The AGC-80/40 – Page 1

A Regenerative Receiver with AGC for 80 and 40 Meters

July 14, 2008 by Rick Andersen, KE3IJ

Here's a dual-band Regen that came from some encouraging emails from Jerry (K9UT) and another gentleman named Harvey, who built my original AGC-80, and its experimental "Regenerodyne" successor, the AGC-80/30. Jerry and I have corresponded on several occasions, and he tells me that he enjoys both receivers and that they work surprisingly well for such simple circuits. A few other Hams have written to express their satisfaction with the AGC-80 as well. Many thanks to those of you who gave me helpful feedback.

Jerry asked me when I was going to design an AGC-controlled Regen for 40 meters... I pointed out that I had already posted two other 40 meter receivers at my webpage, but neither has AGC. So Jerry's request led to this project, the AGC-80/40.

This is a successor to the original AGC-80, a Colpitts-based Regenerative receiver with audio-derived AGC [Automatic Gain Control] to prevent strong signals from "pulling" or "blocking" the detector. Like its predecessor, it is 'varactor'-tuned [actually I use rectifier diodes as varactors] and has no bulky, expensive variable capacitors. Actually, the AGC-80 did have a PCB-mounted trimmer cap that calibrated the front panel, setting the band limits. This new receiver does away even with that trimmer cap. Band switching is accomplished by a double-pole, double throw toggle switch that switches capacitance values in the "front end" where the signal comes in from the antenna, and simultaneously switches coils (wound on small toroid cores) in the Regen Detector stage, for 80 and 40 meter operation.

The receiver also uses passive filtering with switched capacitance values to kill the extreme highs with a 2500 Hz lowpass filter for voice transmissions, or an 800 Hz peaked low pass filter for receiving CW transmissions.

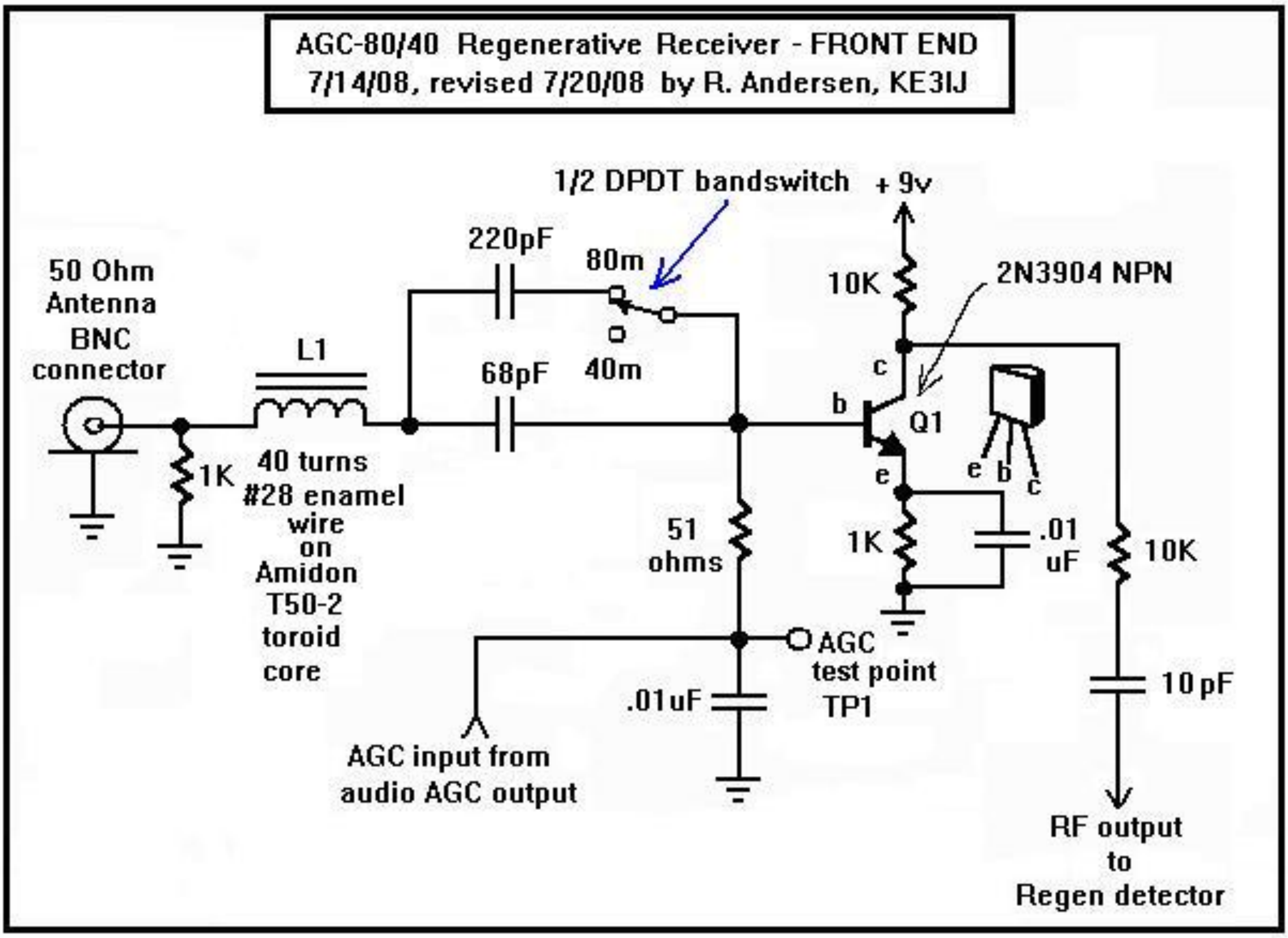
All audio and AGC functions are now accomplished by one integrated circuit, a TL074 quad operational amplifier.

