Micor squelch and tone decode discussion **supplement**
by Karl Shoemaker

Introduction

This document covers the details of the Micor (mobile & station versions) squelch and tone (PL) stock operation (not SRG flat audio modifications). A portion covers the Spectra-TAC receiver version. However, some discussion will reference SRG's operations and some challenges. It also touches on the subject of frequency coordination and people issues involving tone operation and interference. It's intended to be read from a 3-binder. If you are reading this on line (pdf file) you may have to rotate your view on some of the drawings.

Some History:

"PL" is a Motorola trademark meaning "private line" which has nothing to do with operational status of a system, being open or closed. PL does not mean "please leave". The private line name came about possibly to make commercial customers think they had a private channel and could not hear anyone else on "their" channel. In reality, F.C.C. requirement to monitor the channel before transmitting sometimes didn't work out very well. Motorola had DPL as well, for digital PL. For this discussion we will stay with tone PL. Other manufactures have the equivalent such as "Channel Guard" (GE) and "Quiet Channel" (RCA). The universal acronym is CTCSS, which stands for Continuous Tone Coded Squelch System. For amateur systems that "PL" slang became another name for CTCSS so we'll use it in this document.

Tone operation:

The user's station transmits their carrier along with a continuous sub-audible sinusoidal, single tone about 18 db lower than voice in order to activate the system's input. The tone frequencies usually are around from 32 to 200 Hz. Most current radios have this feature, while older ones can be upgraded. Lower frequencies are less distracting however, with slight reduced response time, which can cut off the first word of a user's transmission. With some user discipline, any tone frequency will work.

The Micor squelch: (Introduction)

When a user signal stops transmitting there is a time period where a laud burst of noise is heard during squelch closure. This typically less than a ¼ second for conventional receivers in the industry however, is still annoying to hear. The motorola micor radio receiver has a special squelch. It operates in two time constant modes, long and short. From threshold setting to around 20 dbq (db quieting) or less, the circuit is in the long mode. Anything quieter than that the circuit is in the short mode. This is the best-world compromise between practical range of a system and user friendliness. The idea is a weak, noisy, moving mobile will still be heard in the long mode therefore, the long burst is tolerable. For strong, quiet signals the short mode provides a nice, (click) sound for squelch closure.

"OR" verses "AND"squelch:

Commercial systems normally use PL "OR" squelch in the base station. A valid tone decoded from the mobile would "disable" the squelch (setting) as long as it continued therefore, bypassing whatever sensitivity the carrier squelch was set. The idea was to extend the system's usable range, in the case of the weak mobile in and out of the station's receiver, rapidly, such as picket fencing through the mountains, or with multi-path, etc. The station dispatcher still could to hear the mobile even if it's under difficult or annoying, noisy conditions.

Amateur systems normally are on carrier squelch therefore, are affected by the squelch setting. For PL (tone) "AND" squelch requires carrier + tone decode to open. If either goes away will cause the squelch to close. Others would call an AND squelch a variable sensitivity (adjustable) squelch.

Reverse burst:

The Micor PL decoder is based on a mechanical reed, which vibrates (resonant) when a valid PL tone is received in the base station. The tone needs to be in the narrow range of this reed to resonate. It also has some "fly wheel" effect; which means it will continue to vibrate and send a "valid" decode output, a few tenths of a second after the mobile stopped transmitting. The PL deck's output is a relaxed (off) transistor output during standby (no decode). During a valid (on frequency) PL decode it goes to a "forced" high state. This goes to pin 8 of the squelch IC; thus, disabling the squelch setting.

For amateur use there is a (bad) side effect with this arrangement. Even under good signal conditions, every time the mobile would "un-key" and ending a transmission, the PL reed in the receiver would be still vibrating for a little while afterwards, which would cause an annoying long burst of noise in the dispatchers ear. To null this side effect, "reverse burst" is used.

When the commercial mobile user (subscriber) un-keys the mic, there's about a 1/4 second period where the mobile RF carrier continues to provide a signal to the base station's receiver (provide a quite signal). During this short time the mobile's PL encoder sends out a 240° phase shift on the PL tone (180° for GE). This slam-stops the reed immediately, causing the base receiver's squelch to close quickly after the 1/4 second the mobile stops transmitting. The dispatcher hears only a very short burst or a click. Very nice !

Amateur mobiles do not use reverse burst. And even if they started it would be years before all did, causing some incompatibility for clean operation. To correct this problem the audio board is changed to an "AND" squelch. Therefore, when the user's signal is gone the (carrier) squelch sets the sensitivity and point where it closes, thus creating a "normal" system squelch, with the exception of the long burst feature of the squelch IC during weak signal conditions. To change to "AND" remove the (stock) jumper between P201, pin 3 (PL output) and IC202, pin 8. The PLI output can still be used to signal outside equipment in either way, such as a repeater controller. The well-known dual-squelch still can be used in this case, too.

Radio Interference: (semi-non technical discussion) :

Setting the squelch allows control of the system's sensitivity however; tone squelch only activates on the one tone. This permits other signals not intended for that receiver to be "ignored". This is a good and bad thing. When properly designed into a system (such as SRG) the user can select which path/calling area the user wishes to get in to the System. The other (remote) receivers don't respond because they are on a different tone. This keeps duplicate receiver paths from canceling each other out. Being one system, it knows how to let only one path in, at a time.

However, for different organizations/repeaters, co-channel usage can be bad. Two points to consider:

1. If a repeater system is toned to "filter out" interference, the interference is still there. This does not make the system sensitive. When a user attempts to compete with the interference, the interference confuses the tone decoder at the receiver, so nothing works right.

2. Frequency coordinators sometimes duplicate coordination for a repeater system too close to another. Ignorance shows by coordinating different input tones for each system would be the solution. Sadly, the opposite is true. When one user is using a repeater that cannot be heard by the users of the second system, that second set of users are unaware of their repeater's input is heard by a "foreign" user tone. This can disable the second repeater access (input) and causes user confusion and frustration. Everyone looses. Technical education is the best way to correct this. People problems are beyond the scope of this documentation however, it's fair to say that tone access has to be properly thought out before using.

