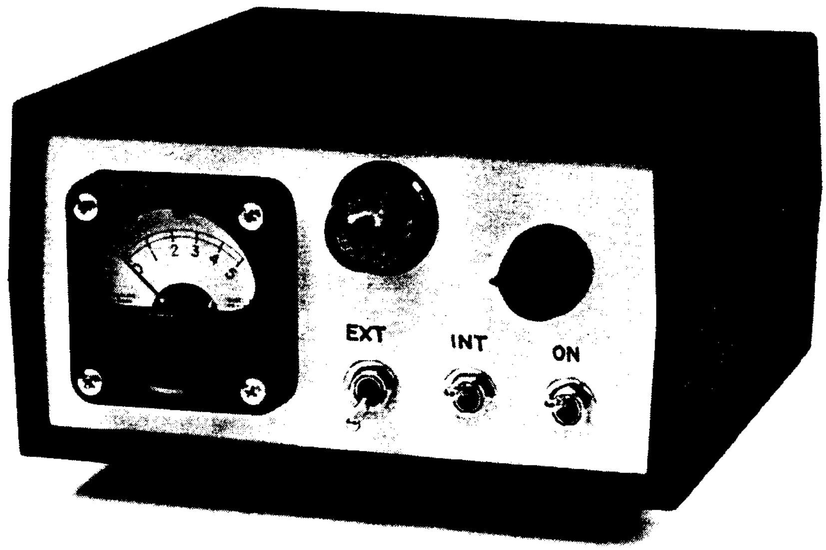
A Sensitive Integrating Squelch Circuit



Squeeze new contacts out of band openings you'd otherwise have missed! With this simple receiver accessory, you can easily catch 10-m and VHF band openings!

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Sporadic-E propagation is appropriately named: Although there are seasonal and other indicators, you never know *exactly* when the band is going to open.[1-3] This is true for 10 and 6 meters, and even more so for the higher-frequency VHF bands. Even when you know there are E clouds above, and are busy working 10 or 6 meters, you want to be alerted to those rare 2-meter short-skip openings, some of which last only a few minutes. What you need is a receiver squelch circuit—like this one—that will sound the alarm. You're sure to find a need for it during the coming F_2 season so you'll be sure to catch any possible 6-meter openings.

Many older receivers do not have squelch systems, and built-in squelch circuits may not be as effective as you'd like them to be. They may show poor response to very weak signals, and react unduly to short noise pulses. That's why I developed the squelch circuit described here. It's not meant to provide receiver quieting during communication, but acts as a band-opening alarm for weak-signal CW and SSB work.

Circuit Features

The squelch circuit I devised connects between the receiver's audio-output jack and a speaker, requiring no modifications to the receiver or transceiver. This accessory operates from a 12 V dc wall transformer for fixed-station use, or from a battery for portable or mobile operation. I wanted the squelch unit to be portable so I could use it with my 2-W, 6-m IC-502A transceiver, which I like to take along on camping trips.

[1]Notes appear on page 29.

The heart of the circuit is an op amp integrator that has a memory and a slow reaction time. Thus, a short-duration noise pulse has little effect on the circuit, but a weak signal—if present for a few seconds—has a *cumulative* effect, and eventually charges the integrator enough to trigger the alarm circuit.

> ***You never know* exactly *when the band is going to open...***

The integrator charging rate depends on the signal strength and its duration. A strong signal reaches the trigger level almost instantly. The memory action operates even between words on SSB, or dots and dashes on CW. This enables you to hear weak signals that might otherwise go unnoticed. The integrator charge is maintained for a few seconds after the signal level has dropped, keeping the circuit triggered.

When the squelch is triggered, audio is fed to the speaker, and a panel lamp lights. A buzzer and/or remote signal indicator can also be triggered if desired. The external alarm jack can be used to ring a bell in the kitchen, flash all the lights in the house, or control just about anything you'd like.

