronic problems involving power factor, complex impedances, and decibels. However, this is not the type of problem that has proven to be a stumbling block for a large number of NRI students. The Litronix 2260 can perform all mathematical operations encountered in the first dozen or so lessons of any electronics program offered by NRI. Machines with logarithms and trigonometric functions cost much more than the Litronix 2260. At the present time, the least expensive machine which combines all these functions with the desirable attributes of quality construction, small size, and a reputable manufacturer's warranty is the Hewlett-Packard HP-21, which sells for $125. Because of this large price differential, I strongly believe that the Litronix 2260 is an exceptionally good buy for students of electronics.

BIBLIOGRAPHY

In searching for information and different points of view for this article, I have come across a variety of books about electronic calculators. I am sharing this list with you now so that, if you like, you can broaden your knowledge of this interesting subject.

1. *The Calculator Handbook* by A. N. Feldzamen and Faye Henle, published by Burkley, $1.25 (paperback). General interest book aimed at household use of four-bangers.

2. *How To Get The Most Out of Your Pocket Calculator* by Henry Mullish, published by Collier Books, $1.95 (paperback). More of the same.

3. *Getting The Most Out of Your Electronic Calculator* by William L. Hunter, published by Tab Books, $4.95 (paperback). More of the same, greatly overpriced.

4. *Fingertip Math* by Edward M. Roberts, published by Texas Instruments, $2.95 (paperback). Same general type of book as three previous ones, but stands head and shoulders above the crowd. Highly recommended!

5. *Electronic Calculators* by H. Edward Roberts, published by Howard Sams, $5.95 (paperback, available from CONAR). Goes into the technical details of how calculators work. Very interesting.

6. *How to Entertain With your Pocket Calculator* by Oleg D. Jefimenko, published by Electret Scientific Company, $3.50 (paperback). If you like to play with numbers and mathematical puzzles, this book is for you.

7. *Scientific Analysis on the Pocket Calculator* by Jon M. Smith, published by John Wiley & Sons, $12.95 (hardback). Discusses scientific applications of basic, scientific, and programmable calculators. If you are seriously interested in calculators, you won't want to be without this book.

Switching Regulators

by Steven L. Williams

INTRODUCTION

Within very recent years, dc voltage regulators have become so common in electronic equipment of all sorts that it is now quite unusual *not* to encounter some form of voltage regulation in every piece of equipment that finds its way onto your test bench. This can range from a simple zener diode-and-resistor network to some elaborate and expensive regulator unit complete with a cooling system and automatic short-circuit protection.

One of the most sophisticated voltage regulator circuits is the switching regulator. This type of regulator is characterized by an extremely high efficiency and large circuit complexity.

This article will help you to understand the circuits employed in the switching regulator. Someday you will very likely have to repair a switching regulator, especially if you work on such things as guided missiles, radiotelephones, or anything else that must be powered from large batteries with voltages considerably higher than those actually required by the electronics involved.

Voltage regulators operate by taking an unregulated dc voltage supply at its input and converting it to some lower, fixed (regulated) output voltage. A guided missile, for instance, may be powered by a 30-volt battery. This same battery must also supply the stable 5 volts required by the many integrated logic circuits that are used in guiding the missile. A heavy vehicle like a truck or bus will probably be equipped with a 24-volt battery, while most modern mobile radiotelephones are designed for 12-volt ignition systems.

Since a greater number of technicians are more likely to encounter a radiotelephone than a guided missile, let us consider a switching regulator circuit that is typical of some that the author has seen used with mobile radios. However, apart from differences in input and output voltages and load currents, you could expect switching regulators used in any type of equipment to operate similarly, and their circuits will closely resemble the ones that we will show you on these pages.

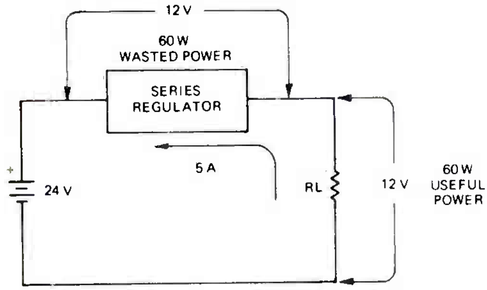


FIGURE 1. BLOCK DIAGRAM OF A SIMPLE SERIES PASS REGULATOR.

COMPARING SERIES AND SWITCHING REGULATORS

The familiar series voltage regulator works well enough, so why would a manufacturer want to build a more complicated box that demands more sophisticated parts?

Going back to the example of the bus with a 24-volt battery and a 12-volt radio, let us see what happens when the series pass element has to dissipate such a large part of the available power, as is the case here.

From Figure 1 we see that the efficiency of such an arrangement can never be more than 50% (half of the power supplied from the battery is wasted in the series regulator). In fact, the actual efficiency of such a circuit might be much worse than 50% due to circuit losses. This can become an expensive design habit.

On the other hand, the switching principle makes a much more efficient circuit (wastes less power). An efficiency of 85% or more is obtainable with this type of circuit (only 15% power waste).

However, the switching regulator is not without drawbacks. Probably the worst drawback is that switching transients arising from circuit operation can be a troublesome cause of EMI (electromagnetic interference). These switching transients can be brought within acceptable limits by proper shielding and filtering techniques.

THE SWITCHING PRINCIPLE

In a switching regulator, the conversion from a high to a lower voltage is accomplished by alternately applying the input voltage (E_{in}) and 0 volts (ground potential) to a filter network, as shown in Figure 2.

The filter network shown in Figure 2 is actually a low-pass filter. When pulses such as those shown in the figure are applied to the filter input, the network filters out the high-frequency pulse edges. The pulses also contain dc elements, represented by the flat portions of the pulse waveform at E_{in} and 0 volts. The dc content of the input pulses will readily pass through the filter.

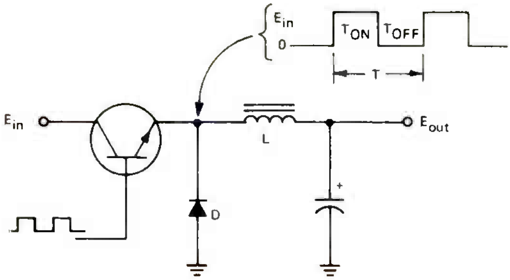


FIGURE 2. BASIC OPERATION OF THE SWITCHING REGULATOR.

Keeping in mind that only the dc portions of the pulses are passed through the choke, what we have here is a pulsating direct current not unlike the output of a half-wave rectifier, with which you are better acquainted. Just as you would expect from this type of filter circuit, the capacitor at the output is there to smooth out the ripple.

The output voltage, E_{out}, will be the average value of the amplitude of the switched waveform. If, for the sake of simplicity, we ignore the slight voltage drop across the transistor and diode, the output voltage will be:

$$E_{out} = E_{in} \times \frac{t_{on}}{T}$$

which, in the case of a symmetric square wave and a 24-volt input, will be:

$$E_{out} = 24 \times 1/2 = 12 \text{ volts}$$

In addition, there will be a small amount of ripple voltage whose fundamental frequency is the switching frequency. The operating frequency of a switching regulator is usually designed to be around 20 to 25 kHz.

Notice that the output voltage, according to our formula, is quite independent of the load current. The important parameters are:

(1) Input voltage
(2) Switch on/off time ratio

Look at the block diagram of the switching regulator in Figure 3.