Cooperation with fellow amateurs is needed.

SRG design and history:

Early design used a (simple and cheap to build) a time domain voter (TDV) for the "Spokane" coverage area. Sometimes a fixed station would get "stuck" on a noisy receiver. One could set the squelch for any amount of quieting required to get into the receiver, so you can adjust the coverage. In other words, adjusting the squelch determines how noisy of a signal will be let through, or to reject it for system standards, such as keeping all (Spokane area) signals 20 db S/N or better, if not, that receiver is considered unusable, which works in a TDV voting system. For a single receiver, conventional system, without a voter this was not practical, since you would greatly reduce the system's input range therefore, you would set the squelch for the weakest, noisy signal you would allow in.

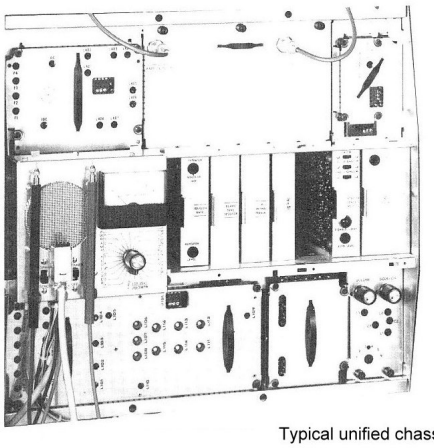
Even though this document is for a receiver of a single "area" coverage unit (no voting) standardization is important for SRG's design. RnD indicates that the "AND" squelch poses no problem for future system changes and improvements. In addition, the squelch sensitivity can be adjusted at any time to increase the users input range. Currently, the remote (out of Spokane) receiver's squelch's are set to break at 5-10 db of quieting. As long as it's tone protected as an "AND" squelch nothing should get through (weak interference) without the proper tone. With this setting, typical (usable) sensitivity is -120 dbm at the antenna port.

Micor mobile receiver:

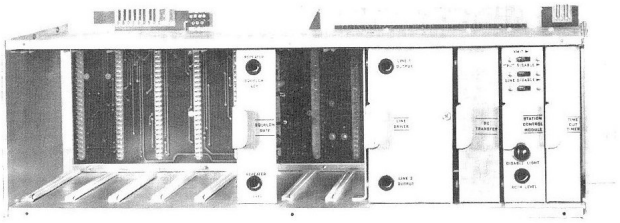
Refer to the diagrams on the next page. The pin-out assignments for the squelch IC are difference between the mobile and base stations. The receiver audio and squelch board for the mobile and some of the compa stations contain two integrated circuits. Both are labeled with the "IC" designator. For this discussion is IC202. The RUI (receiver unsquelch indicator) is on pin 10 and used for other purposes within the radio possibly for the busy light adapter. The short squelch (time constant) capacitor is designated as C229, is on pin 13 with a (stock) value of .22 uf, mylar or similar type. The long squelch capacitor is designated as C231; is on pin 12 with a (stock) value of 3.9 uf of the same type.

Micor base/repeater receiver:

To recap, the Micor (Compa) base stations came in two versions. The upper image shows unified chassis while the lower is the early, non-unified chassis. It's believed some of the interconnect pins of the chassis interconnect boards (AKA "back-plain) are different.



Typical unified chassis



Typical non-unified chassis

While SRG's remote receivers have used the latter (image below) for most of the sites, there are a few that use the unified chassis, such as the Yakima-20 station. It's believed that an organization would prefer the unified version because of advanced packaging, being that the control, receiver and transmitter modules (units) are all together in this one chassis. Therefore, this discussion will be based on the compa unified and the Spectra-TAC Chassis.

The receiver audio and squelch board contains two ICs. Two are labeled with the U designator while the third with the IC. For this discussion is U202. As shown in the middle image the RUI (receiver unsquelch indicator) is on pin 10 and is not used. Normally, pin 6 is used for the RUI.

The short squelch (time constant) capacitor is designated as C235, on pin 13 with a (stock) value of .22 uf, mylar or similar type. The long squelch capacitor is designated as C236 on pin 12 with a (stock) value of 3.9 uf electrolytic or tantalum type.

After 2005 a real (signal-to-noise) voter replaced the TDV to provide good switching for the Spokane coverage area. As time permitted the receivers squelch's were turned down to the SRG standard. The philosophy behind this to the fact it's better to get a noisy signal though the system instead of none. Obviously, the Spokane area voter will select the best (quietest) user signal so most signals will be good and quite. There's more about this on a separate document on SRG's web site.

Squelch constants:

A problem was discovered around 1999 on the Wenatchee-20 AP. While an Ellensburg mobile was talking, Spokane reception would hear occasional dropouts. This would occur when the (Ellensburg) mobile was around 35 db of quieting while a traveling higher speed; say, above 30 MPH, with muti-path, sometimes when a quick swish occurs. (which causes the "cos" to blank out just for a fraction of a second). For the local area coverage this was not a problem (Ellensburg to Ellensburg) however, with the additional (scanning) links the dropout time was increased.

Due to travel and weather conditions tests could not be done at the site of the affected receiver at the time of discovery of the problem. Therefore, a spare receiver was used in the lab to "duplicate" the condition. With the receiver under test, sitting on the bench a signal generator was connected to a piece of small coax, with a short (rubber duck) antenna terminated on the far end. With a medium signal to the receiver (not full quieting) the antenna was swirled around quickly, in a circular motion. While observing the carrier indicator pin 10 of U202 on an oscilloscope on a slow trace, the DC squelch gate was observed to intermittently change state only for a brief moment (fraction of a second); therefore, the swirling of the antenna somewhat simulated multi-path in the lab environment.