I probably should have add an internal audio amp and speaker; right now, I route the audio to a front-panel jack and into my trusty old Radio Shack Amplified Speaker (see the photos in the AGC-80 article).

The AGC-80/40 Front End

Radio signals present at the BNC jack (see Front End schematic, below) are brought into the receiver front end across a 1Kohm resistor whose job is simply to dissipate any static charges, that might be present on the antenna, to ground. Since the impedance looking into the front end of the receiver is 50 ohms, this 1K is "invisible" to the normal functioning of the circuit.

The front-end "Pre-selector" is a simple series L-C circuit consisting of L1, an Amidon T50-2 red-gray toroid core wound with 40 turns of #28 enamelled copper "magnet" wire (sold by Radio Shack) and having an inductance of about 7.4 micro-Henries, and a 68pF silver mica capacitor, for the 40 meter band [7.0 - 7.3 MHz]. *[This is a revision; the first release of this* *receiver on 7/14/08 had a 3-winding antenna transformer, but I found that going back to the same series L-C that I used in the original AGC-80, worked better in this receiver too.]*



When the band switch is flipped from 40m to 80m, another 220 pF of capacitance is connected in parallel with the 68 pF cap, increasing the total capacitance to 288 pF and lowering the circuit's resonant frequency to the 80 meter band [3.5 - 4.0 MHz]. This is a very simple preselect and band switching arrangement that works best with a 50 ohm antenna. I use a 'resonant' antenna tuner to accomplish impedance matching and to get some extra "preselect" band pass filtering via the tuner.

Originally, I was going to have a tuneable "preselector" up front, like the one on my old Drake 2B commercial receiver -- but I wanted to stay true to my goal of having NO variable capacitors anywhere in the radio. So I went with the switched-capacitor method which required the use of a DPDT band switch -- remember that I also have to switch the coils in the Regen detector simultaneously. This decision caused another problem: bleed through of signal into the detector stage, bypassing the AGC controlled RF Amp stage, which, among other things, caused unacceptable pulling/chirping as the AC bias voltage bounced around, which was defeating the whole purpose of having an AGC in the first place! So I had to put some thought (and a fair amount of hair-pulling) into physical layout and shielding of the front end, Regen detector, and band switch, before the receiver would work properly.

For the front end and in the Regen detector stage, I avoided ceramic capacitors -- way too much temperature-related drift, and I have no NPO ceramics -- so I opted for silver mica caps. This helped stabilize things and the addition of a 6.8 volt Zener diode as the Regen stage's supply helped even more. *Most* of the drift is gone, although there is still a tiny bit still lurking in there.

Once the 80 or 40 meter band has been (pre)selected at the input L-C tuned circuit by the band switch, the signal is now automatically blocked for DC by the capacitor(s) in that series tuned circuit; after that it's terminated by a 51 ohm resistor. [I have a sort of "fetish" for making sure a 50 ohm antenna is really terminated in a 50 ohm load, which I presume helps in rejecting out-of-band AM bleed through. (47 ohms through 68 ohms work fine, by the way.) This may reduce the apparent sensitivity of my design, but the RF amp stage that follows has gain built into it. The price I pay is increased receiver noise, which can be heard without any antenna connected; however, much of the noise in my receiver is probably due to the op amp used in the audio/AGC section. I am willing to live with it.]

What this boils down to is that the receiver, like your transmitter, works best when the antenna is tuned to resonance (or when an antenna tuner or "ATU" is used to tune it electrically to resonance) and looks like a 50 ohm RF source to the receiver. I presently use a horizontal loop antenna, cut for 80 meters, and fed into the shack with cheap 300 ohm TV twin lead that I got on sale from Radio Shack. So I know that my receiver is seeing something other than 50 ohms +j 0 ohms of impedance at its antenna jack. I use a resonant ATU to match my antenna system to my transmitter on 80 and 40; the AGC-80/40 works best when fed through a resonant ATU which matches the impedance of the antenna to that of the receiver, but also provides extra band pass filtering to further suppress strong out-of-band signals from overloading the receiver. (If your ATU is the more common PI-type or T-type filter, you won't get the extra band pass filtering between antenna and receiver, but at least the impedance match will be correct.)