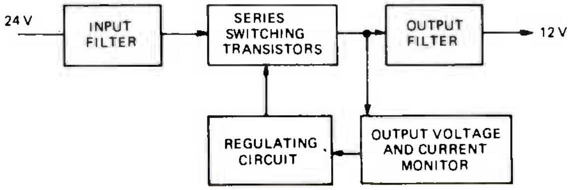


FIGURE 3. BLOCK DIAGRAM OF A COMPLETE SWITCHING REGULATOR.

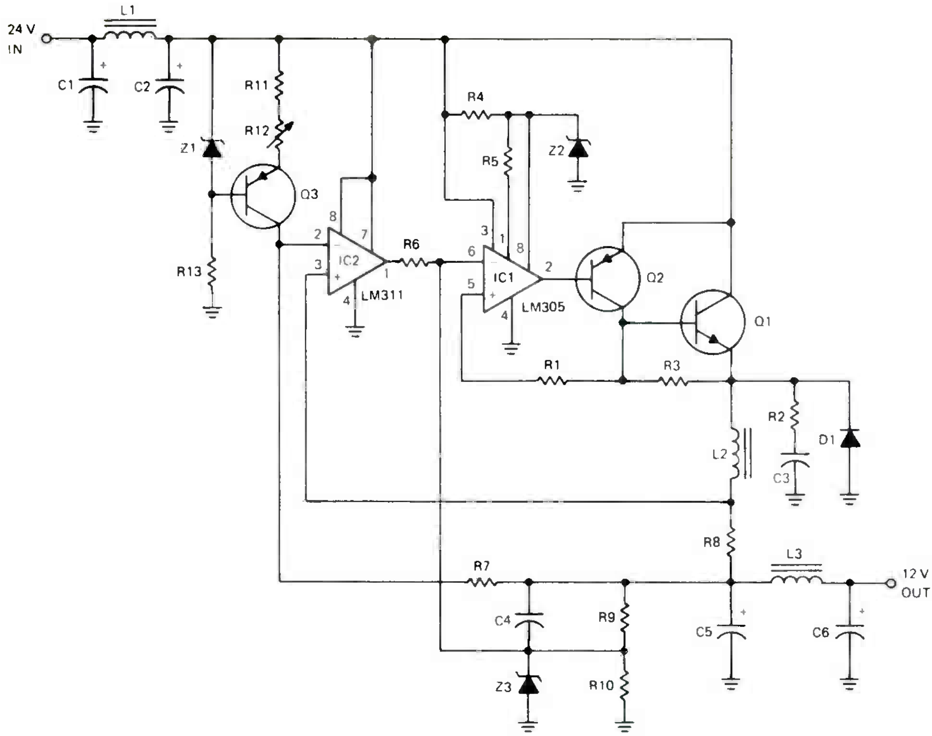


FIGURE 4. COMPLETE SCHEMATIC OF SWITCHING REGULATOR.

The 24-volt potential from the battery is applied, via an input filter, to the series switching transistors. When the switching transistors are turned ON, current passes through to the output filter and hence to the 12-volt output. When the transistors are switched OFF, of course, no current can flow from input to output.

Monitoring circuits monitor the output voltage and current, providing signals to the regulating circuit. The regulating circuit compares the voltage monitor signal to an internal reference voltage and accordingly regulates the time the switching transistors are ON and OFF to maintain the output voltage at the proper level. If output current becomes excessive, the current monitor signals the regulating circuit to turn the switching transistors OFF, protecting them against being destroyed by overloads or shorts at the power supply output.

Refer now to Figure 4, which is the complete schematic diagram of a switching regulator.

C1, L1, and C2 make up the input filter. Q1 and Q2 are the series switching transistors. The output filter, consisting of L2, C5, L3, and C6, is a two-section, choke-input filter network. IC1 is the regulating circuit and IC2 is the output current monitor. Q3 is the current limit reference. D1 is called the catch diode and together with L2 has a very special function, which we will explain later.

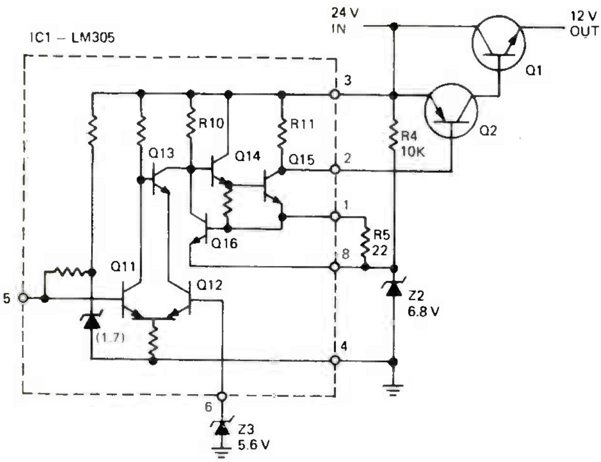


FIGURE 5. SIMPLIFIED DIAGRAM OF LM305 CONNECTIONS.

Notice that although the regulator operates from a pure dc source (the vehicle battery), it includes an input filter as well as an output filter. The input filter is necessary in order to keep surges from being thrown back into the input line, thus affecting the rest of the car's electrical system. The output filter, of course, smooths out the 20 to 25 kHz ripple. For best results, a two-section, choke-input filter network is employed here. The output filter functions like the simpler, single-section filter explained earlier (see Figure 2), except that the addition of an extra filter section greatly improves output regulation.

THE SWITCHING ACTION

Refer to the simplified diagram in Figure 5.

The LM305 integrated voltage regulator, IC1, drives the pnp switching transistor, Q2. An additional npn transistor, Q1, enables the circuit to handle the heavy currents required by the output load.

Q11 and Q12 make up a differential amplifier within the IC package. The input at IC pin 6 is the inverting input, referred to here as the feedback input. The noninverting input at pin 5 is called the reference bypass. The reference bypass is held at a potential of 1.7 volts (typical value) by the internal IC circuitry. This potential is called the reference voltage.

If the voltage on input pin 6 is less positive than the reference voltage at the base of Q11, the differential amplifier turns Q13 OFF. This is how: Q11 conducts, pulling the base of Q13 LOW while at the same time Q12 cuts off via emitter feedback, preventing any emitter current from flowing through Q13. When Q13 goes OFF, its collector is pulled up by R10, turning Q14 and Q15 ON. Notice that Q15's 600-ohm collector resistor, R11, is also the emitter-base biasing circuit for Q2, the switching transistor. Thus, when Q15 is driven ON, the collector current through R11 turns Q2 ON as well. Q2 supplies drive to Q1, which also switches ON.

Now, if a voltage more positive than the internally generated reference voltage is applied to IC pin 6, Q12 will go ON, cutting Q11 OFF. The differential amplifier now forward biases Q13, which goes ON. The current through Q13 and R10 then pulls the base of Q14 LOW, turning Q14 and Q15 OFF. With no collector current through R11, Q2 loses its forward bias and switches OFF, also switching Q1 OFF.

The circuit of Figure 5 also incorporates an interesting automatic current limiting feature. Base current for Q2 flows from ground, through Z2 and R5, then through Q15 to the IC booster output, pin 2. The 22-ohm resistor, R5, is called the current limiting resistor and is also the source of emitter-base bias for Q16 on the IC chip. Whenever base current for Q2 tends to exceed the limit set by the value of R5, Q16 will begin to draw current through R10. This reduces the bias to Q14 and Q15, creating a state of equilibrium where the amount of base drive to Q2 is determined by the value of R5.

