THE WEST RAND AMATEUR RADIO CLUB

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ANODE

Inside this issue:

Editor's Comments

This months issue

This month I have put two articles in. Both are "Wayne Green" articles; one from 73 magazine and the other from Kilobaud. Both have some interesting aspects for the constructor.

Nearly 5 million hard drives die because of plastic poisoning!

Its certainly turning into the major IT disaster of the new century. Fujitsu have declared hands-off and retreated into hiding whilst suing Cirrus Logic who in turn will probably sue Sumitomo Chemicals.

New Anode CD's

Reworked and compiled version of the Anode CD Compendium available at the club meetings and boot sales.

Trials and tribulations of construction

John (ZS6WL) has been testing/trying to build a "Q" meter for some time now. The requirements are fairly straightforward but the oscillator section is giving him some trouble. Making an oscillator cover the range with a consistent output level is not easy. In our discussion Thursday night we came to the conclusion that the mak-

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The Magical Audio Filter

Jim Pepper W6QIF
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A variable-frequency notch filter plus a peaking circuit will do wonders for your reception. And this project will almost build itself.

Audio filtering is a well-known process for improving receiver selectivity and many articles have been written on the subject. Because I have been in the process of building a direct-conversion receiver, I have been most interested in the subject. However, in order to further improve the receiver, I wanted more than the usual passband type of filter. Since one of the receiver modes is CW, I wanted a notch filter with a variable frequency and a variable-frequency peaking circuit. The notch filter could also be used on SSB reception to reject heterodynes from AM stations. Some of the requirements that I wanted for the notch filter were:

- A high Q (so the bandwidth at the 3-dB point of the notch frequency was approximately 200 Hz with a rejection of greater than 20 dB)
- The capability of shifting the notch frequency from 500 to 3 kHz
- A minimum number of parts.

The Frequency-Notching Circuit

Most articles I have seen

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Special points of interest:

- Contact details on back page

Editors Comments

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ing of a semi-synthesised frequency generator is a good starting point for this useful piece of equipment. See the May 2001 Anode for details.

This is related to my current project of making a pure sinewave generator for audio frequencies. The aim is to provide a module of pure dual sine wave generation for testing ssb transmitters. The module would then be available for general purpose testing having very consistent output level and purity.

I got a 'bargain' at the boot sale, did you?
[I keep getting black looks from one of my cats.]

This month's Anode distribution is going to be different. I am uploading the .pdf file to the Mweb server and letting the people download it from there. This should also get everyone used to the idea of a West Rand club amateur radio page. We shall see.....

The latest version of Adobe Acrobat reader (V5.x) is sluggish even on my machine and occasionally crashes. It still cannot catalogue the .pdf files that you have and this has led me to remove it and go back to version 4.

Alaska to the United Kingdom using one watt on 136 KHz. But wait there's more....

Reaching Alaska from the United Kingdom using just one watt ERP is quite a feat for any band, but Laurie Mayhead, G3AQC, has just achieved this on the 136 kHz band. And in doing so he has set a new record. RSGB Newsreader Jeremy Boot, G4NJH, has the story:

In the early hours of the 15th of February he transmitted to KL1X in Anchorage, and just before UK dawn at 0615 his call sign was clearly identified. G3AQC was using QRSS - very slow CW - with a 60-second dot period. The distance was 7278

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KIMCTR Measures Capacitance

This enhancement to KIMCTR (May 1979) results in a 1pf to 999.999 uF capacitance meter.

Clement S. Pepper 3270-96 Caminito East Bluff La Jolla CA 92037

If you are using KIMCTR (Kilobaud MICROCOMPUTING, May 1979, p. 34), you will be interested in this low-cost scheme for measuring capacitance. If you are not using KIMCTR, this may give you the urge to do so. If you have no intention of using KIMCTR but do want to measure capacitance, read on because this circuit can be employed with other microprocessors, counter/timers or just an oscilloscope alone.

I have many capacitors on hand-most of them used that I have acquired from various sources. Many capacitors have unreadable markings; some have in-house markings that tell me nothing. So for some time I have thirsted for a simple, low-cost way to measure capacitance. There are also times when I need to know the value of a capacitor to some reasonable accuracy. More often I simply want to match capacitance. This circuit meets all of these needs.

The Concept

If you charge a capacitor at a constant rate, its voltage will increase linearly with time. If you properly scale the charging current and measure the time required for a precise, one volt increase, the value of the capacitance will be proportional to the transition time.