Getting back to the circuit description, the bottom of the 51 ohm base resistor is RF-grounded through a .01 uF capacitor, while at the same time riding at about 600 milli-volts DC [the AGC voltage] which biases the base of transistor Q1. Notice that there is no other resistor on Q1's base to act as a 'pull-up'; this is a departure from the AGC-80 receiver which used a 680K ohm resistor from base to +Vcc, which played "tug-of-war" with the 51 ohm resistor below it to set the gain of the transistor. The new design uses the AGC voltage, entirely, to bias Q1. The AGC voltage at the bottom of the 51 ohm resistor (see TP1 in the schematic) varies up and down with the amplitude of the signal and static coming into the receiver; with the antenna disconnected and the Regen control popped out of oscillation, TP1 will settle out at around 700 to 750 mV. When moderately-strong SSB Ham signals are being listened to, the AGC voltage may fluctuate on voice peaks from approximately 600 to 400 mV. When a very loud SSB signal is tuned in, the AGC may lower itself to about 200 mV. Very strong broadcast stations may send the AGC voltage *negative,* which is actually cutting off Q1-- signals are evidently bleeding through in spite of Q1 hiding its head in the sand. [I found during the R & D stage that I could *short-circuit* the leads of the antenna to the copper ground plane on which the receiver circuitry was soldered-- and still have a strong signal coming in. I think a lot depends on shielding and layout, plus the use of a metal case.]

Q1 is configured as a common emitter amplifier having a 1K emitter bias resistor, bypassed for RF, and a 10K collector load resistor. This arrangement deliberately gives "too much" gain, and the output level of the stage would ordinarily overload the Regenerative Detector stage (Q2) severely-- but this Q1 stage is controlled by the AGC bias voltage in a negative feedback loop, such that the base voltage is pulled lower whenever the level of the input signal increases. Conversely, the AGC bias goes more positive when the input signal is weaker, raising the front-end gain. The overall effect is to counteract strong SSB and CW signals that would ordinarily distort and "block" the Regen stage. (The AGC action also helps to make static crashes more tolerable; strong AM carriers of foreign broadcast stations on 40 meters, unfortunately, still clobber this simple receiver-- they're just not quite as ear-splitting as they would be with no AGC at all.)

As mentioned above, I have not been able to solve the AM-blanketing problem entirely... the problem being that, on 40 meters, the monster shortwave stations are *within* the band, not outside of it where the preselector and antenna tuner could help filter them out. They're not too noticeable *when the detector is oscillating in the SSB/CW mode,* unless the amateur radio signal you're listening to happens to be too close to a loud broadcaster's squealing carrier. But when you back off the regeneration and pop the detector out of oscillation, for AM-mode listening, suddenly the loud SW broadcasters are audible over much of the dial. [This problem with loud foreign broadcasts on 40 meters is as old as dirt, and is a late-afternoon through evening prime-time phenomenon; the band belongs to the Hams during the day, while 80 meters goes dead during daylight and revives at night.]

If you're a shortwave listener with the receiver on 40 meters, setting the Regen control near the threshold of oscillation enables you to tune each loud AM broadcast station individually, with sharp selectivity just before the point of oscillation with its carrier-squeals; backing the control off makes them all kind of blend into one big mush of Arabic, Japanese, and American Gospel broadcasting. As I write this in July 2008, Christian gospel programming of "Family Radio" with Harold Camping sometimes makes it difficult to copy CW in the lower portion of 40 meters at night. (The gospel station is at 6.8 or 6.9-something MHz, and is strong enough to cause interference in the 40 meter band when the signal peaks, with this little radio.)

When the detector is in oscillation, the carrier squeals from the AM broadcasters can be very loud (beware!); the AGC voltage at TP1 shoots down hundreds of milli-volts negative, yet the AGC is unable to squash them down as far as I'd like. Oh well, at least the AGC does what I wanted it to do with 80 and 40 meter *Ham* signals, which was to attenuate them enough to prevent blocking and distorting the Regen stage.

With all the extra gain built in, we can afford to couple to the Regen stage quite lightly-- notice the small-value 10 pF cap and the series resistor of 10K ohms. This combination was found to work decently without "pulling" the detector excessively.