This is the case in the "Wenatchee receiver" with the TLN6006 series audio and squelch board (non-unified chassis compa station). It was concluded the best possible reason for the blanking at pin 10 was the receiver's squelch was in the short mode. To "slow" this circuit down slightly it was decided to increase the value on C229 on pin 13 from the .22 to 1 uf on the test receiver. Later, at the remote site the 1 uf cap was just tacked soldered on the PCB run, leaving the (stock) cap in place, so effectively, C229/C231 would now be a 1.22 uf cap.

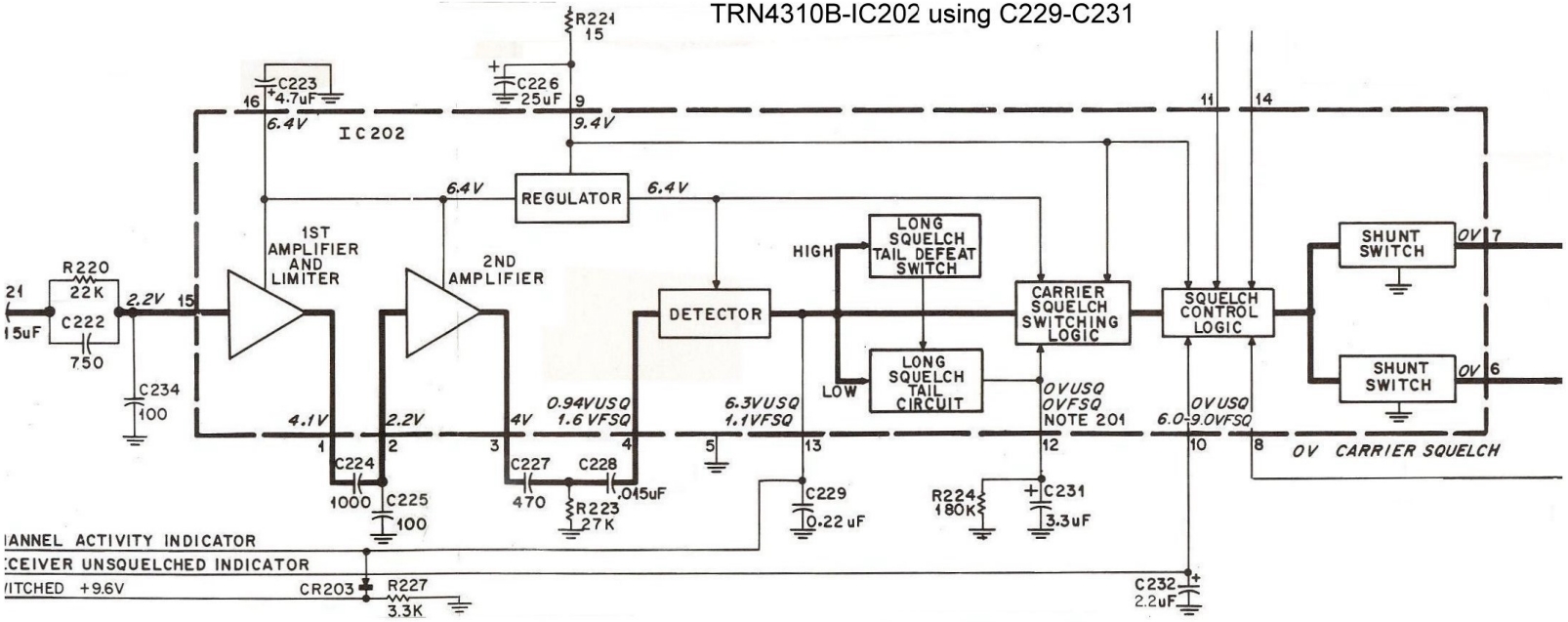
For the Spokane voter Spectra-Tac receivers the short burst capacitor, C11 should be between .68 uf and 1.0. For difficult areas (such as Colville) it can be increased to 2.2 uf. For Spokane short burst capacitor, C12 should be 2.2 uf to avoid "off-vote" noisy long burst to being heard. * *

This caused the "short burst" to be a little longer for stability, but still pleasant to listen to. Rather than a little "click", a larger, fatter "click" will be heard on squelch closure. The "long squelch burst" is still functional, which switches in when the signal is around 20 db quieting or less. Additional research after 2009 will plan to change (not add) the value of C229/C235/C11 (short constant cap) to 1.00 uf using a tantalum type capacitor. (in 2019 it's planned to use MLCC type caps instead.)

It was also observed that using a much lower value for the cor pull up causes the speaker audio to be lower. Reason was unknown at the time however, recent information in 2018 has evidence that the lower pull-up value is wrong. In addition, the shunt outputs are now believed to be a transistor emitter and not a collector as previously thought. Therefore, future pull-up value is planned to be 150K ohm. Current pull-ups (10K and other values) are also planned to be corrected to the new standard for SRG.

The drawings on the next pages show differences in regard to version of receiver relevant to this test and some of the IC's pins and functions. In 2018 all the Spokane remote receivers were replaced with the "Spectra-Tac" version. At that time the test will be performed again in the lab. Reason this is mentioned the audio and squelch functions are performed differently to the extent they are on a separate "card" on a control shelf of that type of chassis and arraignment. There is a separate document covering that version of receiver on SRG's web site.