Zener diode Z2 keeps the regulated output voltage at IC pin 8 at approximately 6.8 volts. Z3, a 5.6-volt zener diode, is wired to IC pin 6. This ensures that the voltage to the feedback terminal cannot rise higher than the voltage at IC pin 1. Otherwise, the circuit could latch up and burn out.

THE OSCILLATOR CIRCUIT

Now we are ready to see how the regulator switches automatically. Refer to the simplified diagram of the oscillator circuit in Figure 6.

The integrated voltage regulator, IC1, monitors the output voltage by measuring the portion of the output voltage that is dropped across R10. It also measures the full amplitude of the output ripple via bypass capacitor C4. Thus, the instantaneous ripple amplitude adds with the sampled dc voltage at input pin 6 of IC1.

When power is initially applied to the regulator, there is no voltage at the output. Therefore, there can be no bias available at pin 6 of IC1, and the internally generated reference voltage present at the noninverting input, pin 5, will then be able to drive the IC ON, which in turn drives Q2 and Q1 into conduction as well.

A positive voltage now begins building up on the collector of Q2 as well as on the emitter of Q1. A small portion of this rising voltage is fed back through resistor R3 to IC1 input pin 5. The amplitude of the feedback signal is determined by the ratio of R3 to the input impedance of the terminal. The polarity of the feedback signal is such that it causes the voltage at pin 5 to become even more positive. This regenerative feedback therefore increases the gain of the amplifier, driving Q1 and Q2 even harder. (In fact, the amplitude of the feedback signal is sufficient to sustain oscillation in the circuit.) Of course, this all happens very quickly during the rise time of the square wave pulse.

Meanwhile, filter capacitor C5 is charging up to the input voltage through L2 and Q1. The dc charge on this capacitor is divided between R9 and R10. Remember, too, that C4 bypasses ripple voltages (including charging waveforms) around R9 directly to pin 6 of the regulator IC.

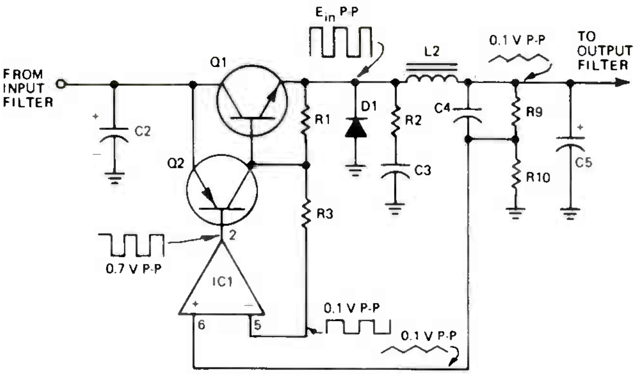


FIGURE 6. SIMPLIFIED DIAGRAM OF THE OSCILLATOR.

At some point the combined ac and dc voltages as seen at pin 6 of IC1 will become greater than the bias at pin 5, that bias being equal to the internal reference voltage *plus* the instantaneous value of the feedback signal through R3. Now when the potential at terminal 6 is more positive than that at terminal 5, the regulator switches state and turns Q2 and Q1 OFF.

When this happens, the magnetic field induced in L2 will attempt to maintain the current flow through the coil and in so doing biases catch diode D1 into forward conduction, in effect grounding the emitter of Q1. As seen at IC pin 5, the regenerative feedback via R3 is now a negative-going pulse. This is, of course, the correct polarity for driving the integrated amplifier and the switching transistors even further into cutoff.

The circuit remains cut off until C5 discharges enough so that the potential seen at pin 6 falls below that at pin 5 (the reference voltage *minus* the feedback signal). At this point the IC switches state again and the circuit continues to oscillate at a frequency determined by the reactance of L2, the capacitance of C5, and the amplitude of the feedback signal. Feedback resistor R3 is what determines the amplitude of the feedback signal.

(It is worth mentioning here that the output voltage does not reach its full 12-volt potential immediately, but in several increments governed by the oscillator excursions and the frequency of oscillation. However, once the output voltage reaches its full value, it remains constant with only a very slight ripple voltage present.)

Now we have seen how the oscillator works by amplifying a slight portion of the positive- or negative-going pulse edges that appear at the input to the low-pass filter formed by L2 and C5. These pulses are labeled E_{in} in Figure 6. The actual feedback signal is about 100 mV in amplitude, as Figure 6 also indicates. The feedback signal is applied to the reference input of IC1. The resulting rise or fall in the output voltage at C5 amounts to about the same value. The full amplitude of the ripple across C5 is fed back to the feedback input of IC1 via C4. IC1 oscillates between its ON and OFF states for definite periods of time, governed by important circuit constants like R3, L2, and C5.

How do these components work together in determining the behavior of the oscillator circuit? We will discuss this next.

The amplitude of the feedback signal, typically 100 mV, determines the switching time (t_{on} and t_{off}). Remember that each time the regulating IC switches state, the output voltage has to catch up with and slightly surpass the new input condition, whether in the positive- or the negative-going direction, before causing the IC to switch back again. Thus, the ripple superimposed on filter capacitor C5 will have essentially the same amplitude as the feedback signal voltage. With L2 and C5 as circuit constants, the *rate* of charging the filter capacitor is also constant. This means that if the capacitor has to charge (or discharge) to a relatively greater voltage before the oscillator switches state, it will take a longer time to do so. On the other hand, if the feedback amplitude is relatively less, the charge on C5 can reach the threshold levels for the differential inputs at pins 5 and 6 in less time. This is what determines the frequency of oscillation. As mentioned earlier, this type of circuit normally operates at around 20 kHz.

An RC network consisting of R2 and C3, across catch diode D1, is a damping circuit used to attenuate switching transients that appear across the diode.

As already mentioned, D1 conducts heavily when Q1 is turned OFF. Just as Q1 turns ON again, D1 will still conduct because of its inherent reverse recovery time. The diode will thus act as a short circuit and a strong surge will pass from input filter capacitor C2 through Q1 and D1. When all the charge stored in the catch diode is removed, the diode no longer conducts and pulse transients arise. At this point the damping circuit must handle the surge transients.

This current surge, with its attendant transients, is the main cause of RFI (radio frequency interference) generated in the power supply.

Not just any old diode can be used successfully in this circuit. The catch diode has to handle rather large inductive currents and must be able to recover rapidly, so a special diode having these capabilities must be selected for this application. Newer components, where the catch diode is grown right onto the power transistor chip, Q1, have recently been developed. The matching and close proximity of the two elements greatly reduce the diode recovery spike, causing far less noise and RFI. This means that smaller LC filters can be used, reducing the size and weight of the power supply even more.

HOW THE OUTPUT CURRENT LIMITER WORKS

Refer now to the simplified diagram of the output current limiting circuit in Figure 7. (The heavy arrows show the direction of *electron* flow.)

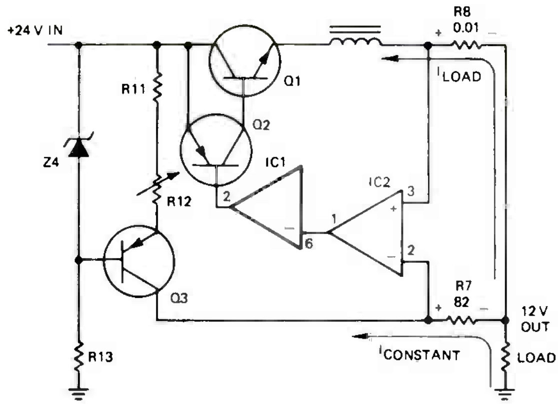


FIGURE 7. SIMPLIFIED DIAGRAM OF THE CURRENT LIMITING CIRCUIT.

