HAMTRONICS® TD-3 SUBAUDIBLE TONE DECODER MODULE

FUNCTIONAL DESCRIPTION.

The TD-3 is a CTCSS Decoder and Encoder designed especially for use with Hamtronics Receiver modules in repeater use, but allowing also for general use in other radios. It is tunable to cover the entire range of tone frequencies from 63 to 250 Hz.

The unit normally is used to inhibit a repeater transmitter from responding to received signals which do not have the appropriate subaudible tone to gain access. This is done by inhibiting the COS signal from the receiver squelch circuit which is required to make the transmitter respond. It may also be used in non-repeater receiver systems where muting of the receiver audio is required so that only stations with the proper tone are heard.

While the unit normally is used only for receiver control by decoding tones on the received signal, circuitry is also included to generate that tone to be applied to the Exciter module in a repeater or transceiver so that the subaudible tone is also transmitted.

THEORY OF OPERATION.

Refer to the schematic diagram. The heart of the unit is the 567 phase-lock loop decoder chip, U2. The frequency of the loop detector is set by R6/R7 and C9-C12. Audio input for the chip is derived from the discriminator of the receiver and processed through active low-pass filter Q1 to reduce the level of audio in the normal voice range and enhance the relatively low level of the subaudible tone. Since the response bandwidth of the phase-lock loop in U2 is proportional to the incoming audio level, R4 is adjusted to provide adequate sensitivity without overdriving U2, thereby optimizing the bandwidth of tones which will activate the unit.

Bias for Q1 normally is provided by the +4V riding on the discriminator output of the detector ic in Hamtronics receivers. If another type of receiver is used, it is necessary to supply bias for this stage as described under installation procedures.

U2 pin 8 normally rests at a logic high with no tone signal present. The bias current through R5 turns on Q2, which provides a ground to the output at E2. When the proper tone is detected, pin 8 goes low, and Q2 is turned off, removing the ground from E2.

The ground at E2 normally is used to shunt the COS signal from the receiver to ground, thereby preventing the COS signal from activating the COR board in the repeater. This disables the transmitter unless the proper tone is received. Another way to use the TD-3 in a transceiver is to mute the audio from a receiver unless the tone is present. This is done by using the ground at E2 to short the audio path before the speaker amplifier in the receiver.

Q3 provides a tone signal for use by a transmitter, when required. Some of the square-wave audio tone signal from the phase-lock oscillator in U2 is low-pass filtered by R8/C13 and R9/C14 to provide a quasi-sinewave tone signal. This is amplified by Q3 and applied through level control R11 to the mic. input of the exciter. The series resistance of R13 prevents the amplifier from loading down the normal audio applied to the mic. input of the exciter.

ASSEMBLY.

Construction is fairly simple. Refer to the parts list and component location diagram, and solder all parts in place, using short leads. Following are some special points to consider.

a. Install the ic socket with the notch facing to the left as shown. Then, plug in the ic, being careful not to let pins bend over instead of going in the socket.

b. Resistors mounted vertically are shown with the body of the resistor designated by a circle.

c. For the most common frequency range, R7 is a combination of a 10K resistor in series with a 2.2K resistor. Install one in each hole, and join them at the top. Twist the top leads together, solder, and clip off the excess. For the other frequency ranges, a single resistor (not supplied) can be substituted. See table 2 for values.

d. Install R8 with a 1/4 inch high loop formed in the right-hand lead to act as a test point.

e. Observe polarity on electrolytic capacitors, diodes, transistors, and ic's.

f. Cut hookup wires to length, strip each end 1/4 inch, and then solder one end to terminal pads as follows. Wire lengths are as required to conveniently mount the TD-3 behind a Hamtronics receiver module. Note that no wire is prepared for E5, the transmit af output, since this function normally is not used. If you do use it, attach a hookup wire to it as required for your installation.

TABLE 1. HOOKUP WIRES.

COLOR	LENGTH	PAD	FUNCTION
ORN	9"	E1	DISC AUDIO
BLU	8½	E2	RCVR COS
BRN	6¾	E3	CTCSS DISABLE
RED	8¾	E4	B+ INPUT

g. Check over construction to be sure all parts are installed in the proper holes with the proper polarity. Check all solder joints for bad joints, solder splashes, etc.

SELECTING FREQUENCY RANGE.

The value of R7 sets the tuning range of TONE FREQ pot R6. The value of the resistors used for R7 supplied with the unit (10K in series with 2.2K) provides a tuning range which covers the 100 Hz tone which is used most often. If you are using another tone frequency, consult the chart below, and install a resistor (or two resistors in series by placing one in each hole and tack-soldering the two leads at the top). The information is given as a guide. If you don't have the exact value(s) required, use a combination of resistors which will come close, and tune the unit before mounting, so the resistors can easily be changed.