The AGC-80/40 – Page 5

The Regenerative Detector Stage

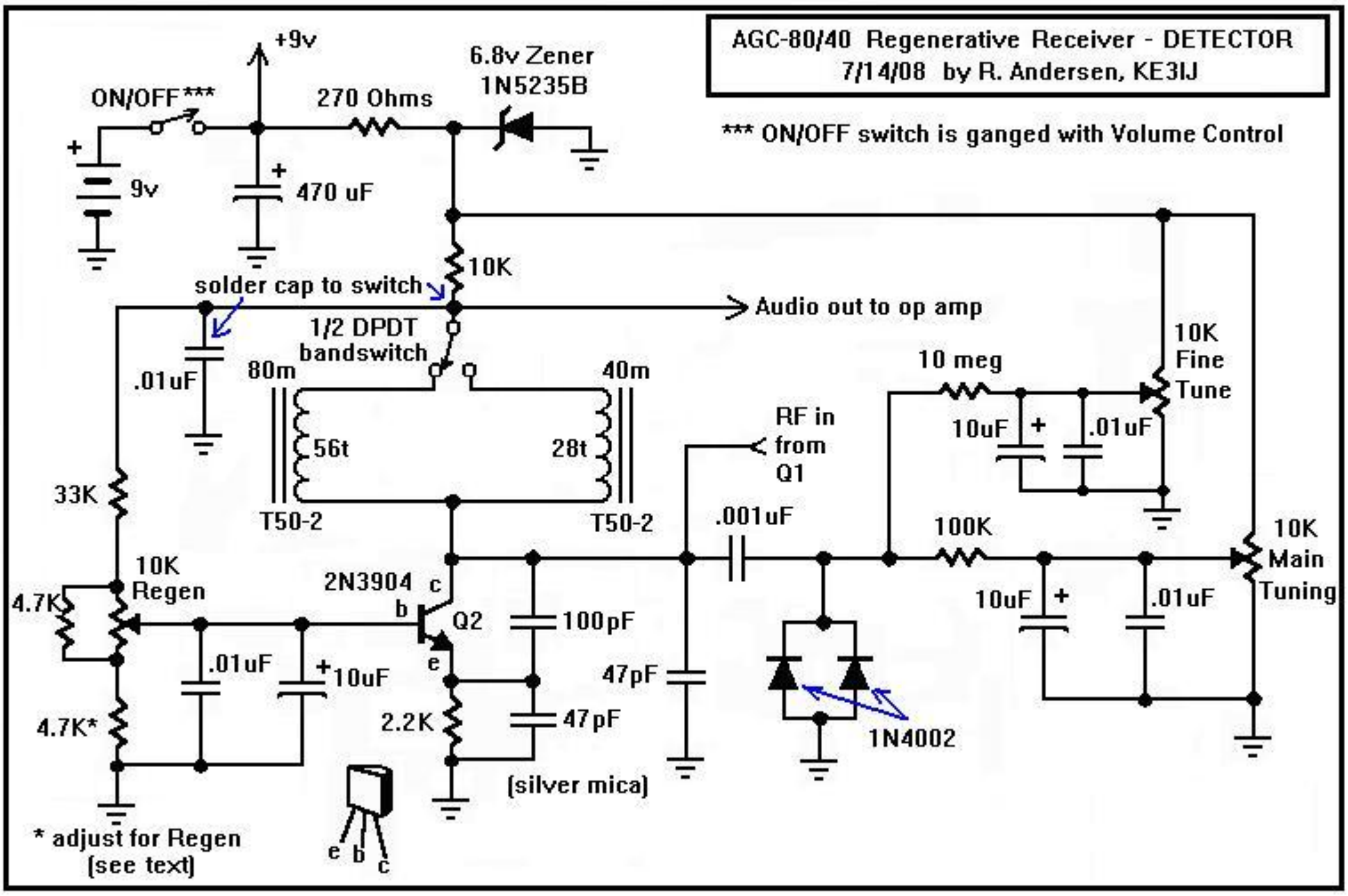
As I've indicated in several other of my project articles at this website, I favor the Colpitts over the Armstrong-type of regenerative detector. The design I use here is basically a common-base Colpitts oscillator whose base bias is varied by a potentiometer on the front panel, called the "Regen" control. Tuning is accomplished by another front-panel pot, the "Main Tuning" control, which varies the amount of reverse bias voltage on two paralleled 1N4002 rectifier diodes, which I use instead of a 'real' varactor diode. With the parts values given in the schematic, my prototype AGC-80/40 tunes approximately 3.45 - 3.85 MHz in the 80 meter band, and about 6.8 - 7.6 MHz in the 40 meter band. This is a wider range than that of the old AGC-80; the AGC-80 tuned over a 150 KHz range vs. about 400 KHz for the AGC-80/40 on 80 meters. On 40 meters the new receiver tunes quite a bit more than the 7.0-7.3 MHz of the 40 meter Ham band. I suspect this is due to the changes I made to the capacitive voltage divider across Q2, as well as to changing from a 1N4001 to 1N4002 diode. I left things this way because I wanted to make sure, with my simple method of band switching, that there was extra "slop" space for component tolerances, etc., and that I wouldn't find that part of 40 meters would be "cut off" because of too-tight a tolerance requirement.

All of this makes the new receiver a bit harder to tune-- it's "touchy" and the tuning rate is a little too "fast." To compensate, I've included another 'tuning' knob on the front panel, called "Fine Tuning", which acts as a "clarifier" [borrowing some CB lingo here] for single-sideband signals so that the voices don't sound like Donald Duck or saxophone grunts, and so you can tune the pitch of a CW signal so that it peaks in the middle of the CW audio filter passband. So you tune in to a signal as best you can with the Main Tuning knob, then "clarify" it with the Fine Tuning knob. [Note that the Regen control also affects the apparent pitch of the CW or SSB signal; normally the Regen control is set so that the detector is just past the point where oscillation begins, for maximum sensitivity. If the incoming signal is very strong, and even the AGC is having a hard time taming it, you can advance the Regen control farther into the oscillation region, which in effect increases the "VFO injection level" so that it adequately "covers" the signal. But beware: Advancing deeper into the oscillating region also detunes the receiver and messes up any calibration marks you may have tried to put on it. So all three controls actually affect the tuning, even though this is not really desirable.