In this scheme I employ four switch-selected constant currents of 1, 10, 100 and 1000 uA. A low-high limit comparator detects a one-volt change in Vc and provides a pulse out. The pulse width is measured and displayed on KIMCTR. It may also be observed on an oscillo-

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KIMCTR Measures Capacitance

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scope or measured on any suitable timer. Measurement span is 1 pF to 999.999 uF on KIMCTR, with four ranges.

Parts cost is low-anywhere from about $10 to $50, depending on what you have on hand and where you buy needed items. You can use an unused flip-flop and exclusive OR gate in the KIMCTR circuit to save two les.

Though the concept is simple, some effort is required to ensure accuracy of the measurements. Access to a 4 1/2 digit DVM with 10nA and 10uA resolution is needed for calibration. There are few constraints on construction; I built mine up on perf board. The primary concern is to keep wiring short in the capacitor circuit to minimize stray capacitance. You should exercise the usual care with the comparator wiring to minimize coupling between input and output. I used five-way banana jacks for connection to Cx.

Example 1

Vcn = I /C * tn
where I = the charging current from the constant current source, and C units of capacitance, from which

C = I / Vcn * tn

if Vcn can be forced to unity, this reduces to C= I * tn

I is then scaled to yield C n units of time as pF, nF or uF

Basic Principles

An ideal capacitor that is charged from a constant current source will develop a voltage that increases I linearly with time. Assuming a zero initial voltage and commencement of current flow at start time, to, the voltage at any later time, is shown in Example 1.

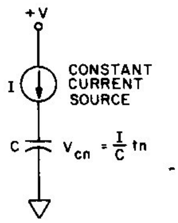

Fig. 1a. Capacitor charging from a constant current source results in a linear voltage that is proportional to current and time.

Fig. 1a shows a constant current source charging a capacitor. The current must be truly constant over some defined range of v, for vc to be a linear function of tn.

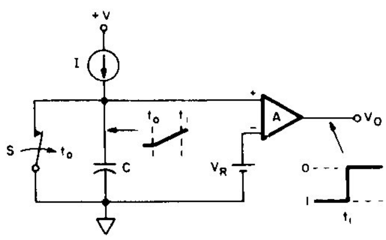

Fig. 1b. Addition of a shorting switch and comparator with a reference input provides a step output at time t_1 that is proportional to the value of C.

In Fig. 1b, C is bypassed with a shorting switch. A voltage comparator is connected across C. The non-inverting input is connected to C. The inverting input is connected to a stable voltage reference. At start time to, the switch is opened and a voltage is developed across C. At some later time, tl, Vc=VR, and the comparator output changes state. If VR = 1.000 volt the differential time will be proportional to C. However, this is not a practical circuit because the switch will have some resistance and the initial value of C will not be zero.

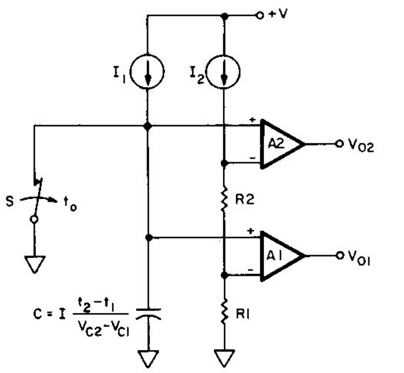

Fig. 1c. Two comparators in a low-high limit detection circuit eliminate error due to switch offset.

The effects of switch offset are eliminated in the low-high limit detector of Fig. 1c. Resistor R1 is selected such that the low-limit voltage, will be greater than any expected offset. Current source 12 maintains a precise 1.000 volt drop across R2. Then Vc2 - Vc1 1 = 1.000 and C = W2 - tl).

The outputs of the two com-

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The Magical Audio Filter

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on this subject showed at least three or four operational amplifiers plus a multitude of resistors and capacitors and therefore did not satisfy my third requirement.