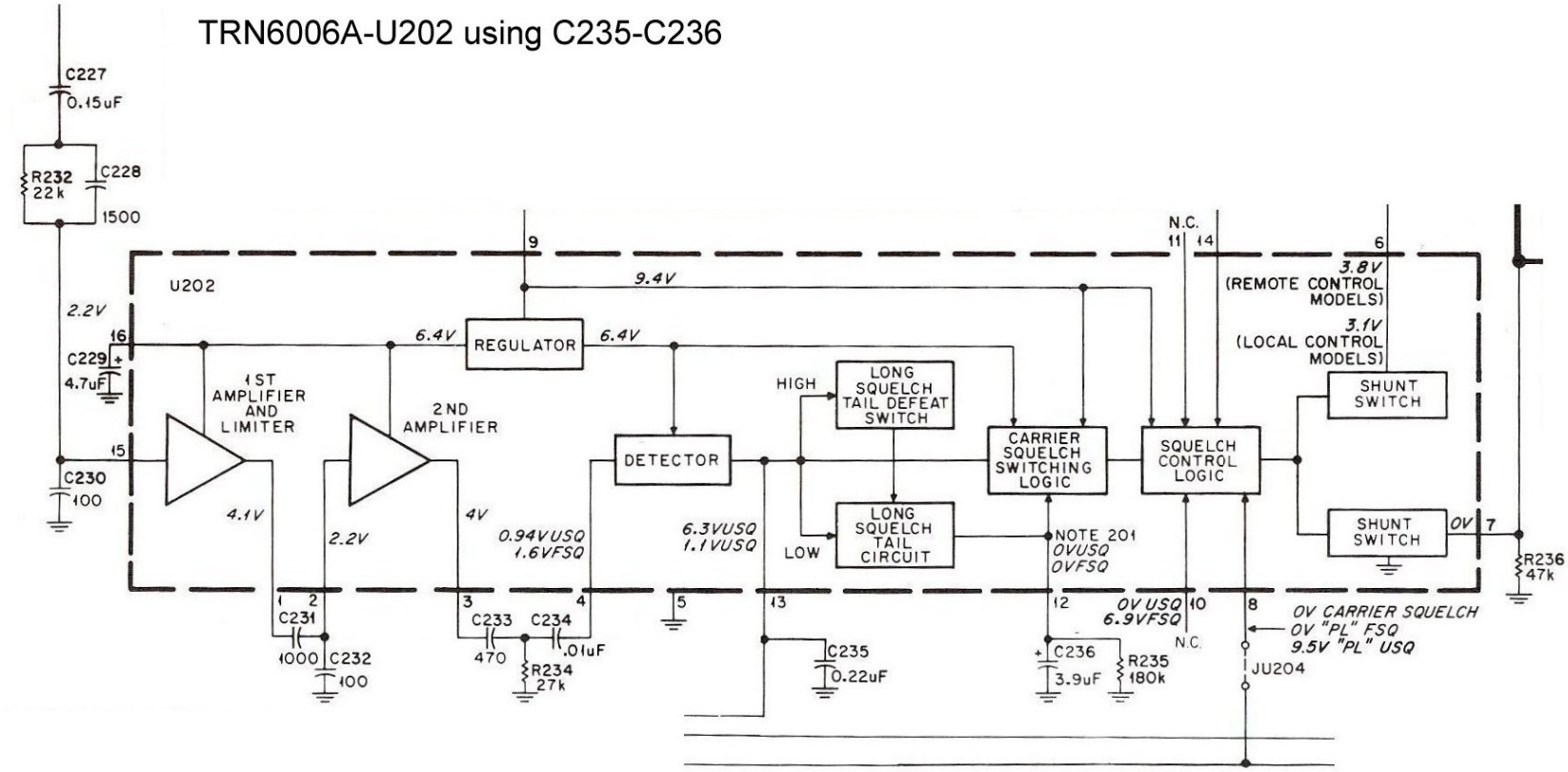
TRN4310B-IC202 using C229-C231



Short constant cap: C 229

Long constant cap: C 231

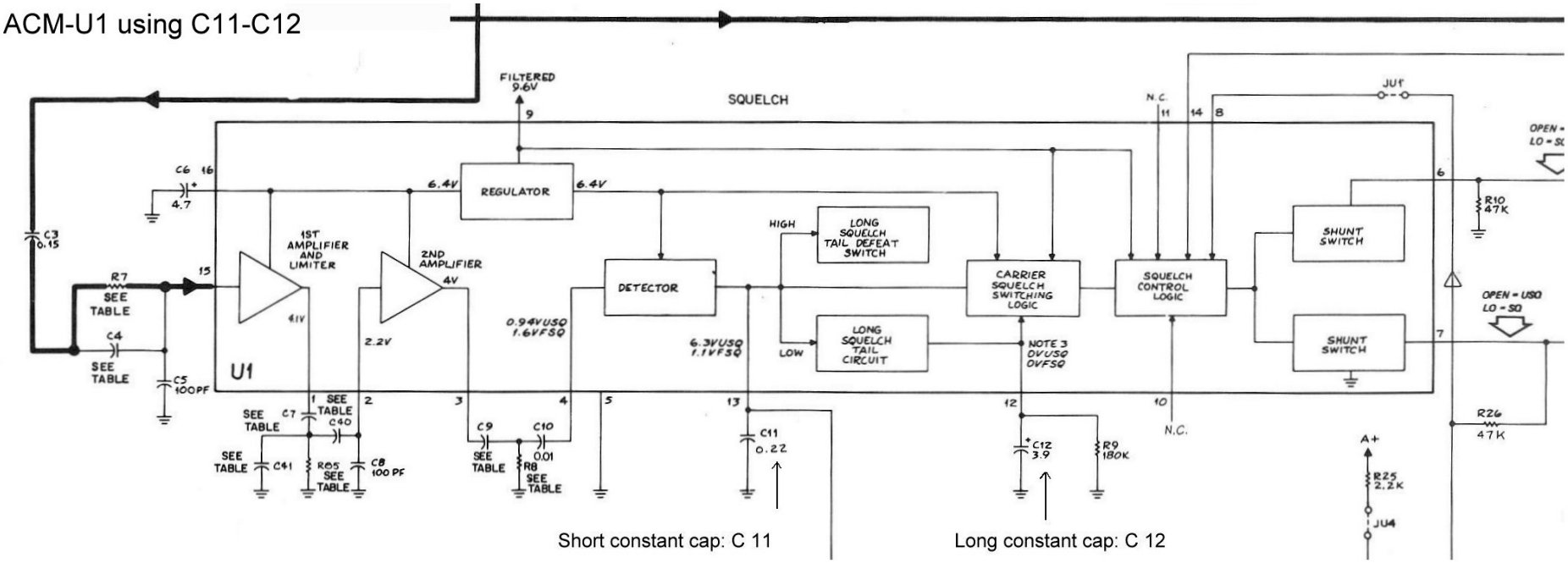
TRN6006A-U202 using C235-C236



Short constant cap: C 235

Long constant cap: C 236

ACM-U1 using C11-C12

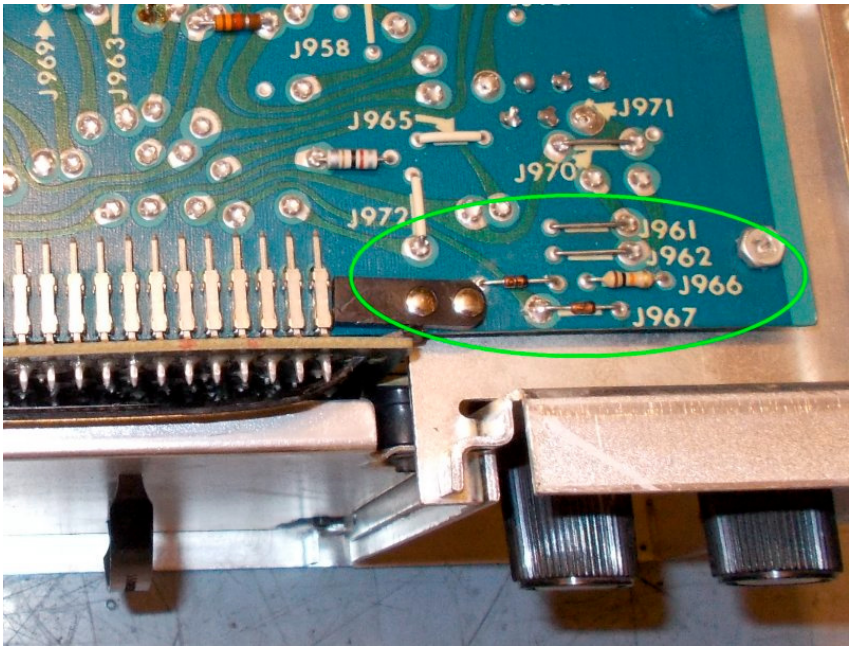


Short constant cap: C 11

Long constant cap: C 12

AND squelch (for station-compa versions)

The Micor “OR” squelch is not good for amateur operation. You need to have “AND” squelch. In the event you are working with a stock station and wish to change the station to an AND squelch type (as mentioned on page 1) you need to make some changes. The OEM 68P81013E65-K manual shows this under the green receiver tab. However, being in upper casing (caps) is an obsolete way for documentation and possibly annoying to read, especially for