Now to the detector circuit itself:

Q2, another 2N3904 NPN silicon transistor, is configured as a Colpitts oscillator with a 100 pF and 47 pF capacitive voltage divider connected across the collector and emitter, respectively. Paralleled with these capacitors is a 47 pF from collector to ground. All three caps are Silver Mica.

Notice that there is no variable capacitor used in this circuit-- not even a pc board trimmer cap which the AGC-80 used as a "band-set" capacitor. The only "variable capacitance" in the circuit is that provided by the paralleled 1N4002 diodes, which are made to vary several 10s of pF by varying the reverse bias applied to them via the wiper of the 10K ohm Main Tuning pot. A 100K resistor isolates the RF on the tuning diodes from the electrolytic cap across the pot wiper to ground; the 100K also limits the range of the diodes' capacitance swing. A 10 uF electrolytic cap bypasses RF and AF noise to ground at the pot wiper (scratchy pot noise modulates the oscillating detector and can be annoying if not suppressed); the .01 uF cap in parallel is there to guarantee that any RF present at the pot wiper is shunted to ground if the electrolytic doesn't catch it [electrolytics don't always work well at RF].



A second pot, also 10K in value, connects to the tuning diodes, but through a 10 *Meg*ohm resistor rather than 100 *Kil*ohms-- this is the Fine Tuning (Clarifier) pot. The 10M resistor guarantees that the full-range of the pot (varying its wiper voltage from 0v ground to 6.8Volt Zener) will only very slightly change the capacitance of the diodes; this is how we get fine-tuning. Normally the Fine Tuning knob will be left in the middle of its range, and then varied + or - from that point to get the best-sounding voice quality on the SSB signal coming through.

The inductance in this Colpitts detector is different for each band: Two Amidon T50-2 toroids wound with #28 enamelled copper 'magnet' wire, which are connected to the collector of Q2, but switched by the 2nd half of the DPDT band switch at their other ends. The 80 meter band toroid has 56 turns of wire, and the 40 meter coil has 28 turns. The "cold" end of each coil connects to a position on the band switch, and there is a .01uF bypass cap to ground at the middle terminal so that the selected band's coil (the "cold" end) gets bypassed for RF right at the band switch. This bypassing was found to be necessary to help squash "crosstalk" between the front-end antenna switching (on the other pole of the switch) and the

Regen detector stage. [I may revise some details of the circuit, as I'm not 100% convinced that the problem has been solved entirely.]

Regeneration is accomplished by varying the bias on Q2's base, which is grounded for RF and audio via a .01uF ceramic and 10uF electrolytic cap. The resistor above, below, and across the Regen pot are "scaling" resistors which spread the regeneration control out like a band spread control does for tuning; i.e., we want some smoothness of transition from AM to Sideband (oscillating) mode-- not an extremely abrupt transition.

The 4.7K resistor between the bottom of the Regen pot and ground is a "TBD" value [to-be-determined], which means that it should be varied or "calibrated" to suit your particular radio. Specifically, if you find that the receiver never breaks into oscillation *anywhere* over the range of the Regen control, -OR- if the receiver cannot be made to *drop out* of oscillation for AM-mode listening, then that 4.7K resistor needs to be changed to something else. In the original AGC-80 I found that I needed a 3.9K resistor for my Regen pot to work correctly. You may need a different value.

I thought about making that resistor a trim pot, but decided I could live without it.

I had some trouble with drift when the AGC-80/40 was in the "spider-web connection" stage early in its development, on my workbench. Heating the capacitors in the Colpitts circuit by soldering nearby caused a very noticeable frequency drift, as did blowing cool air on them. They were ceramic caps, non-NPO types, so I bought silver-mica types and substituted those in the capacitive voltage divider circuit around Q2.

Also, you will notice that the entire Regen detector is powered, not by the 9v battery directly (as are the Front End and the Audio/AGC circuits), but by a separate line regulated by a 6.8 volt Zener diode (1/2 W, part number 1N5235B). The 9v battery voltage is dropped across a 270 ohm current-limiting resistor and then shunted by the Zener diode. This also counteracted the drift. It doesn't eliminate all of it, but most of it. There remains some drifting, which is more noticeable on 40 meters than on 80.

The battery supply is bypassed after the ON/OFF switch (which is ganged to the Volume control, discussed later) by a 470 uF electrolytic cap, which supplies 9v directly to the Q1 and op amp circuits, whereas the Regen detector stage (Q2) is powered by the Zener regulator -- two separate power paths.