One day, I accidentally ran across a number of circuits in a 'National Semiconductor Linear Applications Manual.' The circuit that interested me the most was the one providing variable frequency-notching using a variable capacitor. This circuit was constructed on a proto board and performed quite well, but the frequency range was limited by the maximum value of the capacitor. The basic circuit is shown in Fig. 1. The major drawback of this cir-

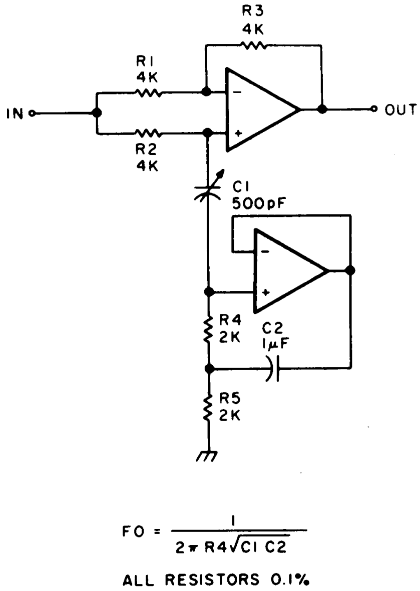

Fig. 1. Original circuit.

cuit was the large physical size of the capacitor as compared with the rest of the circuit.

Looking at the formula for the notch frequency (Fig. 1), one can see that the frequency is. a function of R4, C1. and C2. The frequency varies directly as R4 and by the square root of C1 and C2. Thus. if the resistor is doubled in value, the frequency doubles. Doubling the capacitors only gives 1.4 times the change. I decided to build the circuit with R4 variable and again results were very good. The frequency-range requirements were met and the rejection was greater than 20 dB. It did have one problem that was also experienced with the variable-capacitor circuit. In order to achieve maximum rejection

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KIMCTR Measures Capacitance

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parators in response to the rising capacitor voltage are diagrammed in Fig. ld. Charging begins at time to. The low-limit detector changes state at tl, the high limit at t2.

We need a scheme to measure the difference time. The exclu-

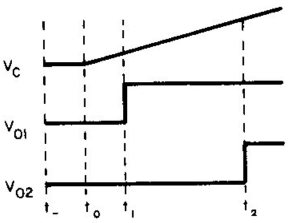
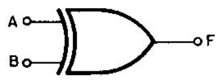


Fig. 1d. Timing diagram for the low-high limit comparator circuit.

sive OR gate provides a solution. Its truth table is provided in Fig. le. The gate output will be high in the interval t, -t2; at all other times, it will be low. The pulse width is the value of C.



A	B	F
0	1	0
0	1	1
1	0	1
1	1	0

Fig. 1e. Exclusive OR gate and logic table.

The Transistor Current Source

A single-transistor current source provides the capacitor charging. The basic current source circuit is shown in Fig. 2. This simple circuit will source a consistent constant current with a high degree of stability. The transistor is operating in a dc common-base configuration. The voltage reference, VR, establishes a constant voltage between the base and emitter. The emitter current IE must adjust itself so that the product]E. RE = VR.

There are two inherent features of the common-base mode that contribute to its utility as a constant current source: The leakage current, Ico, of the collector-base diode is not amplified by the transistor, and the output resistance of the transistor

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The Magical Audio Filter

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at the high end vs. the low end, R3 had to be varied. Experimenting further, I found that if R5 were varied and R3 and R4 were properly chosen, only one control was necessary. Almost equal rejection could then be achieved across the whole range. A typical response is shown in Fig. 2.

The Peaking Circuit

Since the above circuit was rather novel (there is no signal inversion from input to output at the off null point), I started to look at voltages at various points with an oscilloscope. To my amazement, I found that when the output was going to null on IC1, the output was peaking on IC2. Eureka! -Here was the second circuit I was looking for. To accomplish peaking, only IC2 was needed. This circuit was constructed and the results are shown in Fig. 3. Rin is necessary to prevent saturation of the amplifier. The gain of this stage is about 10-therefore the input must be less than 0.5 volts. The power supply used was plus and minus 8 volts to be equivalent to the supply to be used in the final construction.

It will be noticed that there is an additional resistor that can be switched in or out in the final circuit. When the resistor is in, the peak is broadened and the circuit can be used on AM or SSB to modify the speech characteristics of the transmitted signal being received. It can reduce the low frequencies and accentuate the frequencies that transmit the spectrum that contains the most intelligence. It also reduces higher frequencies, thereby reducing background noise.

Combination Notch and Peaking Circuit

Fig. 4 shows the final circuit combining the two circuits. The circuit was constructed on a perfboard using wire-wrap sockets. The perfboard is mounted in a Radio Shack box with 1-inch spacers. Both the LM383 and the transformer are mounted to the box. One note of caution, the 0.22uF capacitor on the output to ground on the LM383 should be mounted on the device terminals. The input cable, the output jack, and the 115-V-ac input all come in on one end of the box and the potentiometers mount on top.

For some reason, not many articles ever use perfboards and wire-wrap sockets. PC boards should be used for rf work, but the perfboard does very well for audio frequencies. The nice thing about wire-wrap circuits is that if you make a mistake, it can be corrected or modified easily. The following are some hints on building with a perfboard and wire-wrap sockets.