Besides the current limiting capabilities of the LM305 integrated circuit, we also need protection for those circuit parts that handle the heavy power load, particularly Q1 and Q2. This is accomplished by a comparator, IC2. This circuit compares the voltage drop across the 0.01-ohm resistor, R8, with the drop across the 82-ohm resistor, R7. (A low-value resistor like R8 could be no more than a short length of resistance wire, one or two inches, so don't let that take you by surprise.) Resistor R7 is in series with the constant current generator, Q3, so the voltage drop across this resistor will be constant. Resistor R8 is in series with the output load, so the voltage drop across R8 will not be constant, but will depend upon the load current.

Figure 7 shows the relationship between these two parallel current paths and how the voltage drops across R7 and R8 bias inputs 2 and 3 of IC2.

As long as the load current remains below a certain limit, the voltage drop across R8 will be less than that across R7, and IC2 is held OFF. When the load current increases, so does the voltage drop across R8, and if the current surpasses the set limit, the voltage across R8 becomes greater than the voltage across R7. Now, just the opposite condition exists: IC2 goes ON, driving IC1 OFF, which in turn switches Q2 and Q1 OFF as well.

The maximum allowable load current before limiting will take place is set by adjusting potentiometer R12. Since R12 is in the emitter circuit of the constant current generator, Q3, its setting determines the voltage drop across R7.

SERVICING THE SWITCHING REGULATOR

A good practice to observe when servicing a switching regulator is to keep the output loaded while testing the unit. A rheostat of suitable power rating is always an excellent means of checking the performance of a power supply under varying load conditions. Also, if a switching regulator of this type is allowed to operate unloaded, the oscillator tends to run irregularly. This is a normal phenomenon and has no bad effects upon the regulator, but the erratic operation could be misleading to the service technician.

If the regulator seems to be operating correctly but the output voltage is wrong, check R9 and R10. The ratio of these two resistances determines the output voltage.

If the resistance of R10 increases in value, the percentage of the output voltage dropped across it will also increase, and IC1 will switch the series transistors OFF too soon. The voltage across R10 will overcome the 1.7-volt reference voltage before the output voltage reaches 12 volts.

If the resistance of R9 increases, the percentage of the output voltage dropped across R10 will be less, and IC1 will switch the series transistors OFF too late. The output voltage must rise proportionally higher than 12 volts in order to overcome the 1.7-volt bias.

CONCLUSION

By now you should have mastered the operating secrets of switching regulator power supplies. Although on first look they might scare you with their seemingly complex circuitry, this is only an electrical complexity as opposed to the mechanical complexity of series regulators. Most of the apparent complexity is due to unfamiliarity with the new circuit. Now that you know what to expect, your newly won confidence and knowledge will be your most valuable servicing tools the next time you face one of these devices on the shop bench.

In this Journal you have met a fellow NRI student, Steven Williams, writing about switching regulators from his home in Denmark. Steve enrolled first in the Radio-TV program in 1959, successfully completing this course in August 1960. Not being satisfied with this course alone, Steve next enrolled in the Communications course, graduating in March 1964. Now, in order to keep abreast of the fascinating field of digital electronics, he is enrolled in NRI's Computer course. We look forward to more fine articles from Steve in the future.

Helpful Hints 2

Like other components, circuit breakers can fail. Some technicians have a bad habit of shorting across circuit breakers to determine if they are defective. You should check for low resistance paths to ground before you substitute or bypass a circuit breaker. Circuit breakers can also short from one of the terminals to the case. This will cause repeated tripping of the circuit breaker because the case of most circuit breakers connects to ground. A safer method of testing for a defective circuit breaker is to solder a pigtail fuse of the appropriate current rating across the circuit breaker's terminals. If the fuse holds, the circuit breaker is probably defective. On the other hand, if the fuse blows, it is unlikely the circuit breaker is defective. More than likely there is an unwanted low resistance path to ground.

—*by James Crudup*

Repairing Tuners

There's more to it than just finding the bad part

by James Crudup, C.E.T.

This set turned out to be a little more difficult to repair than I had anticipated. It was brought to me by a friend of mine that I just happened to owe a favor. This meant I wouldn't receive very much profit if any on the job. Therefore, I wasn't too enthusiastic about repairing the set immediately and I could think of a million other things to do. Finally, a few weeks later I got around to it. I turned the set on and I found that it had a beautiful raster (white screen) but no video or sound. I pulled the back off the set and looked for an AGC control. Some black-and-white sets don't have them and I wasn't surprised when I didn't find one on this set. If the AGC control had been misadjusted it could cause this symptom.

This was a small Admiral TV chassis TK2-1A and I had all of the tubes I needed on hand. This appeared to be a signal problem so I substituted the tubes in the tuner and the tubes in the i-f section one by one with no success. Then, I visually inspected the set for obvious damage but couldn't find any. Next I put the old tubes back in their sockets. I wasn't making much progress so I decided I'd better pull out the schematic. Fortunately I had the Sams diagram on hand for this particular receiver.

I turned on my test equipment and decided to make a few checks. The voltages in the i-f stages appeared to be normal. A defective video detector diode could cause the symptoms. In this set the video detector was before the sound takeoff point so I decided to check it. I removed the shield and disconnected one end of the diode and made a forward and reverse resistance test on it. To my surprise the diode checked good. It had a high front to back resistance ratio. I soldered the diode back in the circuit and reinstalled the shield. Then, I checked the transformers and coils in the circuit and they all seemed to be good. I had a feeling it wasn't my day.

Back to the schematic. I thought I'd better sit down and look at the schematic for a while. After all, I had checked most of the stages that could be causing the trouble. After a good look at the schematic I decided that I'd better make some voltage checks on the tuner; perhaps one of the stages in the tuner was at fault. Most of the voltages looked good so I decided I'd better do some signal injecting. I turned on my trusty Conar Model 280 signal generator and waited for it to warm up. I set it to the i-f or 45.75 megahertz and turned the modulation switch on. Next, I connected the generator ground clip to the ground foil on the TV circuit board and touched the probe to the i-f input point in the receiver. Since the Model 280 generator uses a transformer and it has an isolation capacitor in the input lead, the danger of shock when working on line-operated sets is eliminated. Black bars appeared on the screen. I turned the modulation control up and the bars became blacker. As I reduced the control the bars became lighter. The number of bars that you will have on the screen will depend upon the modulation frequency. Of course, the number of the bars is not important. You simply want to know if the modulated signal is getting through the i-f stages to the picture tube. In this case it was and this told me the problem was in the tuner.

I set the generator to the frequency of Channel 2 and applied it directly to the antenna terminals. I was rewarded with the blank raster again, so I knew I had tuner trouble. I had tested the voltages at the tuner test points and they seemed normal so I decided to take the side shield off the tuner. Looking closely, I spotted a burned resistor. The resistor connected directly to the B+ terminal on the tuner and from the schematic I could tell that it was supposed to be R208, a 1-kilohm resistor. I attempted to check the resistor. I touched the probe to one end of the resistor but I wasn't able to get my hand down into the tuner to connect the other lead. I might also point out at this time that it's very important not to disturb the placement of components in the tuner when you attempt to repair a tuner. If you replace parts, cut the leads of the new part to the same length as on the old part, and install the new part in a similar manner as the old part. Upsetting the location of components can cause adverse affects on the operation of a tuner.