> ***The squelch circuit requires no modifications to the receiver or transceiver.***

Circuit Description

Refer to Fig 1. Receiver audio is routed through the SQUELCH ON/OFF switch (S1) to relay K1, which controls the audio output to the speaker. A miniature, reverse-connected transistor audio-output transformer (T1) steps up the audio signal voltage, and a THRESHOLD control sets the level for the detector, D2. The detector output drives the noninverting input of the integrator (U1A), which drives the integrator output high. With no incoming signal, the integrator output is held low by the presence of a small bias voltage on the inverting input, which also provides a discharge and reset function.

The integrator output feeds the noninverting input of a comparator, U1B. With no signal present, bias on the inverting input keeps the comparator output low. When a signal drives the integrator output above the comparator reference level, the comparator's output goes high, actuating the relay, K1.

Circuit Details

C2 and D2 form a peak detector. U1A's high input impedance provides a time constant that is long enough for the peak signal level to charge the integrator during an entire audio cycle, even with a weak signal that is above the bias level for only a small fraction of a cycle.

The R1/C1 time constant, and the level of the detected signal above the bias, determine the charging rate. Discharge rate is determined by R1/C1 and the bias level. U1A acts as a current source during charge, and as a sink during discharge. The bias on the inverting input of the integrator is kept at the lowest practical level to obtain high sensitivity at low-volume levels, still