1. Make a Xerox copy of the IC sockets. Remember the schematic, every time you put in a wire, mark it
down. This is especially helpful should you put the project away and come back to it later.
2. Using a marking pen on the wire side of the board, indicate which pin is #1 for the ic sockets. Remember that the numbering on the wire side is opposite to that on top.
3. l use model-airplane cement to hold the IC sockets in place. If you want to reuse the perfboard, this, type of glue allows the socket to be easily removed. Clean the board with acetone when the sockets are removed.
4. It is also helpful to use different colours of wire for different parts of the circuitry.
5. Push-in terminals (Radio Shack #270-1392) are used to mount the resistors and capacitors. The wire-wrap wires are soldered to these terminals on the wire side of the board. (A special tool is available to insert these terminals but is not available from Radio Shack. Long nose pliers can be used but are nowhere near as satisfactory as the tool.)
6. Mount the components when the push-in terminals are in place so as not to lose track of which terminal goes with which component.
7. Wire-wrapping is done with a manual tool to conveniently allow interchanging of wire colours. If you have never used a wire-wrap tool, the operation is very simple. In learning, the best way is to

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measure the distance between the two points to be wired and add 1 1/4 inch if wire-wrap to wire-wrap, add 7/8 inch for wire-wrap to terminal, and add 1/2 inch for terminal to terminal. For good measure, add on about 1/2 inch so the wire will not be too tight. Strip both ends 5/8 inch for wire-wrapping and 1/4 inch for terminals. Stripping is done with a special tool provided with the wire-wrap tool. The, bare wire is inserted into the end of the wire-wrap tool with the wire entering the smallest hole on the end of the tool. Place the tool over the terminal post to be wrapped and rotate the tool in a clockwise direction for about ten turns. The connection is now made. When you make a mistake, a tool is available to rotate in the opposite direction to remove the wire.

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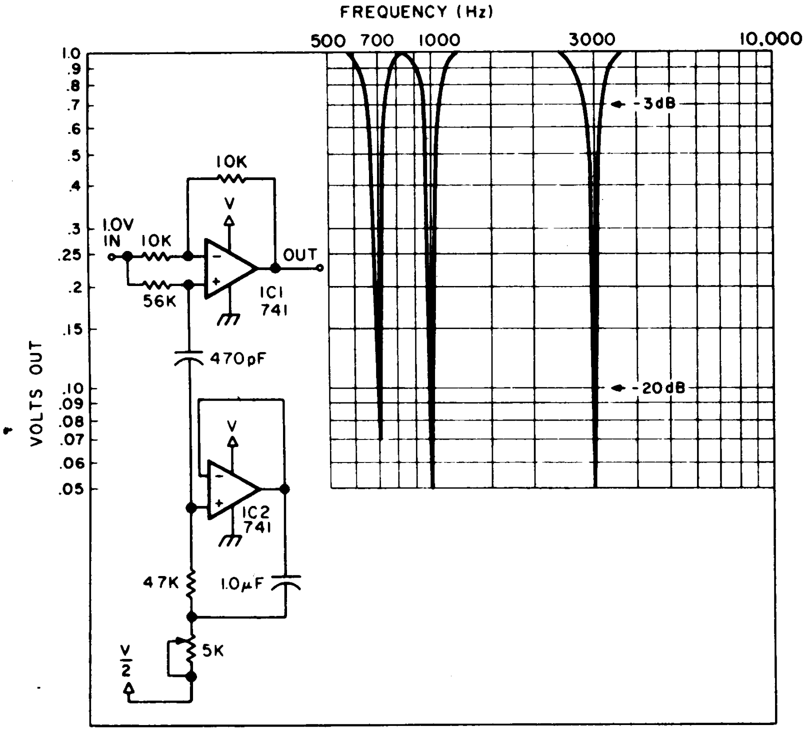

Fig. 2. Notch circuit.

Editor's Comments

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kilometres, a record for one watt ERP on 136kHz.

Last year G3AQC became the first person to cross the Atlantic on the 73kHz band. KL1X is perhaps better known to UK amateurs as Laurence Howell, GM4DMA.

Laurence said, "What is more surprising than the distance is that the path is notoriously poor between south-east Alaska, on the east coast of the Pacific, and Europe.