After thinking about the problem for a minute I decided to clip the ground lead right to the B+ connection on the top of the tuner and touch the probe to the other side of the resistor down in the tuner. The resistor measured open so I decided I should check the 5GS7 on the tube tester. It showed a plate cathode short.

It seemed a simple job to remove and replace a resistor. If the job had not appeared to be a simple one I would have removed the tuner and mailed it off to one of the tuner repair shops. As mentioned earlier, the resistor was mounted down in the tuner and it was rather difficult to reach. I tried my soldering iron and then a soldering gun but the tips just weren't long enough to reach. This was beginning to be too much like work so I decided to set the job aside for a few days until I could give the matter some thought.

A few days later, a brainstorm struck. I decided that perhaps I could reach the connection if I obtained a longer tip for my iron so I went out to buy one. I got the longest tip that my wholesaler had for the iron but when I got home I found out that it wasn't long enough. It finally came to me that when in a pinch I had often used heavy gauge wire as a soldering tip for my soldering gun. I scrounged around in the rear of my basement and found a short length of No. 12 house wiring cable. I clipped off a piece, removed the insulation and formed the wire into a long, skinny loop. Then I connected it into my soldering gun. I heated the iron, tinned the tip and attempted to remove the resistor. The long home brew tip that I made worked fine. I was able to unsolder the resistor and install the new one with no difficulty. I fired up the set and wasn't surprised to see a good picture and good sound when I put in a new 5GS7. I buttoned up the set and returned it to my buddy, charging only my cost for the new tube.

HAM NEWS

By Ted Beach K4MKX

This time I am going to discuss a topic which, while not directly related to ham radio, is of interest to those people who like to experiment along various lines in digital electronics. Let's face it, digital is the buzz word today, and we'll all have to know a little something about the field soon or we just won't be able to keep up. Repeater control, for example, is *all* digital control as are frequency synthesizers, counters, and so on.

At any rate, I am going to describe a circuit (actually *several* circuits) to you that you may find useful in experimenting, and at the same time perhaps you can learn a little something about "digital" circuits. This circuit is one that can generate a single pulse or a train of pulses, depending upon how it is interconnected. You should be able to duplicate the thing for about a dollar (if you have a good junk box) and can probably find lots of uses for it.

Incidentally, I'm not going to give you any circuit board layouts or anything like that for this project. Instead, I suggest you get a piece of perfboard with 0.1″ spaced holes, an IC socket, and go to it. There won't really be much wiring involved for any of the circuits. Figure 1 shows the terminal numbers for the CD4001AE CMOS gate chip you will need. You can use any of the gates you want in the package, taking care to connect any unused input pins to pin 7 (ground) or pin 14(+V). Supply voltage can be anything from 3 volts to 15 volts.

To begin with, the basic circuit that is used to generate a train of pulses is shown in Figure 2. This is a standard astable (free-running) multivibrator which makes use of two CMOS inverters or dual two input gates (as shown).

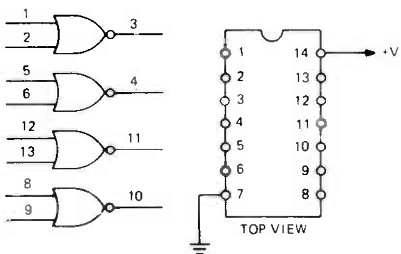


FIGURE 1. CONNECTIONS AND PIN-NUMBERING OF CD4001AE.

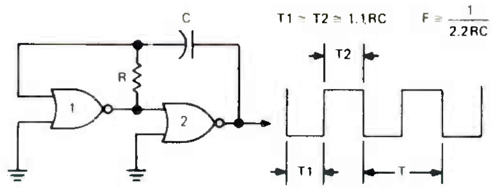


FIGURE 2. BASIC CMOS ASTABLE MULTIVIBRATOR.

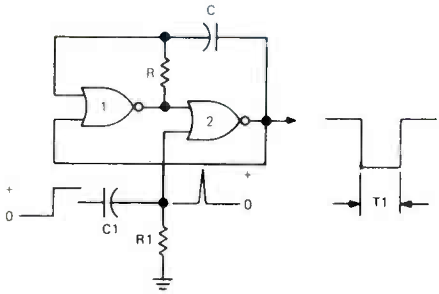


FIGURE 3. BASIC CMOS MONOSTABLE MULTIVIBRATOR.

The pulse train output from gate 2 will have a period (T) of about 2.2RC, from which you can find the frequency (f = 1/T). My favorite slow speed combination is a 10 meg resistor and 0.01 μf capacitor. This works out to be a period of 0.22 second or a frequency of 4.55 Hz. Depending upon the particular characteristics of the two gates, the pulse train may or may not have a 50% duty cycle (T1 = T2). This is relatively unimportant for most uses of the pulse generator.

By making a very simple alteration to the circuit of Figure 2 we can have a unit that will generate a single pulse on command. Such a circuit is called a monostable multivibrator or one-shot and is shown in Figure 3. Notice in this circuit that the input of gate 1 that was grounded in Figure 2 is now connected directly to the output of gate 2. In addition, we have added a resistor and capacitor to the second input of gate 2. C1 and R1 form a differentiator network that generates a very narrow positive pulse when a positive step input is applied to C1. This narrow pulse into the input of gate 2 starts the timing cycle, and gate 2 will have a negative-going pulse, T1, whose duration is approximately 1.1RC as in Figure 2.

Now, the really useful circuit is one that combines the functions of the astable and the monostable multivibrators, and is what this whole thing is all about. The basic configuration of the circuit is shown in Figure 4.

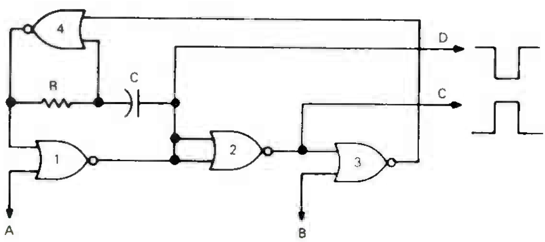


FIGURE 4. MULTIFUNCTION CMOS MULTIVIBRATOR.

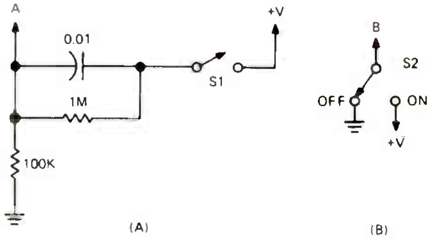


FIGURE 5. MONOSTABLE INPUT (A) AND ASTABLE INPUT (B) NETWORKS FOR FIGURE 4.

Gate 1 and gate 4 are the basic generator gates, but we have added gate 2 (which functions strictly as an inverter) and gate 3. The inverter allows us to have two output signals (C and D) which are 180° out of phase; that is, they are *complementary* outputs. The two points labeled A and B are our control inputs, and we can do all sorts of interesting things with the two of them.

The A input is for the monostable operation and the B input is for the astable operation. We could connect a network like the one shown in Figure 5(A) to the A input, and a switch [Figure 5(B)] to the B input for simple, two-switch control of the two functions. With S2 OFF, closing S1 will generate a single output pulse. With S1 either open or closed, turning S2 ON will enable the astable multivibrator. When S2 is opened, the circuit will *complete any pulse it is generating before it stops*! You can never get a short pulse out of this circuit.