TABLE 2. RESISTOR SELECTION.

TONE RANGE	RES R7
63-72 Hz	22K
72-80 Hz	18K
80-95 Hz	15K
95-125 Hz	10K + 2.2K
125-150 Hz	10K
150-250 Hz	6.8K

MOUNTING.

The usual location for the TD-3

module in a Hamtronics REP-200 Repeater is on the rear panel of the enclosure near the receive coax connector. This is convenient for connections to the feedthrough capacitors on the partition, and it allows easy access to the pots for adjustment. The module is designed to be mounted with the pots at the top, just below the upper edge of the box. To locate the mounting holes, draw a line one inch below the top of the box. Then, mark the two mounting holes 1-7/8 inches apart on the line, with the first hole about 1 inch from the side partition. Attach the module with 4-40 screws and standoffs or spacers as desired.

HOW TO MAKE CONNECTIONS.

Connections are made with the hookup wires previously soldered to the terminal pads on the module. Be sure to read the discussions below if you have not installed a TD-3 before.

B+ for the unit is connected to the red wire on E4. The negative supply normally is connected through the mounting hardware to the chassis. Since an 8 volt regulator is used in the TD-3, B+ can be anything from 10 to 15Vdc.

The most convenient place to pick up B+ and COS lines is at the feedthrough capacitors on the partition. The discriminator connection must be made at the discriminator terminal on the receiver, since this line is not available at any of the feedthrough capacitors. If you wish to use touch-tone control to disable the tone decoder, you will need to add another ft capacitor to the receiver partition and a wire from the other side of the ft cap to the auxiliary control output of a touch-tone controller.

TABLE 3. NORMAL HAMTRONICS REPEATER CONNECTIONS.

TD-3 E1	(orn)	to rcvr disc term
TD-3 E2	(blu)	to rcvr COS term
TD-3 E4	(red)	to rcvr B+ term
TD-3 E3	(brn)	to control board aux function via new ft cap.

AUDIO INPUT.

Audio from the receiver normally should be picked up from the discriminator for connection to E1. Some later model receivers have a terminal pin on the receiver for the discriminator audio. On earlier models which do not have a dedicated terminal, the discriminator audio is accessible at the resistor/capacitor junction of the deemphasis network as follows.

In earlier model R144 Receivers, connect to the right hand lead of R23, at the junction of C38. In the original R451 Receiver, connect to the right hand lead of R29, at the junction of C45. In the R76 Receiver, connect to the junction of R20 and C34.

Input transistor Q1 normally gets its bias from the discriminator in Hamtronics receivers; so there is no bias resistor in the Q1 base circuit. If you are operating from a receiver other than ours, it is necessary to provide a 680K bias resistor from E1 to the 8 Vdc supply line in the TD-3 and to connect a blocking capacitor of 0.1 uF or larger in series with the audio input so the external circuit is does not provide a dc path.

OUTPUT CIRCUIT.

Output terminal E2 is connected to the receiver circuit being switched. Normally, the unit is used to inhibit the repeater by grounding the COS signal from the receiver to the COR board in the repeater. The easiest place to connect is at the COS terminal on the right side of the receiver.

OPTION FOR RECEIVER AUDIO MUTING.

If the unit is used in a transceiver system to mute the audio instead of inhibiting the transmitter, then E2 can be connected to short the audio to ground somewhere in the path from the discriminator to the output stage. There must be a fairly large series resistor (larger than 10K) in the audio path before the connection from E2. Be careful not to connect the shorting output of E2 in such a way that it shorts the source of tone signal to the TD-3. In such installations, the tone should be taken close to the discriminator, and the shorting connection should be applied later in the signal path after a large resistance. It may be necessary to add this resistor to the audio path.

OPTION TO CONTROL TD-3 ON/OFF WITH TOUCH-TONES.

If a our COR-5 Computerized Repeater Controller or the TD-2 (or similar) DTMF Decoder/Controller Module is used to turn the subaudible tone feature on and off remotely, or if a front panel switch is required to disable the subaudible tone function, merely connect it to ground E3 on the TD-3 when you want to disable the tone squelch function. When a ground is applied to E3, output transistor Q2 is inhibited from generating a ground. This option requires an extra feedthrough capacitor to be installed on the repeater's receiver enclosure. If the TD-2 DTMF module is used, the repeater will default with the subaudible tone function enabled.

OPTION TO TRANSMIT ENCODED TONE.