Notice also that there is a 10K resistor above the coils and band switch. The bottom of that resistor is the tie-point for the cold end of the coils and the upper end of the 33K Regen padding resistor. The same point is where the audio is "picked off" the detector and sent along to the audio preamp stage, which in this radio is taken care of by a TL074 quad op amp-- a radical re-design of the AGC-80 which had a two-transistor audio amp here. The RF present in the coils is filtered out (bypassed to ground) by .01 uF ceramic caps; this is why the top of each toroid coil in the schematic is referred to as the "cold" end of the coil. Only the detected audio remains and develops a voltage across the 10K resistor, which AF voltage is sent on to the audio amplifier.

The Audio Amplifier and Filter

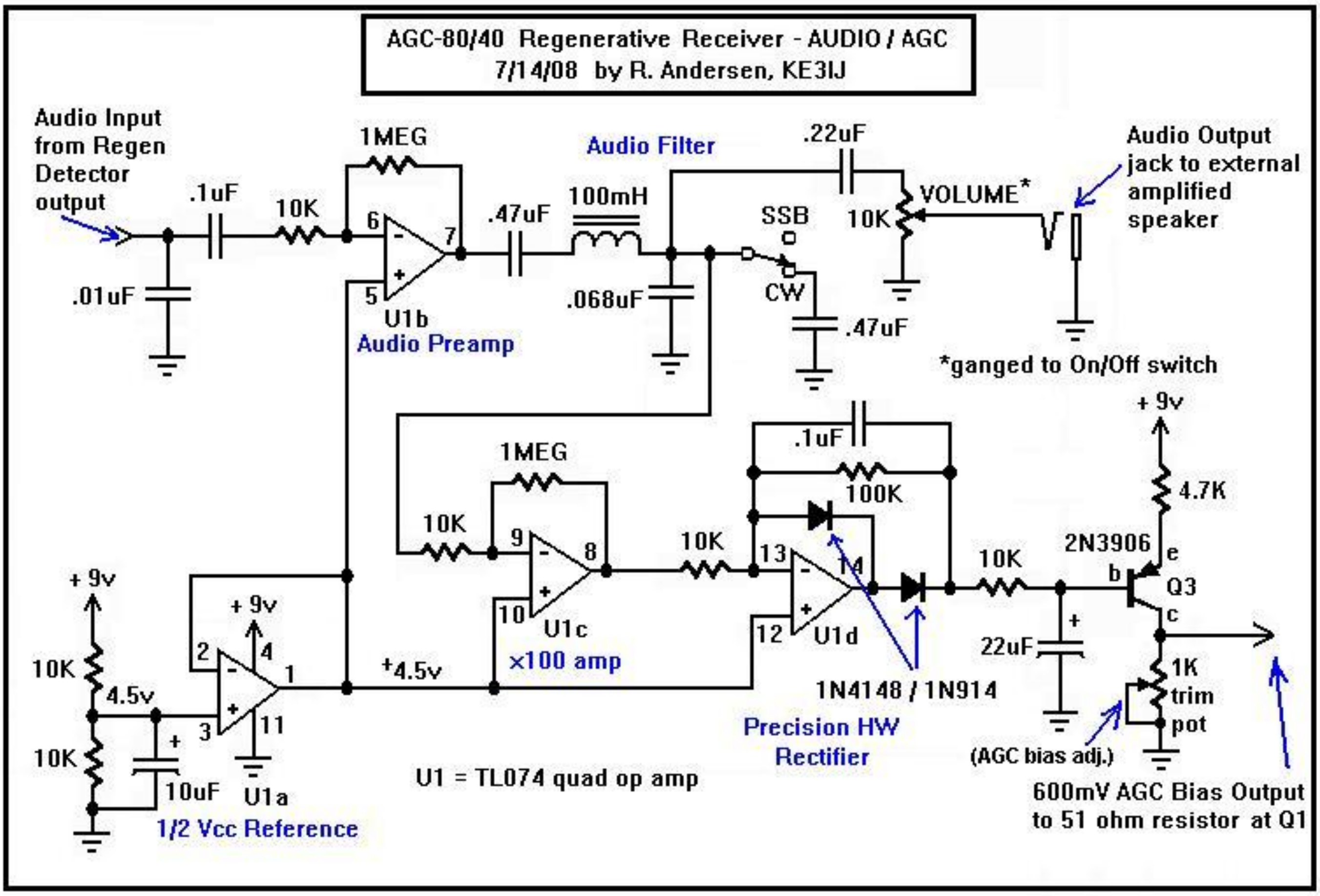
Although my original prototype had discrete transistors for the audio preamplifiers (one stage for audio to be sent out to an external Amplified Speaker, and another stage following the first to boost the audio amplitude to a high level, for driving the AGC charge pump), I saw that the circuitry was beginning to grow too large, and I wanted to redesign the AGC circuit... For whatever reason, the AGC arrangement that worked adequately in the original AGC-80, suddenly didn't seem to be working in this radio. Part of the problem turned out to be the cross-talk from the front end to the detector, that I mentioned earlier. But I wanted something a little more elegant, yet simpler real-estate-wise. So I broke down and entered the 1970's, and decided to consolidate all the audio & AGC circuitry into a quad operational Amplifer (op-amp, for short). I chose the TL074 because I thought it was less noisy than the quad 741 "bread-n-butter' op amp [it wasn't *that* much less noisy!].