The signal would theoretically go on a great circle route to nearly 80 degrees north, over the northern Canadian Arctic, northern Greenland, east of Iceland, Glasgow, then over the UK to the South Coast - across and through the Auroral oval. There are some thoughts that the actual path might have gone round or even under the Auroral zone as no Auroral Doppler was seen on the received signal."

A lot of research and preparation work was carried out by G3NYK, G3LDO, W3EEE and W4DEX. This pre-planning is probably in good part responsible for helping to set this new work 136 kHz record. (GB2RS)

[Isn't making a smoking section in a restaurant like making a peeing section in a swimming pool?]

KIMCTR Measures Capacitance

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is the dynamic source resistance of the collector. For small currents this will be many megohms.

Care must be exercised in the design and adjustment of the current source, as the accuracy of the measurement is dependent on both the absolute value of the charging current and upon its remaining constant throughout the measurement interval.

The Measurement Circuit

The complete circuit is shown in Fig. 3. I have identified the three functions of the circuit as precision current sources, capacitor charge / discharge control, low-high limit detection.

Precision Current Sources

There are two current source circuits: The first supplies one of four switch-selected capacitor-charging currents; the second establishes the reference voltages for limit detection. The Motorola 1N 4565 is a temperature-compensated reference diode, specified for a temperature coefficient of .01% / C drift at a diode current of 500uA. CR1 is a diode-connected transistor. Its function is to track the base-emitter diode of transistor Q1.

In constructing the circuit, I first assembled the current sources and made a preliminary adjustment of the current for each switch setting. A final adjustment must be made when assembly is completed. I used a four-position DIP switch for range selection. I used style RV6, 1/2 Watt, single-turn composition potentiometers with good results. I used them because I have a number on hand; if I were to buy a new one, I would purchase a cermet trimmer, such as the Beckman series 66. I used carbon resistors, but for best long-term stability, metal or cermet film would be preferable.

Leakage current measurements of the transistor diodes should be made to ensure good devices. Leakage should be about 10 to 20nA. I made all measurements with a Keithley model 179, 4 1/2 digit DVM Since Q2 operates at a relatively large current, a 6.2 volt zener and IN914 compensating diode are a satisfactory reference, assuming room temperature use.

Though measurements are made at alternate counting intervals, two sets of data will appear on the display. This is because discharging the capacitor yields a pulse that is also measured. There is no confusion between the two; the value measured is large compared to the discharge time. For many small capacitors the discharge time will read zero.

Capacitor Charge/ Discharge Control

Capacitor charging is controlled by transistor Q3. This switch has two functions: to discharge the capacitor at the end of the charging cycle and to limit the maximum voltage across Cx to about 2.5 volts.

The cycle is controlled by the counter reset pulse. You may wonder why a flip-flop is in the circuit. It takes a certain length of time for Cx to discharge. Large capacitors, and electrolytics in particular, require a longer time to discharge than is available between counting intervals. The 4013 sets and resets Q3 through the LM339 for alternate charge and discharge sequences. The LM339 assures adequate drive for the transistor.

CTR captures the first pulse it sees; if that is a 3 MS spike, that is what you read. I read a lot of them before i solved the problem. The solution has been very effective.

The network is not needed on the high-limit comparator. KIMCTR will detect the first transition and stop the count. Output pull-up resistors R21 and R22 are both bypassed for equal reset times.

R19 and R20 should be metal film resistors for low-noise and long-term stability. The absolute values are not criti-