the Author. Therefore, something “gentle” is described here. To NOTE: This document section covers the non-unified chassis receiver interconnect board. Therefore, some of the component’s labels will be different from the unified chassis version. For example, JU966 (as shown below) is JU956 in the unified chassis version. The OEM manual(s) should “sorta” show this.

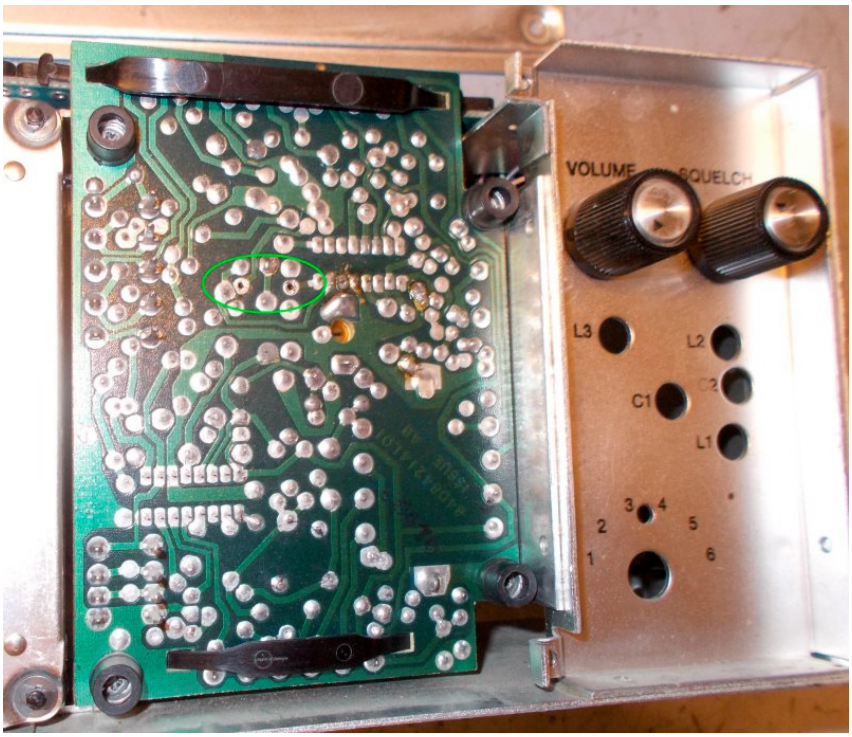


Remove JU966 and install a 10K-ohm resistor (R952) in its place.

Install a diode (CR955) with the cathode to the right, in the spare eyelets just to the left of the (new) R952.

Remove JU967 and install a (second) diode (CR956) in the same orientation (as above) in its place.

The image to the left shows this. Obviously, the silk screen on the PCB does not show the (new) parts to be installed however, the OEM schematic drawing does.