Figure 6 is another interesting input network for the combination pulse generator. In this one we have only a single switch, which, for most convenient operation, is preferably a push-button switch having two positions. The normal (unpushed) position is as shown. The B input is grounded through the diode and the 1 meg resistor and the A input is grounded by the 100K resistor. Pushing the button generates a positive spike at the A input just as the network of Figure 5(A) did, and we generate a single output pulse. If we now release the button, that's all that happens – we generate a single output pulse.

Suppose, however, that after pressing the button and generating the single output pulse we keep the button pressed for about two seconds. The 10 μf capacitor will be charging through the 100K resistor toward +V and after about two seconds point B will be positive enough to turn on the astable generator and we will get our train of pulses. Releasing the button will quickly discharge the 10 μf capacitor through the diode (any old diode will do) to turn off the astable multivibrator.

This multifunction operation is quite handy when testing counting and gating circuits. Press the button to generate a single pulse, and if you want a whole string of pulses, keep the button pressed. Otherwise, you'll generate just one pulse each time you push the button.

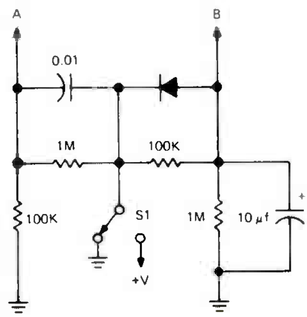
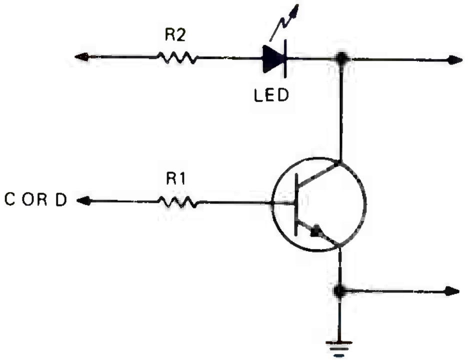


FIGURE 6. SINGLE SWITCH CONTROL FOR FIGURE 4.



+V	3	5	9
R1	4.7K	8.6K	16K
R2	120	230	500

FIGURE 7. TRANSISTOR BUFFER FOR MULTIVIBRATOR OUTPUT.

The circuit of Figure 4 combined with the control input of either Figure 5 or Figure 6 is fine for working with CMOS circuits only, since the C and D outputs are not capable of supplying (sourcing) or drawing (sinking) any appreciable current. In fact the entire unit consumes less than 1 microampere from a 9-volt battery! This makes an on-off switch an unnecessary luxury.

There will probably be occasions when you will want to run some TTL circuits with this little generator, so I suggest you add a simple buffer (similar to Figure 7) to the output(s). With an output stage like this you can drive many TTL gates, and at the same time have a visual indication of the operation of the circuit via the light emitting diode (LED). The table in Figure 7 indicates resistor values for R1 and R2 for various supply voltages which will give a diode current of about 15 ma (assuming a transistor Beta of 30). The transistor is any silicon switching type (2N5134 or equal). The LED can be any type at all, and in fact does not need to be there at all – I just like to see the lamp blinking to tell me the thing is working. Besides, with a very slow clock speed (R = 10 meg, C = 0.01 μf) you can easily count the output pulses visually.

Figure 8 is a photo of a unit I built up in a small case and which uses the input configuration of Figure 5. I also have a switch to select various values of timing capacitor (C) and a variable resistor for R. This is a bit more elaborate than usually needed, but what the heck, it was fun to put together!

Well, I guess that's about enough for the digital circuits this time – if this topic is of any interest to you, maybe we'll pursue it some more at a later date. In the meantime, let's see who we've heard from since last time.

FIGURE 8. PROTOTYPE MULTIFUNCTION OSCILLATOR.

Tom	WN1UUZ	N	Housatonic MA
Matt	WN4MXN	N	St. Petersburg FL
Fred	WB5LKE	G	Dallas TX
George	WN5NZS	N	Abilene TX
Dick	WN5OCP	N	Wichita Falls TX
Bill	W8GPG	T	Maineville OH
Al	WN8UDB	N	Cuyahoga Falls OH
Jean	VE2DNG	–	Sherbrooke PQ, Can
Dick	K1GKR	T	No. Grafton MA
Myles	WB2MAP	A	Little Silver NJ
Henry	WA4MSY	*	Seminole FL
Fred	WN5OGD	N	Little Rock AR
Chris	WN6JYH	N	El Cajon CA
Jerry	WB7AVO/6		Lancaster CA
Vince	WØGP	–	Bloomington MN

As usual, the first eight people listed are students or graduates of our Amateur courses, while those listed after them are from the ranks of other NRI courses.

The only notation on the QSL card from WN1UUZ was "Thought I'd never make it!!!" – Tom. It couldn't have been all that bad, Tom!

Fred, WB5LKE, works 20 and 40 CW with an SB 102 and dipoles, and is hard at work on his Advanced License. I know it's a lot of work, but it will be well worth it, Fred.

WN5NZS appears to be in a situation like me – his name is Gordon but he goes by the nickname George on the air. Oh well, if I can get Ted from Edward, I guess George is O.K. for Gordon.

WN5OCP uses a Yaesu FT 101B on 80 and 40 meters. Dick uses a 14AVQ vertical on 40 and an inverted vee on 80 and says he has had quite a time tuning the vee for an acceptable SWR. I haven't had too much experience with this type of antenna, but from what I've seen and read, the apex angle should be about 90° (not 100° Dick) and should be fed with a balanced line through a balun or transmatch. Line length becomes a factor with coax feed and you can have that bad SWR problem.

Unfortunately the note I got from W8GPG was incomplete as it was written on both sides of his report on Training Kit 1R, and I got a photocopy of only the front side. It looked as if the other side would have been interesting too. Bill said in part that he had had a license 50 years ago (he's presently 70 years young) and it was 8CGR. Now he is trying to get up-to-date in amateur radio and (continued on other side). . .

VE2DNG's QSL had a note in both English and French on the back. I'm glad Jean had the English there too, since my knowledge of French is zero. Thanks (merci) for the card, Jean.

The Dick that goes with the K1GKR call is none other than Richard Moore, one of the Vice Presidents of the NRIAA. Nice to have you in the Ham News too, Dick, and we hope you'll be able to get your rig repaired soon and find the time to start working on that Advanced or General license real soon.

WN5OGD is a student in our Communications course and got his FCC First Radiotelephone license in February of this year. He got so wrapped up in radio that he took and passed his Novice exam a few weeks later, receiving the ticket in April. Fred says of this event ". . . I couldn't be more proud." Presently, he is keeping busy on 80, 40, and 15 meters using a DX 60B and HR 10B outfit with three separate dipoles. Fred is also trying to get an amateur club organized at the plant where he works, noting that with help from his fellow employees he can get a lot more done than he could as an individual. How true, Fred.

WN6JYH got his license in February and expects to go for his General sometime in July. In the meantime, Chris is pounding away with a Tempo 1 rig which he is thinking of trading in on a Yaesu FT101B for use in his car. Fine business, Chris, and best of luck on the exam!