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KIMCTR Measures Capacitance

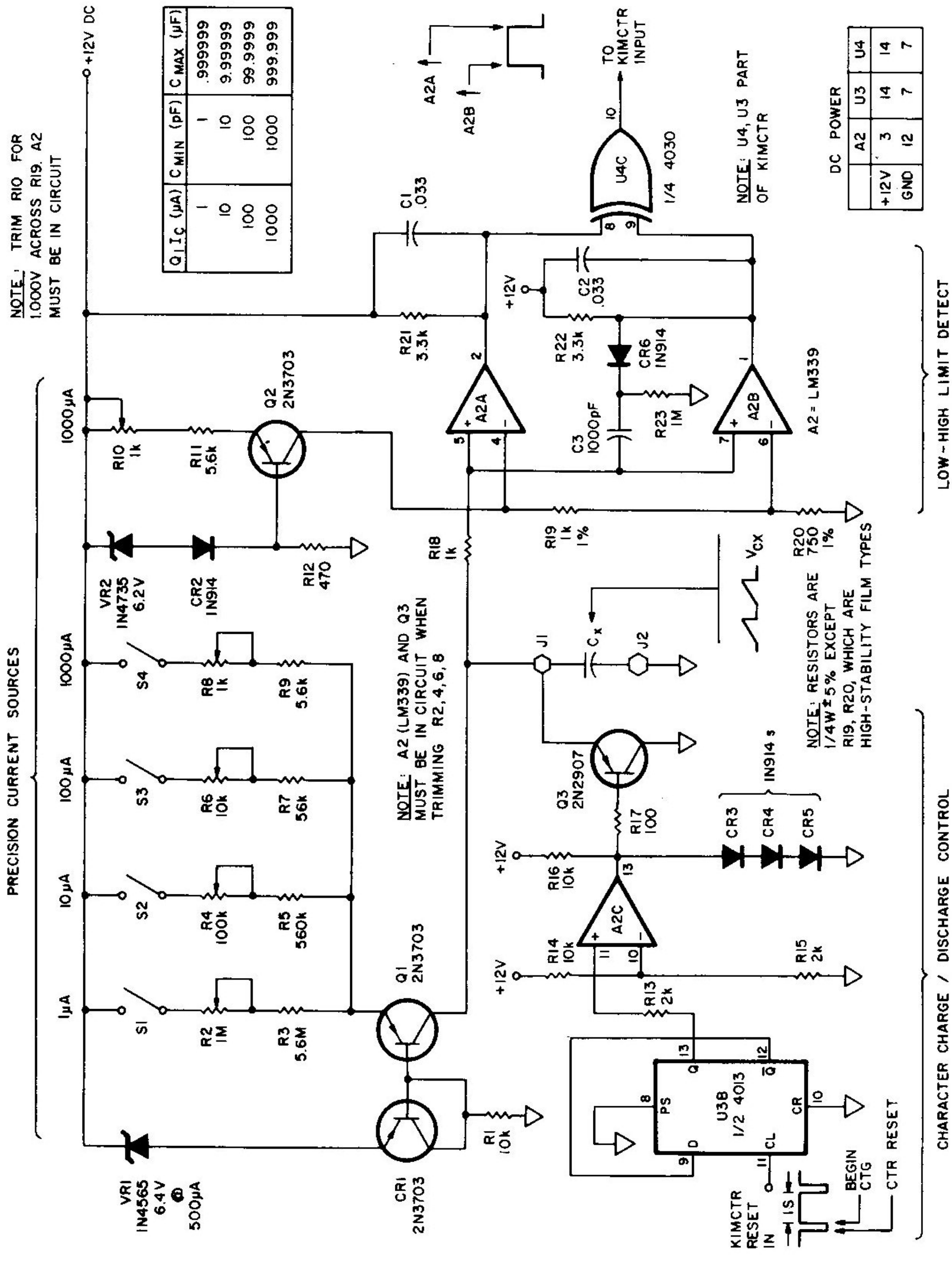

Fig. 3. The complete circuit schematic of the capacitance meter.

KIMCTR Measures Capacitance

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cal because the 1.000 voltage across R19 must be obtained by an adjustment of R10 when the circuit is fully assembled.

Low-High Limit Detection

The primary problem I encountered with this circuit was oscillation of the low-limit comparator. The oscillation occurs because the input is a slowly rising ramp. The conventional technique for handling this is to provide hysteresis with positive feedback from a resistor to the + input. This approach cannot be used because the feedback current is then summed into the charging current. A 10M resistor will contribute about 1uA of current, which is unacceptable.

Since I could not eliminate the oscillation, I decided to use it to my advantage. The capacitor voltage builds up with time until it is equal to the voltage across R20, about 750 mV. The comparator output then jumps from low to high. That is what we want, but unfortunately it doesn't stay there. Various factors cause the output to jump back and forth until the rising input passes through the transition region, allowing the output to stabilize in the high state.

The network of C3, CR6 and R23 conducts the initial output rise around to the + input to force a small rise in voltage, sufficient to maintain the high output state. The diode forces the capacitor to discharge through the 1M resistor. The long discharge provides time for the input to rise sufficiently to maintain the output.

A clean leading edge of the output pulse is essential.

KIM-Measurement Accuracy

Two factors affect the achievable measurement accuracy. One is internal, that is, the accuracy with which the current sources are adjusted and their stability, both long and short term. The other is external in that capacitor leakage will distort the measurement. The LM339 inputs contribute a bias current that sums in with the charging current. You can measure this current by simply connecting your multimeter across the Cx terminals with the four DIP switches open. I measured 115nA. Fortunately, this current is nearly constant, with a positive temperature coefficient (doubles each 10% rise in temperature).