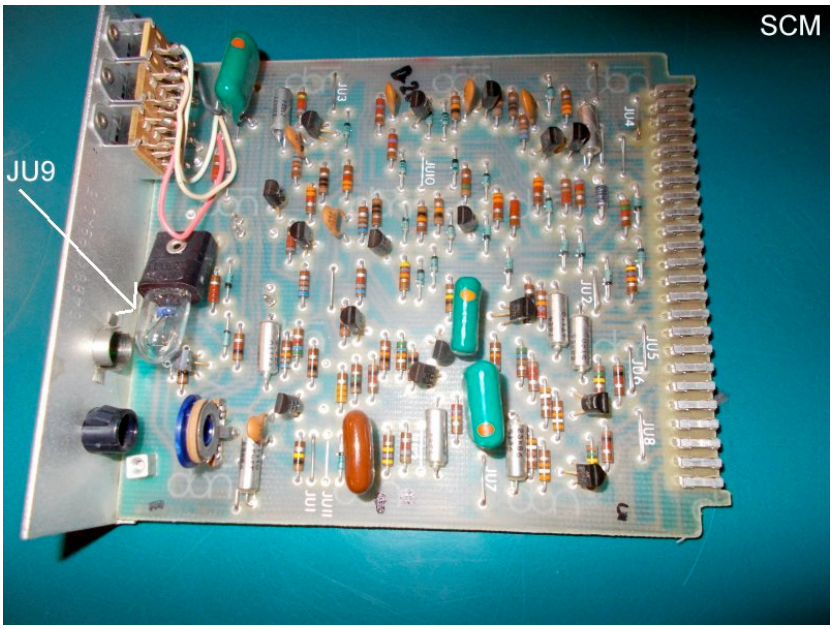
On the receiver audio-squelch board remove JU204. This removes U202, pin 8 (on the TRN6006 board, for example) from being controlled (overridden) from pin 5 of the PL decoder board (previously with the “OR” squelch function). The image to the left shows this.

This now creates multi-level "logic" depending if you are in stand-by, carrier squelch (panel switch bypass function) or a tone decode condition.

If you are running PL (tone) squelch you may want to remove JU201 to enable the high-pass audio circuit (on the PL deck) to filter out the PL received tone.

Repeater (compa-station versions)

In the event you are setting up a stock (OEM) compa station as a repeater there are some additional changes you need to make on the control shelf.

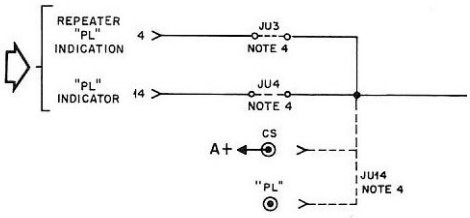


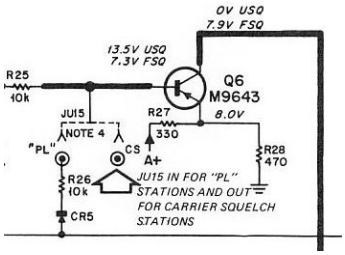
Install JU9 on the SCM (Station Control Module). It's right behind the disable lamp indicator.

Also, a nice modification the Author found is to install a jumper from pin 3 to pin 19 on the edge connector (pads). This allows you to disable the transmitter with the "line disable" slide switch. This is handy when working on the station and you don't want the transmitter to key-up.

On the SGM (Squelch Gate Module) move JU14 from "CS" to "PL". Move JU15 from "CS" to "PL" as well. Both these jumpers have push-down pins on the one end making this an easy task as shown in the lower image.

This now creates a repeater to be on tone squelch. As most OEM stations of this brand there are some compromises for amateur radio operation. (the reason the Author created many SRG modifications on other projects). For example, the local speaker (using the test set) will be on tone as well. To monitor for signals (without tone) you wound need to slide the "PL" disable switch to the left on the SCM.





Another point to remember is that using the "PL" disable switch does not put the repeater (PTT-keying) in carrier squelch, only the local speaker and possibly the repeat audio. For example, during the tail being up you could open the local squelch (turn the knob on the front CCW) to hear the noise on the transmitter frequency.

Other squelch notes

Receiver user signal drop-out issue is future researched. Analysis of the frequency response of the noise amplifiers would be in order as time permits, to see if the original blanking problem was upper harmonics fooling the squelch, from the quick multi-path fade. It was determined this affected both Wenatchee-20 in 1999 and Colville-45 in 2019 to which both site's receiver's constants were slightly increased to correct this condition. This may be another reason "OR" squelch was used in the commercial service. The OR squelch would override any momentary squelch drop-out. This is from the PL reel's flywheel affect of squelch closing time.

For the squelch IC, CAI on Pin 13 can drive a high resistance input or anything higher than 100K. If lower, it could load and affect the IC's squelch operation, disabling the short burst and making all squelch closes a very long burst, which is undesirable. If desired, this pin 13 can drive a high impedance buffer, such as the cor/audio board designed by the Author. Since this is an analog DC output you would need to set a second "DC squelch" adjustment for desired signals. The bias, or reference on the op-amp would work nicely for this method. This method was investigated and decided not to be used for this receiver package. The shunt (pin 7) with resistor pull up was used in the case of the mobile board). For Spectra-TAC's would be pin 6.

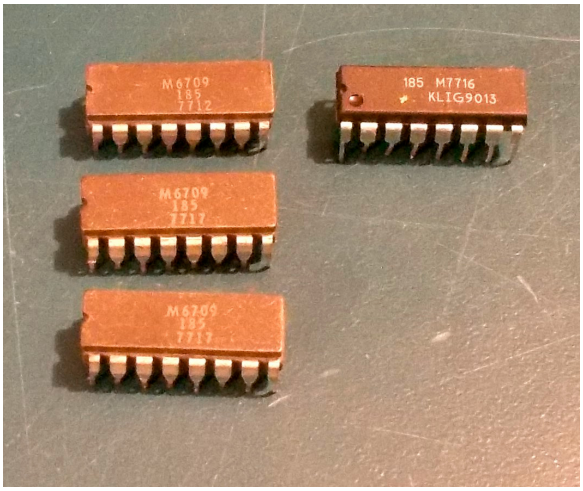
RUI: (repeat and further research on the Receiver Unsquelch Indicator) This point of the IC drives the two shunt outputs, pins 6 and 7. One of them is used for the cor output (with the 150K pull up) for SRG equipment. During production work in 2018 with the Spectra-Tac receiver units, more research was done to confirm the way the M6709 (U1) IC on the Audio Control Module (ACM) works. It was also determined (for this discussion) better documentation (service manuals) for the Micor "compa" base station was found. Since the squelch operation is almost the same this should not impact the project understanding.