WØGP, a student of our Computer course, suggested that perhaps there is some easy way that the NRI Model 832 Computer could be set up to send CW. Well, Vince, with the rather limited memory available it's not likely to program too well. However, just as soon as we finished the first prototype here in the lab I got to thinking the same thing. The only thing I came up with was to set up a continuous bit pattern in the switch registers, slow the clock down to a reasonable speed, and then disable the Execute phase, taking the MDA or $\overline{\text{MDA}}$ output as the code to key an oscillator. This was so long ago that I've forgotten just how I did all this, but I think I disabled the Execute phase by bending out the clear input pin (6) of IC6 on the M1 board to keep the flip-flop from going set. As far as writing a program, I don't think it is possible, even with 16 RAM locations. If you come up with something, let me know.

Well, it looks like we've run overtime this time, and right now we'll have to close up the store until next time. Have a nice summer and do let us hear from you.

Very 73 –

Ted – K4MKX

A Reminder

Always be sure to include your student number whenever you contact NRI. This will help to ensure that we can serve you promptly and efficiently.

NRI HONORS PROGRAM AWARDS

In the tradition of NRI's pursuit of excellence in training, the following graduates who earned NRI electronics diplomas in January and February also earned unusual recognition under the NRI Honors Program. On the basis of their grades, these graduates distinguished themselves by earning the right to honors listed below and to the appropriate Certificate of Distinction in addition to their regular NRI Diploma. This distinction is made part of their premanent NRI records.

WITH HIGHEST HONORS

John Geary, Glenview, IL
Hans E. Karlsson, Los Gatos, CA
George S. Landfield, Winnetka, IL
Billy M. Menees, Key West, FL
James G. Schrock, Jr., APO San Francisco
Thomas L. Sego, Glendale, AZ
Charles P. Steward, Jr., Hiram, GA
David M. Swan, Sanford, NC
Charles E. Whipple, Jr., Toledo, OH
Kermit B. Widener, Jr., Bristol, TN

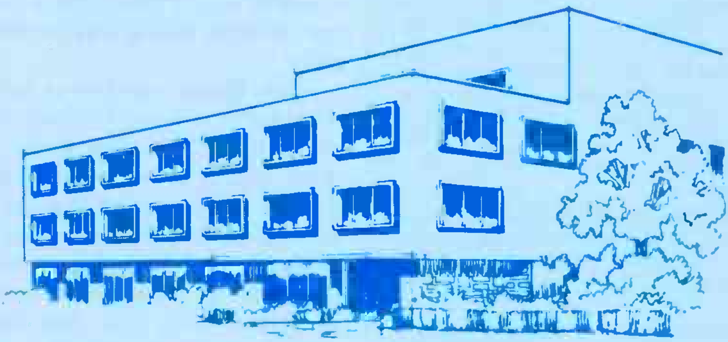
WITH HIGH HONORS

Aleksandar Aleksandrov, Ypsilanti, MI
Michael R. Baker, Brandon, MS
John H. Barber, Fredericksburg, VA
M. H. Capps, Tallahassee, FL
Robin S. Chaster, Duncan BC, Canada
Harvey J. Cone, Kansas City, MO
William P. Cunnane, Vienna, VA
Carl H. Duhon, Pasadena, TX
Merrill Eastcott, Jr., APO New York
Arthur Eza, New Britain, CT
Gerard V. Faloon, Park Ridge, NJ
Hendrick Fisher, Jr., Manchester, NH
Charles A. Furtak, JR., Elmhurst, IL
Edward Gold, New York, NY
Tony Jacobs, Ione, CA
Chester F. Kowalski, Erie, PA
Lawrence E. La Flair, Roy UT
Paul H. Matsuda, Wailuku, HI
William Morris, Graham, WA
Christopher C. Roseman,
Upper Marlboro, MD
Robert G. Sanford, Laurel, MD
Ronald C. Schoepflin, Baltimore, MD
Larry Seefeldt, Eporia, KS
Jimmy W. Smith, Brancroft, MI
William Solano, Monroeville, PA
William C. Stewart, Jr., Griffiss AFB NY
J. B. Vaughn, El Paso, TX
Jack E. Wigal, Washington, WV

WITH HONORS

George R. Addison, Cottageville, SC
Guy E. Aliotta, Poughkeepsie, NY
Dalton Allen, Liberty, KY
Mr. Richard L. Bell, Socorro, NM
Albert Jay Berwick, Richmond, VA
J. W. Bowles, San Antonio, TX
Ray Brazzel, Homer, LA
Stanley D. Brownell, Syracuse, NY
James L. Cathey, Pocahontas, AR
Jog Juh Chen, Fort Worth, TX
Charles T. Clancey, Fort Huachuca, AZ
John W. Cooper, Marion, IL
Albert J. Del Rosario, Oklahoma City, OK
Anthony Delucchi, Jr., Santa Rosa, CA
Hugh E. Despain, Gaithersburg, MD
John E. Devous, Bozeman, MT
James F. Dollar, Brighton, TN
George V. Eisenhart, Mountain Brook, AL
H. B. Ely, Charlotte, NC
Barton Evans, Jr., APO New York
Mark D. Fairbrother, Caledonia, NY
Julius W. Fitzpatrick, Saratoga, CA
David L. Gray, Duncan, OK
James L. Harris, Pottstown, PA
William S. Hartsell, Jr., Hanahan, SC
Robert A. Hoffer, Jr., Elgin, IL
Robert J. Hoffman, Raritan, NJ
Leonard Louis Horton, Binghamton, NY
Robert C. Hutchinson, Severna Park, MD
Edward E. Jones, Jr., Pensacola, FL
Richard L. Kaercher, Williams AFB, AZ
Cleo H. Kain, Coldwater, MI
Vernon T. Keesee, APO New York
Billy R. Key, Eaton, NJ

Chris Laird, Salt Lake City, UT
Martin J. Lamar, Boise, ID
James R. Lamb, Hayward, CA
L. Gary La Ronge, Sunnyside, WA
Douglas J. Linthicum, Colorado Springs, CO
Clarence W. Lutz, Anomosa, IA
Roddie A. Mac Kinnon, Mabou Inverness NS, Canada
Donald K. Mancha, Jr., Monongahela, PA
Yvan Marleu, Belleville ON, Canada
Felix Marty, Montreal PQ, Canada
Gerry D. Mc Callum, Kirkland, WA
Jorge A. Morales, New York, NY
Russell Muzzey, Jr., Newport, NH
Joseph F. Norgard, FPO New York
Patrick D. O'Hara, Fremont, CA
James A. Ollerich, Evergreen, CO
John W. Parkhurst, Hughesville, MO
J. M. Poynter, San Ramon, CA
Ferdinand Presseau, Montreal PQ, Canada
Roscoe Proffitt, Jr., London, KY
Hadley T. Reniker, San Jose, CA
John L. Rise, Sidney, OH
R. K. Robertson, Aberdeen, SD
Lynn C. Sagers, Tooele, UT
Gary A. Samarija, APO San Francisco
James A. Sevanick, Sheffield, PA
Richard X. Skowronski, South Bend, IN
Mickell J. Smith, Battle Creek, MI
Kevin Carl Stodola, Virginia Beach, VA
Pat Strokesberry, Nampa, ID
John Tenerowicz, Mount Prospect, IL
Richard Teruya, Huntsville, AL
S. R. Thompson, Lanham, MD
Raymond D. Vannevel, Petawana ON, Canada
Philip C. Viehl, Fayetteville, NC
Michael F. Wachter, Arnold, MO
Richard T. Walter, North Highlands, CA
George W. Weidman, Finleyville, PA
Ernie R. West, Erath, LA
Lynwood V. Wilcox, Jr., Raceland, LA
David L. Williams, Cleaiz, AK
James E. Wolf, Kansas City, MO
Gordon Bert Yeryk, Williams Lake BC, Canada
Richard R. Young, Morristown, NJ
Kenneth R. Zee, Monroe, WI



DIRECTORY OF ALUMNI CHAPTERS

CHAMBERSBURG (CUMBERLAND VALLEY) CHAPTER meets at 8 p.m., 2nd Tuesday of each month at Gerald Strite's TV-Radio Service Shop, RR2, Chambersburg, Pa. Chairman: Gerald Strite.