To perform the final current source adjustment, leave the meter across the Cx terminals and adjust R2, R4, R6 and R8 for a precise 1, 10, 100 and 1000uA, respectively. Close only one switch at a time; do not sum the sources.

With some experience you can calibrate the comparator bias current for the measurement of small capacitances. In theory you can measure a 1pF capacitor with the 1 MA current. In practice I found 10 pF to be the minimum. However, you can still measure a 1 pF capacitor with a simple trick.

I stripped two conductors from a 10-conductor ribbon cable, terminated one end with mini clips and then clipped bits off the other end until it measured 10pF. With this calibrated test lead l can measure any value of small capacitance. l connected a 115pF mica capacitor and left KIMCTR running for five days of continuous measurement. From time to time, I looked at the display.

I had performed the final calibration adjustments on one of our typically balmy La Jolla days when my home lab was close to 70'. During the five-day period the temperature increased. I observed a positive temperature coefficient of about 1/3pF pF/'F. The maximum I observed in the display during the five days was 118pF. It never dropped below 115pF.

Capacitor leakage lengthens the measurement time; the capacitor looks larger than it really is. For this reason measurements should be made at the highest feasible current. I use four digits as a target; the 4th digit typically shows some jitter. With careful adjustment of the current sources, you should achieve measurement consistency of 3 percent or bet-

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Circuit Operation

When the project is finished, the input cable can be plugged into the phone jack of any receiver and the output to either a speaker or headphones. Set S1, the peaking-circuit switch, to OUT. Tune in a CW signal and adjust the signal frequency to give about an 800-Hz tone. Throw S1 to IN and turn the peaking control to a point where the maximum audio is heard. The first thing you will notice with the peaking switch in. is the reduction in noise. As you approach the peaking point., the signal will increase greatly in volume. Of course, if some other frequency suits you better than 800 Hz, that is the listener's choice.

The next thing to check is the

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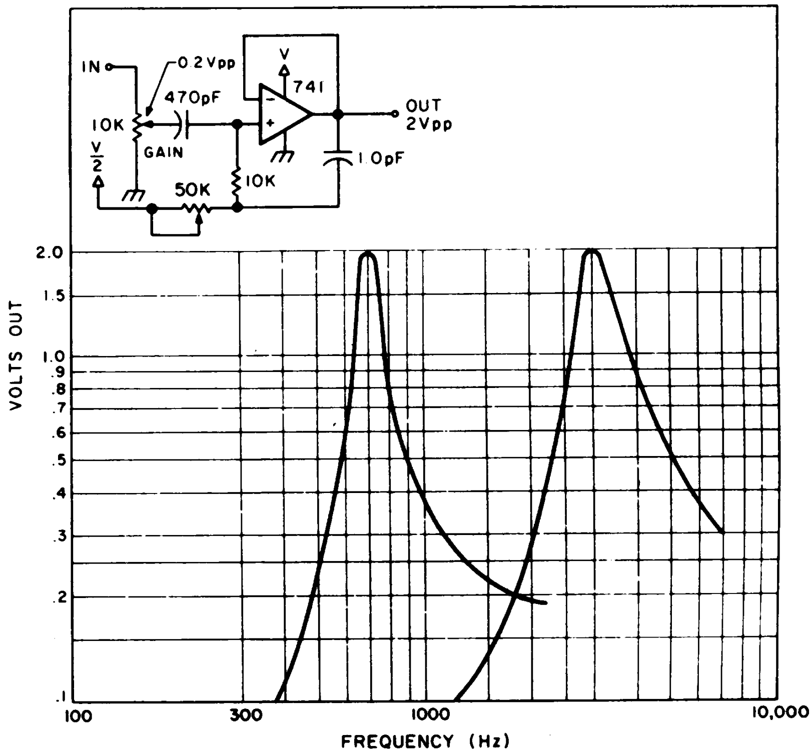

Fig. 3. Peaking circuit.

KIMCTR Measures Capacitance

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ter between ranges with low leakage capacitors. Absolute accuracy of better than 5 percent should be achievable. Generally speaking, all types except ceramic disks and aluminium electrolytics are measurable with fairly decent accuracy.

An assortment of readings from Mylar and mica capacitors showed a scatter ranging from right on to about ±3 percent. If you want to look at the capacitor charging ramp with your scope, be sure to use a X10 probe.