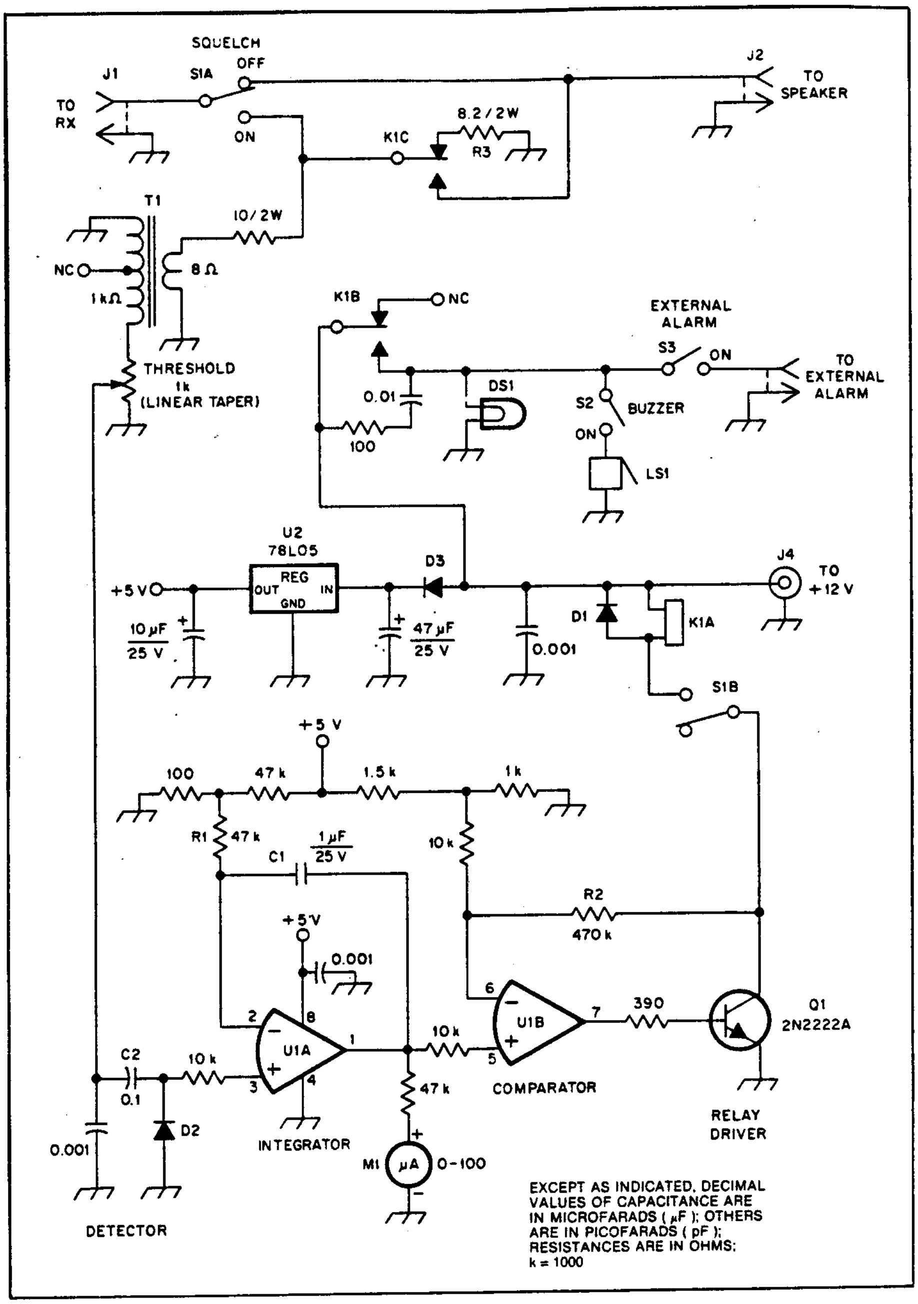

Fig 1—Schematic diagram of the integrating squelch circuit. (RS numbers in parentheses are Radio Shack® stock numbers. Equivalent parts may be substituted in all cases.)

C1—Nonpolarized, low-leakage ceramic, Mylar® or polyester (RS 272-1055).
D1—1N4003 or equiv.
D2—1N270, 1N34A (RS 276-1123) or equiv germanium diode.
D3—1N914 silicon diode.
DS1—14-V pilot lamp, no. 1813 (100 mA) or no. 1815 (200 mA).
J1-J3, incl—Phono jacks.
J4—Dc power jack (AL type DCJ and mating plug DCLID used here).
K1—DPDT, 12 V dc relay.
LS1—Piezoelectric buzzer (RS 273-060).
M1—0-100 µA meter; other ranges can be used; see text.
S1—DPDT switch.
S2, S3—SPST switch.
T1—Transistor output transformer, 1-kΩ CT pri; 8-Ω sec (RS 273-1380).
U1—LM358N dual op amp.
U2—78L05 regulator.

allowing for the input offset specifications of the op amp.

When the relay is *not* actuated, R3 provides a load for the receiver audio output, keeping the signal level to the detector constant whether the squelch is triggered or released. Without this resistor, the speaker load would reduce the input to the detector, causing the relay to cycle on and off. The value of R3 is properly matched to the speaker impedance if the meter pointer, when slowly climbing past the threshold point, does not change speed when the circuit triggers.

Table 1

Component Suppliers

AE	Allied Electronics, 401 E 8th St, Fort Worth, TX 76102, tel 800-433-5700.
AL	All Electronics, Box 567, Van Nuys, CA 91408, tel 800-256-5432; in California, 800-258-6666.
CS	Circuit Specialists, Box 3047, Scottsdale, AZ 85257, tel 602-966-0764.
DK	Digi-Key Corp, Box 677, Thief River Falls, MN 56701, tel 800-344-4539.
FR	Fair Radio Sales, Box 1105, Lima, OH 45802, tel 419-227-6573.
ME	John Meshna, 19 Allerton St, Lynn, MA 01904, tel 617-595-2275.

To prevent relay chattering, feedback resistor R2 introduces a bit of hysteresis for stability. This is not the usual signal-level hysteresis, which results in a loss of sensitivity to weak signals, but a *time* hysteresis. It alters the comparator reference level, but not the integrator threshold level. Although the integrator output must rise to about 2 V to trigger the comparator, it must fall further, to about 1.9 V, to release. Thus, the only effect is that the release time is a fraction of a second longer than the attack time.

Components and Assembly

Parts suppliers are listed in Table 1. Doug DeMaw's article gives many good tips for finding parts.[4] The Radio Shack parts identified in the parts list are posted in their catalog, but local availability may vary.