The TL074 op amp is "tricked" into running with a single 9 volt supply, by biasing the input of the first stage (pin 3) up to 1/2 of the 9v supply, via a voltage divider consisting of two 10K resistors strapped from +9 to ground. A 10uF electrolytic bypasses noise at op amp pin 3. Pins 2 and 1 are connected together, making this a unity-gain buffer with a DC voltage of 4.5v at its output. This 1/2 Vcc feeds the reference (+ input) of each of the other three op amp stages, eliminating the need for dual + and - 9v batteries.

The audio from the Regen Detector enters pin 6 of the op amp through a .1uF coupling cap, a .01uF bypass to ground to filter out any residual RF, and a 10K input resistor. With a 1 Megohm feedback resistor across pins 6 and 7, we have a voltage gain of 100 in this stage--enough to send to the external Amplified Speaker as our audio output. But first we add some passive filtering:

A .47 uF cap rolls off the lowest audio frequencies, and then we roll off the highs with a low pass filter, consisting of a 100 milli-Henry choke inductor in series with a shunt capacitor to ground, with a value of .068 uF. This combination gives an upper cut off or "corner" frequency of about 2500 Hz, with a slight resonant peak, which helps filter out high-frequency noise and accentuates the intelligibility of SSB speech signals. [As any Ham knows, we're not after "high-fidelity, broadcast quality" in communications receivers; our goal is to be able to copy the other guy as well as possible given all the other interference that occurs in the bands, static crashes, etc.]

Flipping the Filter switch to "CW" connects another .47 uF to ground in parallel with the .068 uF cap; this lowers the filter's cut off frequency to about 800-900 Hz, with enough of a resonant peak to give the signals and noise a bit of that "seashell-at-your-ear" band pass sound. This helps separate Morse Code (CW, Continuous Wave) signals and moving the Fine Tuning knob shifts the pitch of the CW tones; when you get one centred at the resonant peak of the filter, it gets accentuated while the others, off-frequency, are attenuated; i.e., you get audio selectivity. (You also get a reduction of background noise in the CW position.)



You may ask why I didn't take advantage of the op amp by making an *active* filter, rather than a *passive* one with an inductor. The answer is that I would need more than one op amp stage to make a decent filter, and I needed at least 3 of the available 4 for audio pre-amplification and AGC; the 4th stage, which I use to generate a low-impedance reference at 4.5v [1/2 Vcc], could have been done with a transistor emitter follower. But, again, that would have freed up only one stage for me to use as a filter. I definitely did not want to add *another* op amp IC since my goal was to keep the circuit simple and compact. Maybe the next revision of the receiver will have an active filter based around a quad op amp. I would like to try a "State-Variable" filter next time, which has all four types of filter output (high pass, low pass, band pass, and notch) and requires all 4 stages of a quad op amp, another IC, which I didn't want to add at this time.

At this point the audio is ready to be delivered to the outside world. Although I could have (and, arguably, *should* have) added an internal LM386 audio power amp and speaker, I opted for what has become my "easy way out" and ran the audio to an output jack at the bottom of the front panel, for either headphones or for connection to my trusty Radio Shack Amplified Speaker. Perhaps if I end up making this project into a kit, I will add the audio amp and speaker so as to make a self-contained dual band radio. But for this prototype, I use an external amplifier. (No pesky motor boating or squealing to deal with.) The signal leaving the audio filter, described above, gets DC-blocked by a 0.22 uF capacitor (there's 1/2 Vcc from the op amp riding on the components of the audio filter and we need to block it so the signal at the output jack is pure AC with no DC component). And last but not least, I provide a 10K potentiometer as a Volume control [yeah, I know the Amplified Speaker already has a volume control, but what if you want to use headphones instead? There has to be some way of controlling the volume].

The Automatic Gain Control Circuitry

Finally we get to the part of the circuit that gives the *AGC*-80/40 its name.
The idea behind the original AGC-80 was to spruce up a simple Colpitts-based Regen into one with an automatic gain control circuit which would prevent pulling and blocking of the oscillating detector when strong Ham signals were being received. It was the marriage of a throw-back circuit of the 1930s [the Regen itself] with an add-on usually associated with the standardization of the Superheterodyne circuit which became popular in the 1940's and thereafter-- the AGC.

In the usual Superhet, a small-signal diode is used as an AM detector after 2 or 3 stages of "Intermediate Frequency" amplification. The 455 KHz I.F. signal is demodulated by the diode, filtered down to audio with a small value capacitor, and sent to the volume control and from there to the audio amp. At the same time, a portion of that detected signal off the diode is sent down another path, to an RC lowpass filter with a time constant of maybe 100 mS or so, where the rectified signal now averages out as a slowly-varying DC voltage-- the variations are proportional to the strength of the incoming carrier signal. The diode in the AM detector is deliberately oriented with its anode toward the AGC and volume control pot; this gives a *negative* rectified output, which means that the slowly-varying DC voltage (now referred to as the AGC bias) goes *more negative* whenever the incoming signal grows stronger, and vice versa. Thus we have established a "negative feedback loop" when we connect that negative-going AGC bias to the bottom of the lower base resistor in the first I.F. amp's transistor circuit. Strong signals "pull down" the base bias, lowering the gain of the first I.F. stage; weak signals allow it to be pulled back up by the upper base resistor, raising the gain of the stage via a "tug-of-war" between the influences of the two base resistors. This is the "tug-of-war" I was referring to in the AGC-80 article.