Overall, 1 am pleased with the KIMCTR capacitance meter. 1 consider it a real bargain in terms of value per dollar of cost and the effort to put it together. I'll get a lot of good use from it. 1 think you will too.

Reference

C. S. Pepper, 'Measure Capacitance Quick and Easy with this Low-Cost Circuit," EDN Magazine, February 5, 1979, p. 130.

64 Microcomputing, October 1979

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notch filter. With the 800-Hz signal coming in, adjust the notch control to a point where the signal drops in volume. On some CW signals with key clicks and thumps, the 800-Hz signal will drop out but the clicks and thumps will still be there. I have found that it is easier to remove a heterodyne with the peaking circuit out; then bring in the peaking circuit, producing an even greater reduction in the interfering signal. When the notch circuit is not used, the pot should be set to the low-frequency end.

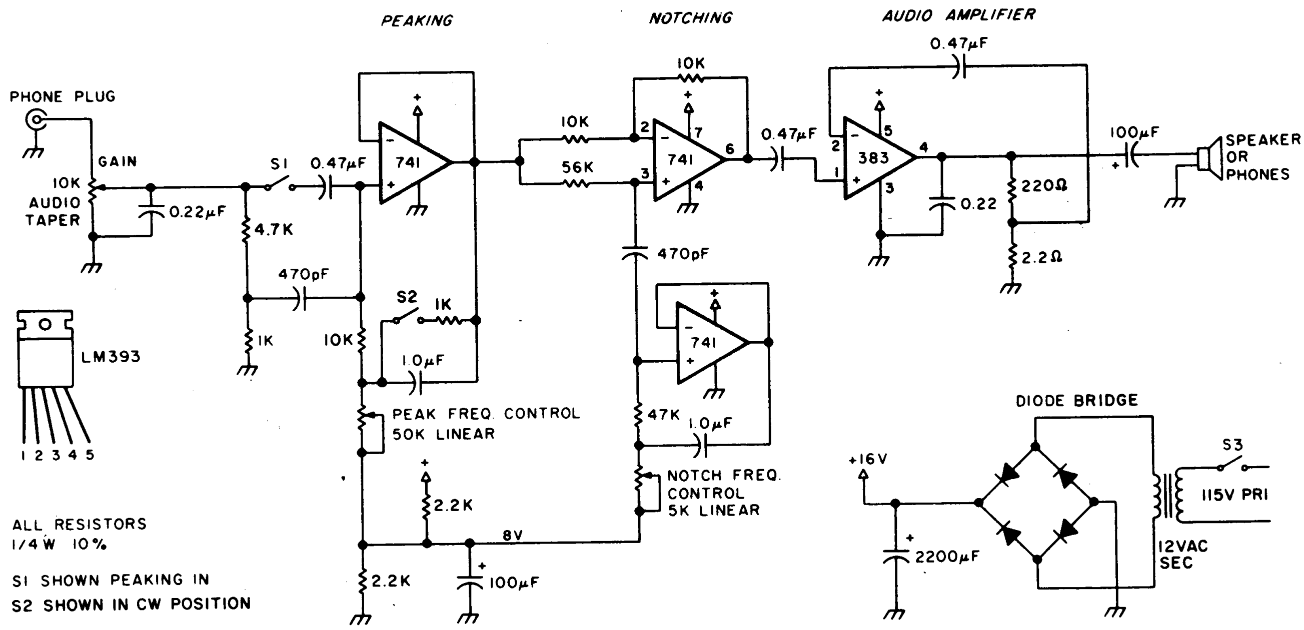

Fig. 4.

Frequency-Selection Circuit

Another circuit is shown in Fig. 5. [not shown here] Although I have not tried this circuit, it could be of interest. I have tried LM567s in frequency-selective circuits, but noise spikes seem to get through, creating an unwanted output signal. A case in point is my garage-door opener. This unit had a vibrating-reed type of frequency detector and I replaced it with a pair of LM567s.

Every once in awhile the door will open without a command due to noise. After I finish this project, reworking the opener will be my next project.

Conclusion

The peaking/notching circuit should be a worthwhile addition to any receiver for a parts cost of about $35 excluding the wire-wrap tool and wire that can be used on many other projects. It is a simple but effective way-to gain a bit more selectivity that should improve any old receiver and maybe some of the newer ones.

A list of parts is given with all but one being available from Radio Shack. Of course, most hams will have many of these parts available in their junk boxes, bringing the overall cost down.

References

1. National Semiconductor Linear Applications Manual, January, 1972, page AN 31-14.

73 Magazine *November, 1983