Surplus resistors are often way out of tolerance. New resistors are available inexpensively in small quantities from DK. I like the lamp holder (PIL-004) from FR because it has a translucent-yellow plastic lens that shines brightly. Lamps are available from AL. The 78L05 regulator (U2) is carried by CS. Of course, you can also use the physically larger 78M05 or 7805 if they're handy. Surplus germanium diodes are often defective and should always be tested before use; they should exhibit a forward-voltage drop of approximately 0.3.

Small surplus meters (for M1) can be purchased for about a dollar; ME has a good selection. Ranges other than 0-100 µA can be used, but will likely require a change in the meter multiplier resistor to yield a full-scale deflection corresponding to 4 or 5 V at the integrator output. The meter scale markings *are of no concern* because you'll only watch the rise and fall of the meter needle, and note the comparator reference level somewhere near mid-scale. (Because of the time delay of the integrator, the meter is essential to show the trend of the charge for purposes of adjustment, but precision measurement is not required.)

The relay-driver transistor (Q1) can be any NPN type with a 25-V, 600-mA (or higher) rating. I use a piezoelectric buzzer for LS1 because a mechanical buzzer will produce enough QRN in the receiver to hold in the squelch. A 12 V dc, 500-mA wall transformer should handle most relay, lamp and buzzer loads. If you use a remote alarm that requires a large amount of current, or uses a different voltage, it should have its own power supply, controlled by another relay. I use a large, red, automobile brake light with my 2-meter rig squelch unit while I'm operating on 6 meters. That lamp flashes an alarm that cannot be ignored, but does not interrupt a QSO in progress. (This monitoring-while-operating method may require that the TR switching disable the squelch because RF from the transmitter could trigger it.)

Construction is noncritical, and the unit can be built into a small, plastic project box. It takes only about an hour to hand-wire the components, and most of them can be placed on a small piece of perf board. The prototype is shown in Fig 2.

Testing and Operation

With the squelch unit connected to your transceiver, the no-signal reading on M1 should be zero. Now, tune in a steady carrier. The meter reading will begin to rise at a rate that depends on the signal level. With a weak signal, the charge on C1 should take about three seconds to reach the reference level of about 2 V, triggering the comparator. Allow the voltage to rise to a maximum of approximately 3.5 V, and tune away from the signal. It should take about six seconds for the voltage level to fall to the reference level, releasing the comparator. The attack ramp is steeper than the decay ramp, so the integrator charges more from a single dot than it decays between dots.

With the squelch unit off and no signal present, set the receiver audio gain control for the desired speaker noise level. Then, turn the squelch on and set the squelch THRESHOLD control just below the point where M1's reading begins to climb. Best results are obtained with the rf gain control backed off sufficiently to defeat AGC action on weak signals, and with the transceiver noise blanker on. The squelch is switched off during QSOs.

Don't forget—the band won't "open" if we *all* just listen! When conditions seem auspicious, an occasional CQ on the national calling frequency might trip an integrating squelch circuit like this one somewhere out there beyond the skip zone—giving you access to a new state or grid square!

Results

Two versions of this gadget were built and used for over a year on the 6- and 2-meter bands with pleasing results. The integrating squelch deserves a large measure of credit for my working 329 grid squares on 6 meters during the 1987 skip season. Even very weak equinoctial 6-meter transequatorial signals arriving from South America have tripped the squelch when I was far from the rig. The resulting alarms led to contacts with 10 new countries for me.

With careful threshold adjustment, the squelch will respond to signals only 1 dB above the noise. But the real-life performance—the ability to remain quiet with no signal and yet react to the very weakest signal—will ultimately depend on local noise conditions. The squelch *will* tell you when that big truck pulls in the driveway with your new tower!

With the circuit in action, you can work other bands, dig weeds in the garden, or take a snooze. All the while, you can be sure that the integrating squelch won't let you miss anything exciting that might happen on the short skip bands.