What I have done is to take, not the *I.F.* signal (since there *is* none in a simple Regenerative receiver!) but the *A.F.* (i.e., the audio) signal, rectify it and smooth it into a slowly-varying negative-loop ["degenerative"] AGC bias, and apply that bias to the RF amp [Q1] right up at the front end of the receiver. This requires that there be "too much" gain designed into the front end, and "too much" audio gain at the back end, to provide a large-enough AC signal to be rectified and filtered down into a useable AGC bias... the "too much" being a part of the negative feedback arrangement. Those of you who understand that a typical op amp IC has an open-loop gain of about 200,000, which is rarely used open loop but which is strapped down to a lower value by the ratio of feedback resistor to input resistor in an inverting amplifier, will appreciate what I am trying to say. All of this requires more audio amplification than that first stage (op amp pins 6, 5 and 7), so we add a 2nd stage (pins 9, 10 and 8) of audio gain; this stage also magnifies the signal amplitude by a factor of 100, giving a total of 100 x 100 or 10,000 [minus the loss due to filtering] -- too much for the outside user but just right for the internal AGC circuit. The reason the audio filter is included within the AGC loop is so that the AGC will work on the signals that are actually audible, and not on some strong signal a few KHz away which could cause the AGC to kick in and desensitize the receiver while we are trying to hear a weak signal.

Now the amplitude of the audio is large enough to be rectified, filtered, and converted into a varying DC which we will use to control Q1 at the front end.

The last section of the TL074 quad op amp, consisting of pins 13, 12, and 14, is configured as a **Precision Half-wave Rectifier** [which, by the way, has a gain of 10, giving a total of 100,000 before filter losses]. With this particular arrangement of diodes and feedback resistor, the op amp stage acts like a diode that has no ".7v speed-bump" that has to be breached before the rectifier will rectify. In other words, it chops the AC input signal in half precisely at 0 volts-- or, in our case with a single power supply, precisely at the 1/2 Vcc reference voltage present at the non-inverting pin 12 (as an ideal diode should).

At the output of the circuit is a rectified version of the audio signal, with its negative half clipped off; this is used to charge a 22 uF [formerly 2.2 uF]electrolytic cap through a 10K ohm resistor, giving a charge/discharge time constant of T=RxC or about 220 [formerly 22] milliseconds. This voltage now biases an "upside-down" PNP transistor, Q3, a 2N3906; this is because we need to do a polarity inversion and level shifting to make Q1 happy. Since the AGC-able (I just made that word up!) region of Q1 occurs when it sees approx. 600 mV at its base, Q3 provides that baseline. Q3's collector output voltage (now called the **AGC bias**) also moves *oppositely* to that of the op amp Precision Rectifier, so that as the input audio gets louder, the op amp Precision Rectifier's output goes more positive, while Q3's output goes more negative, pulling down on the base voltage at Q1, thereby lowering the stage gain. This is the **negative** (degenerative) **feedback** that we need to accomplish our purpose. Now *most* strong signals are unable to "pull" or block the Regen detector.

*[**8/9/08 Update:** Originally I had a 47K emitter resistor and 10K collector output resistor at Q3; I scaled them down by a factor of 10 (4.7K and 1K) and I also decided that it was necessary to change the 1K collector resistor from a fixed resistor to a 1K pc board trim potentiometer; this is the AGC bias adjust, which should be set so that there is an optimum compromise between AGC action (you can hear the background noise pulsate up and down in-between pauses in the signal) and a tendency for the Regen detector to be "pulled" or "chirped" by strong signals. For some reason it seemed that every time I got the values right for the AGC circuit, while developing the circuit on the lab bench, I would later find that strong signals were causing excessive chirping--- exactly what the AGC was supposed to cure. But this chirp seemed to be caused, not by the input signal overloading the detector, but by the sudden shifts in AGC bias which is supposed to counteract changes in signal strength. Adding the 1K pot allows you to fine-tune the AGC bias that's applied to Q1's base at the front end.]*

One other idea that occurs to me is to tap off of the oscillating Regen detector with a transistor buffer, so as not to load it down and pull the frequency out of calibration, then route the buffered output to a front- or rear-panel jack that would enable me to plug the receiver into a Frequency Counter-- giving an accurate digital readout to compensate for the obvious shortcomings of an analog pot dial. Again, for another day.

I hope you will try your hand at building my AGC-80/40 receiver and will let me know if you think this thing merits "kit status." Write me at rick@ke3ij.com

Ricks web site: http://ke3ij.com/radios.htm

The original of this article: http://www.ke3ij.com/AGC8040.htm