There are a few exceptions. As previously discussed, the labeling of some of the ICs is different. Also, the number of ICs used is different. The ACM uses one IC (U1) for the squelch and discreet components (transistors, etc) for the audio shaping, filtering and amplification for the line driver (wireline). The compa and mobile use two ICs (U201 and 202); one for the squelch and the other for the audio filter and driver. It's also used for the local speaker, obviously, an essential part for the mobile.

The Spectra-Tac's squelch IC (U1) is located on the Audio Control Module (ACM) or card, if you will. For the compa and mobile types this IC (U202) is located on the audio squelch board.

U1 (I.C.) on the ACM provides most of the squelch operation. There has been in issue with the "floating" voltage during activity for a cor pickup point. Some pull-up resistance from other cards produce a COR point from pin 6. Occasionally, this pin (output) fails.

Shown here are the various production "versions" of this IC. They are extremely had to find. The Author resorted to cannibalizing this IC from the mobiles, being used mainly for parts, now.



U1 has three part numbers; presumably, from the ara they were manufactured:

- SC6709 - 5184267A09
- M6179 - 5184561L79
- M7716 - 5183977M16

Some points of interest should be mentioned:

- U202 has two shunt outputs; each are an emitter of an internal transistor inside this IC. Pin 6 on the audio and squelch board, TRN6006A, is covered for this discussion. This is mentioned because there are other (older) boards used with possibly different pin assignment and functions.

- It was reported a maximum of 4 volts DC can be applied to the shunt. Since this shunt goes to a ground reference one can only speculate this is talking about any “pull-up” resistor to A+.

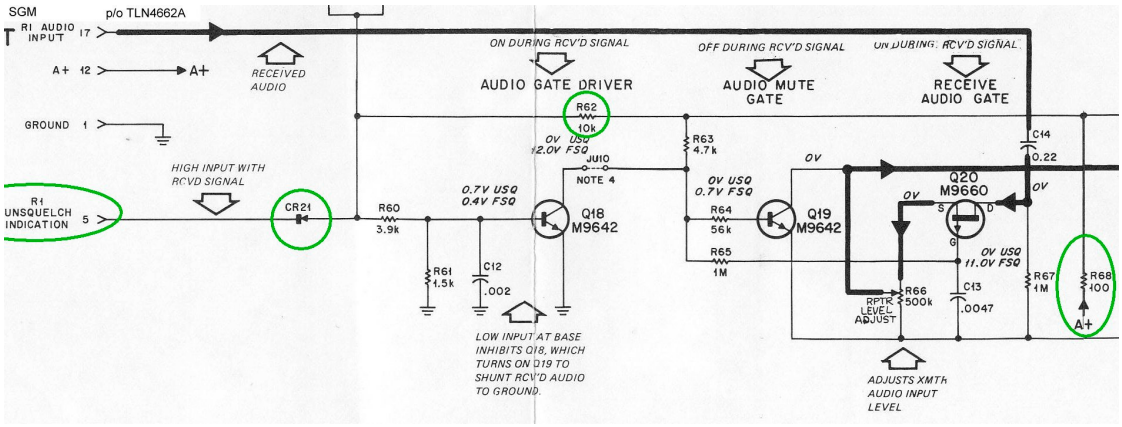
- Such a pull-up was found on at least two other station modules (cards), which is the Squelch Gate Module (SGM) and the Line Driver Module (LDM). This discussion will cover these points.

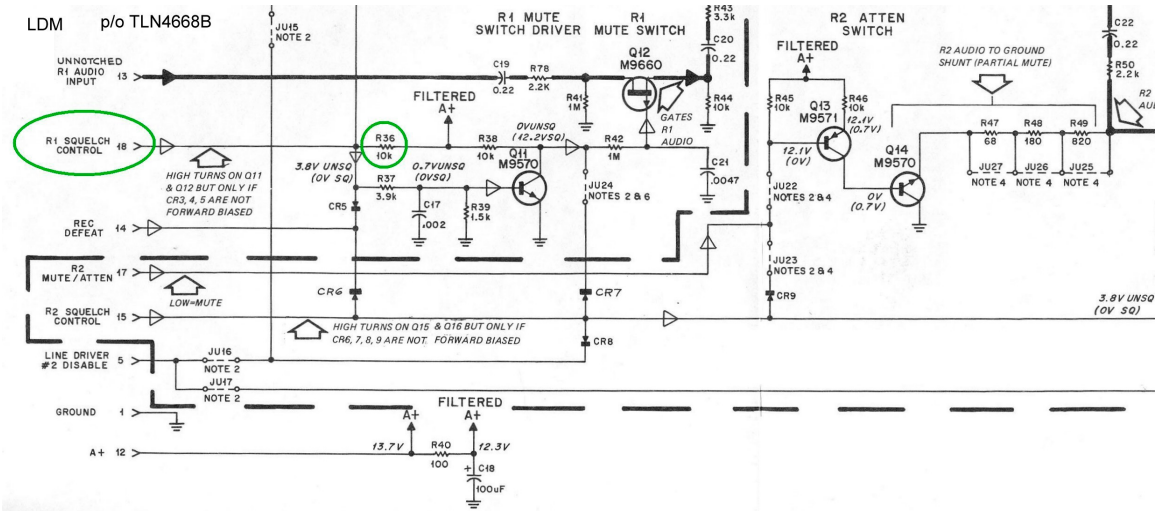
Referring to pin 6, it’s normally turned on, thus, a shunt (low resistance) to ground. Let’s trace the runs that cause a positive going active signal, known as the RUI, or the Receiver Unsquelch Indicator. The areas of interest are circled in green in the following images.