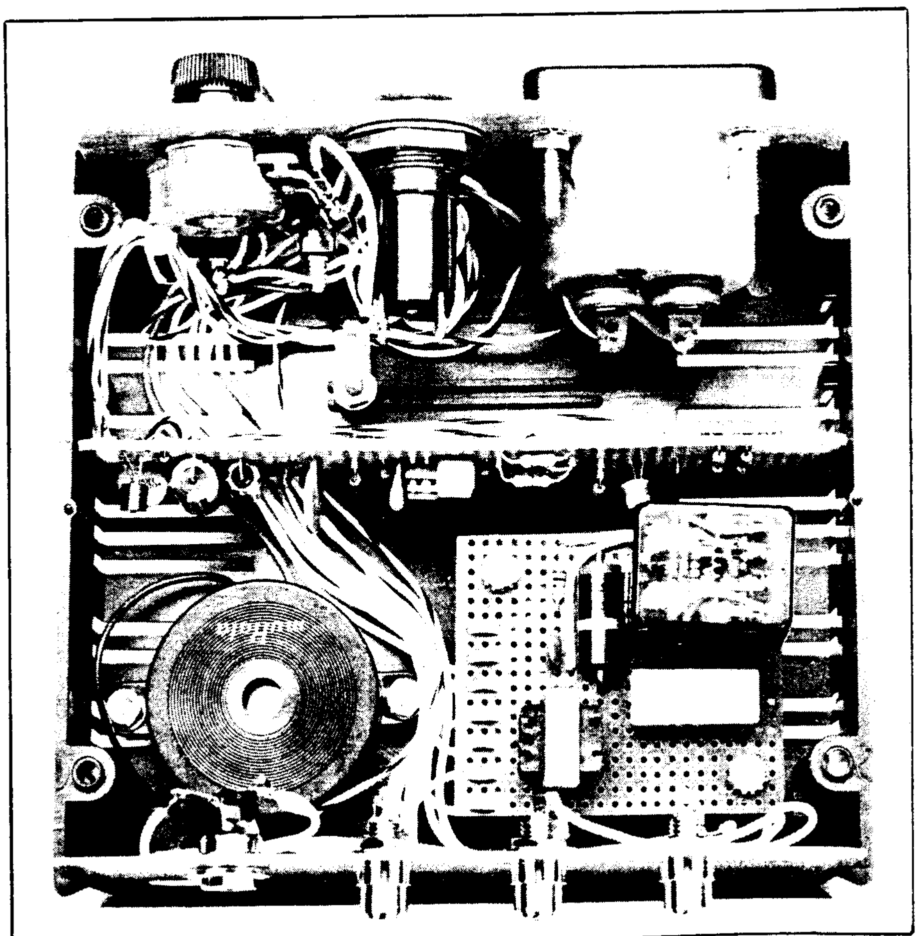

Fig 2—An inside view of the integrating squelch unit. Two small perf boards contain most of the components. The circular, black object at the lower left in the photo is the piezoelectric buzzer. From left to right, the jacks on the rear panel are +12 V (J4), receiver input (J1), speaker output (J2) and the external alarm jack (J3).

Notes

[1]M. Wilson, ed, *The 1988 ARRL Handbook* (Newington: ARRL, 1987), p 22-14.

[2]E. Pocock, "Sporadic-E Propagation at VHF: A Review of Progress and Prospects," *QST*, Apr 1988, pp 33-39.

[3]M. Owen, "The Great Sporadic-E Opening of June 14, 1987," *QST*, May 1988, pp 21-29.

[4]D. DeMaw, "Stalking Those Fugitive Components," *QST*, Oct 1987, pp 24-26.

Mark Mandelkern, KN5S, has been looking for sporadic-E band openings for 40 years, since he was first licensed as W9ECV in Milwaukee, Wisconsin. He enjoys working DX, Sweepstakes, 160 meters and VHF contests. Mark holds the Rocky Mountain Division's all-time record score for the June VHF contest. Mark's station is capable of operating on the bands from 160 through 2 meters, including meteor scatter and moonbounce. Seventy percent of his equipment is homemade, and Mark is working toward the goal of making it a 100% homemade station.

Mark holds a PhD from the University of Rochester, and is Professor of Mathematics at New Mexico State University. He's also a frequent contributor to QST.

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