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. second Wednesday of each month at Andy's Radio and TV Shop, G-5507 S. Saginaw Rd., Flint, Michigan. Chairman: Larry McMaster, (517) 463-5059.

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 at 8 p.m. on the second Friday of each month at The Players Club, located on Washington Square.

PHILADELPHIA-CAMDEN CHAPTER meets 8 p.m., 4th Monday of each month in RCA Building, 204-1, Route 38 in Haddonfield Rd., Cherry Hill, New Jersey 08034. Chairman: Joe Szumowski.

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. and 2nd St. Chairman: George McElwain.

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 N. of Austin Hwy.), San Antonio. Chairman: Robert Bonge, 222 Amador Lane, San Antonio. All San Antonio area NRI students are always welcome. A free annual chapter membership will be given to all NRI graduates attending within three months of their graduation.

SOUTHEASTERN MASSACHUSETTS CHAPTER meets 8 p.m., last Wednesday of each month at the home of Chairman Daniel DeJesus, 12 Brookview St., Fairhaven, Mass. 02719.

SPRINGFIELD (MASS.) CHAPTER meets at 7:30 p.m. the second Saturday of each month at the shop of Norman Charest, 74 Redfern Dr., Springfield, Mass. 01109. (413) 734-2609.

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

SAN ANTONIO CHAPTER VERY ACTIVE

At the March meeting of the San Antonio Chapter, the project for the evening was a Clovis set with an extreme case of snifits. It ended with all heads in the set and everyone with a piece of the Sams Photofacts. Finally, the trouble was traced down to a miswired leg of the flyback transformer. A quick change and the bars were gone.

Bob Bonge was late as usual and arrived after we had finished reading a letter from Sam Steinbaugh. Upon being told he would have to read it for himself, he remarked that he didn't want to hear anything Sam had to say. We felt it was a strage remark and after a moment of silence let it pass. What we didn't know was that Sam was outside, ready to pay us a surprise visit, and Bob was pulling our leg. Refreshments were also special as Sam Dentler's wife baked us three lovely pecan pies. Needless to say the meeting was a success.

At the April meeting we had our annual visit from Tom Nolan, the

NRI AA OFFICERS	
Richard G. Moore.....	Vice President
Homer Chaney..........	Vice President
Angelo J. Colombo...	Vice President
William D. Harris......	Vice President
Tom Nolan...............	Exec. Secretary

Alumni News

National Executive Secretary. Tom's subject was digital voltmeters and frequency counters. [Editor's note: Janet and I were entertained very lavishly at the home of Bob Bonge with a real Texas barbeque sponsored by the San Antonio Chapter. We want to express our appreciation for a lovely evening. The evening was topped off by a visit to "Beethoven's Home" (a German club) where beer and sausage were served and dancing to a German band was in order. Everyone had a wonderful time.]

PITTSBURGH CHAPTER HEARS TALK BY ZENITH SUPERVISOR

At the April 3 meeting Mr. Thomas P. Brutscher, a field service supervisor for Zenith who is connected with the J. A. Williams Company, gave a talk on safety guidelines and high-voltage and sweep servicing guidelines for the 17/19 EC45 Zenith color TV chassis. He gave each one of the members present a booklet explaining the safety precautions and a set of instructions for the 17/19 EC45 high-voltage and sweep servicing guidelines.

The chapter is looking forward to the visit of Tom Nolan, National Executive Secretary, on June 5, 1975.

SOUTHEASTERN MASSACHUSETTS CHAPTER HEARS ELECTRONICS LECTURE

At the March 26 meeting, Mr. Carl Merrill, service manager for Bay State Television Company in New Bedford, Massachusetts, gave a talk on various circuits used in multiplex FM systems.

The first part of Carl's lecture was devoted to a Motorola 1306 using the phase-lock loop with a three-coil system. The latter part of the lecture was devoted to troubleshooting an Olympic tuner with a B&K scope and a WR50B RCA signal generator. Carl pointed out the 19-kHz, 38-kHz, and 67-kHz traps. Carl discovered that this particular receiver, which was picked at random, had a faulty transistor and a cracked core in a transformer.

In this issue is a photograph taken at the above meeting.

Mr. Carl Merrill takes a scope reading during a Southeastern Massachusetts Chapter meeting.

FLINT-SAGINAW VALLEY CHAPTER HAS ACTIVE MEETINGS

At the March meeting, Roger Donaven brought in a black-and-white TV set with horizontal frequency problems. The trouble turned out to be a leaky coupling capacitor from the sync amplifier of the horizontal AFC circuit. After replacement the set performed as it should.

Mr. Jobbagy demonstrated to the new NRI student members how to build an inexpensive capacitor checker using spare parts.

Steve Avetta demonstrated how to check the 3.5-megahertz color oscillator in a color TV by using a shortwave receiver. The receiver is placed close to the television chassis and tuned to 3.5 MHz, and it will actually pick up the color signal.

At the first April meeting, Steve Avetta presented the whole program including a talk on phonograph changers and also a demonstration of a signal generator with a range from 15 kHz to 3.33 MHz.

At the final April meeting Andy Jobbagy explained how to use a black-and-white TV set during a tornado warning. The TV will actually give tornado information within a 20-mile radius. At the same meeting Larry McMaster brought in a condenser analyst and demonstrated its uses.

DETROIT CHAPTER SOLVES PROBLEMS

At the April meeting of the Detroit Chapter Mr. Oliver described his new Sencore transistor checker called the "cricket."

Mr. Nagy brought in a television to be repaired, and Mr. Kelley found the fine tuning to be defective.

Mr. Kelley gave a talk on electron and current flow in transistors.

The chapter is planning a seminar on the design and manufacture of phonograph cartridges in the near future.

SPRINGFIELD MASSACHUSETTS CHAPTER HOLDS TROUBLESHOOTING SESSION

At the April 12 meeting Mr. Charest gave a short talk on his new dual-trace oscilloscope.

Also at this meeting the membership demonstrated defects and effective cause and reasoning using the RCA Dynamic transistor radio demonstrator. During the time of demonstration the transistor radio developed a motorboating effect. Following NRI troubleshooting procedures, the defect was located in the push-pull audio circuit. In this circuit there are two 2N408 transistors. In checking one of the transistors with the VTVM, a short was noted. The 2N408 was replaced and the trouble was over.

Mr. Al Dorman, our past chairman, gave the chapter a problem which involved a complete bridge circuit. The problem was: How does one connect into a circuit a complete unit containing four diodes when the previous components consisted of two dual diodes? The boys are still working on this one.

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- Accurately measures ripple output of power supplies; checks auto radio vibrators dynamically.
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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
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140.01-150.00	14.00	13.75	21.60	7.50
150.01-160.00	15.00	14.75	23.20	8.00
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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
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HOME PHONE .... HOW LONG AT THIS ADDRESS ....

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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

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