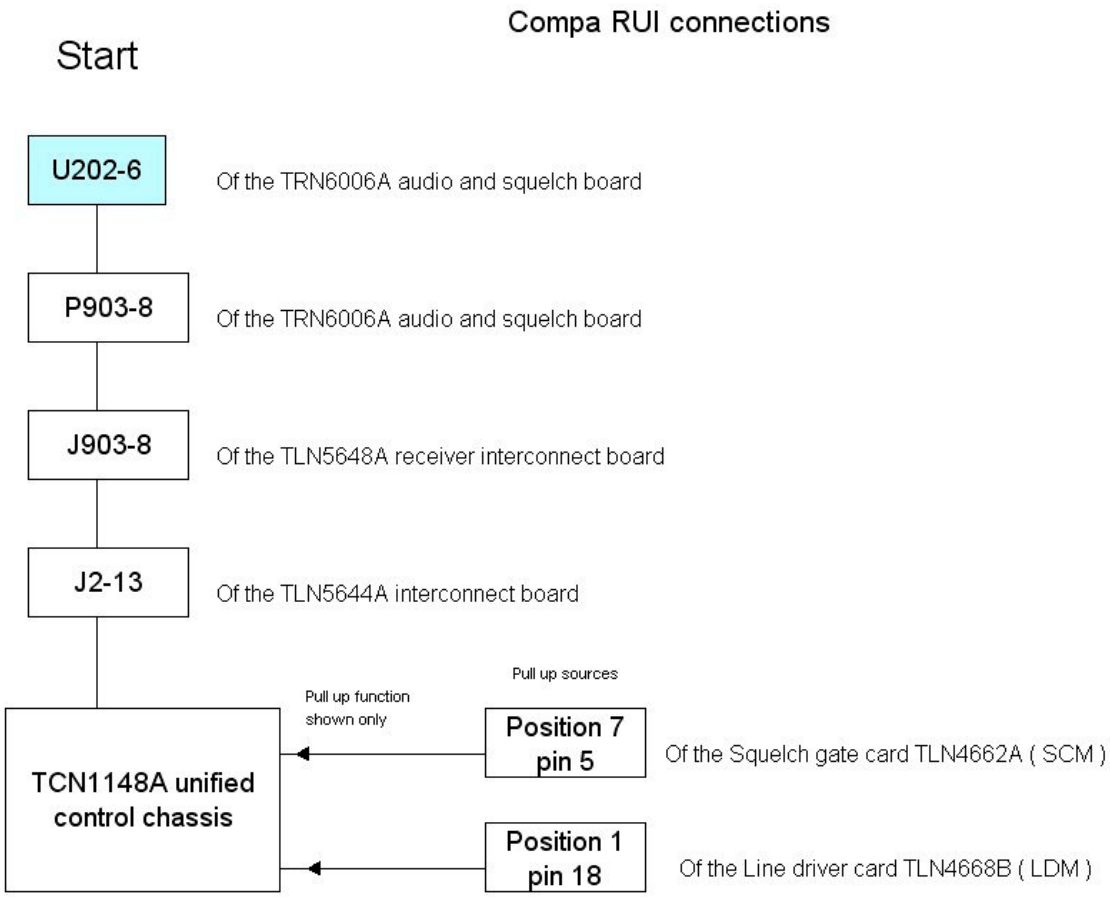
Starting with U202, pin 6 on audio and squelch board, TRN6006A run goes to the board’s P903 pin 8. From there it plugs into the receiver interconnect board pin 8. The interconnect board run goes to J2, pin 13. This board plugs into the unified control chassis’s back-plain board, pin 13.

From here it goes to a few places. Refer to the drawing on the next page. One way goes to the Squelch Gate Module (SGM) TLN4662A on pin 5. On the SCM are a pull-up, 10K resistor, a 100 ohm one and a diode from A+.

It also goes to the Line Driver Module (LDM) TLN4668B on pin 18 as shown on the lower image. On the LDM is a pull-up, 10K resistor to A+. In some cases both of these cards (modules) will be installed as in the case of a repeater/wireline control station. Since both 10K resistors are pulling up the U202 pin 6, it’s the equivalent of a 5K pull-up resistor. However, there may be circuitry not identified to the load down the RUI to the safe limit of 4v during activity, plus the purpose of the diode, CR21 as shown on this upper image.







During the R'nD, another interesting side effect (good or bad) was noticed. You might want to be aware of it. Originally, with a stock arrangement, with the squelch control at threshold, noisy signals have the long burst and stronger (more quieting) signals have the short one. If you turn up the squelch control (increase the noise gain to the noise amplifiers) this raises the noise reference so even more quieter signals (than earlier) still have a long or longer bust than before. For example, if the squelch control is at maximum a signal around 25 db quieting still has a long burst. This makes sense since you are increasing the noise to the noise amplifiers, which "looks" like a noisier signal to them. Now, with the modification of changing C229/C235 almost the reverse happens, when the squelch is at max the burst tends to be on the shorter side. The very short (drop out issue) should not happen as mentioned before, because of increased constant. With the squelch back to threshold it tends to be longer burst. Not a problem, just observations with the particular receiver under test, but it may be attributed to the above comment about the pull-up resistor value used. Perhaps, in the future as time permits, this can be further investigated.

** “Off-vote” is a condition whereas, a user signal is voted on a solid (quiet) path while other paths are ignored (muted). When the user un-keys the radio there will be a short time the voter will “see” other noisy paths. That’s because the micor long squelch time is longer than the (voted) quiet path. To solve this anomaly C12 value is changed from stock 3.3 to 2.2 uf. Now, the noisy path’s squelch should close quicker; about the same time the quiet path (and it’s RF downlink).

The change-over from long to short constant mode happens at about 29 db of quieting, with a short burst, then goes completely to short mode with just a click around 33 db of quieting.

Karl Shoemaker; Updates and corrections (as time permits) were made on Jan 2015, December 2015, January 2017, March 2018, May 2018, August 2018, September 2019, Jan 2020, Mar 2020, July 2023, August 2024, November 2024.