In most repeaters, it is unnecessary to retransmit the subaudible tone; it is only necessary to inhibit the repeater if a station is heard without the proper tone. If you wish to have your repeater retransmit the tone, do the following.

a. Add an extra feedthrough capacitor on the receiver enclosure behind the others, and add an extra feedthrough capacitor on the exciter enclosure about in line with the deviation pot on the exciter.

b. Connect a hookup wire from E5 on the TD-3 to the added feedthrough capacitor on the inside of the receiver compartment. Continue with a wire from the ft cap on the outside of the receiver compartment over to the ft cap at the outside of the exciter compartment.

c. The connection to the exciter depends on which exciter you have. For the TA51 (vhf) Exciter, run a short hookup wire from the ft cap on the inside of the compartment over to the loop at the top of R22. This injects the audio directly into the low pass filter at the input of the modulator. For the TA451 (uhf) Exciter, connect a 47K resistor from the ft cap on the inside of the compartment over to the lead of C11 closest to deviation pot R15. This also injects the tone into the modulator, but the 47K resistor prevents loading of the circuit in the uhf exciter.

d. If you are using your transmitter for an application other than a repeater, you probably do not need the

feedthrough capacitors. Just run a short length of wire directly to the exciter at the connection point given in step c.

e. If you need to connect the tone to another type of transmitter, use a similar approach. It is important to inject the tone into the modulator of the transmitter in a way which bypasses the speech processing circuits for the microphone, but at the same time does not load down the audio coming from those circuits. Normally, there will be a low-pass filter which allows the audio to be injected into the modulator while keeping the oscillator rf signal from getting out into the audio circuits.

Once the mic gain control in the exciter is adjusted for proper deviation of the repeater, XMIT LEVEL control R11 on the TD-3 is adjusted for the desired deviation of the subaudible tone. The TD-3 has a resistor (R13) in series with its output to avoid loading down the exciter audio circuits. If XMIT LEVEL control R11 provides too high a level, even with it adjusted to a low setting, additional resistance can be added in series with output terminal E5 or R13 can be made larger.

Normally, the level of the tone should be set for about 300 Hz deviation. That is sufficient for the decoder to detect. Sometimes people want to use much higher levels on tones, and not only is this unnecessary but it causes the tone to be heard as a buzz on the voice signal, and if set high enough, may even have a detrimental effect on a touch-tone command system.

ALIGNMENT.

The following assumes all of the installation procedures have been done prior to alignment.

The tone frequency can be set in either of two ways. If a frequency counter is available, connect it through a resistor to Test Point 1, which is a loop formed in the right side of R8. A resistor of 10K to 100K normally must be connected in the pick up line at the TD-3 to minimize loading and noise pickup to prevent erratic readings. For an accurate adjustment, it is necessary to remove any possible audio input to the decoder ic by turning R4 fully ccw. With the lowest frequency range, adjust FREQ pot R6 for the desired tone frequency. If R6 cannot be adjusted to the desired frequency, it may be necessary to change the value of R7 as explained in the section after ASSEMBLY on page 1.

The alternate method of adjusting frequency is to simply apply a received signal with the proper subaudible tone present and adjust FREQ pot R6 to the center of the adjustment range in which the ic responds to the tone. Response is indicated by a dc voltmeter connected to E3, which has about 0.6 Vdc with no tone detected and ground with proper tone detection. To locate the exact center of the settings which allow response, the sensitivity pot may be reduced to the point where the TD-3 responds only over a very narrow range of settings.

Another way to check for response of the TD-3 is to monitor the COS voltage at the feedthrough cap on the receiver enclosure.

Since the response bandwidth (range of tone frequencies which will be detected) is proportional to the level of tone applied to U2, it is desirable to adjust the level for optimum tone acceptance. If R4 is set too sensitive (cw), then the bandwidth will be fairly wide, up to three times as wide as optimum. If R4 is set too insensitive (ccw), then some stations may be a little too weak or off the tone frequency a little too far to access the repeater.

Normally, a system should be run with about 300 Hz tone deviation on the transmitters (mobiles using the repeater). Obtain a weak signal with a tone a little below the low end of expected range of levels to be encountered in the system. For example, at our factory, we usually apply an rf signal of about 0.15 uV with about a 200 Hz tone deviation. Adjust SENSITIVITY pot R4 cw from no tone level to a level just high enough so the TD-3 responds. Then, any signal you normally expect to encounter will be able to access the repeater.

We normally use a service monitor with a subaudible tone synthesizer and a deviation monitor. However, you don't need to have a fancy signal generator. Just make sure the signal used for testing has its tone encoder on the proper frequency and at a relatively low level of deviation. You don't want to adjust the TD-3 to match a tone which is off frequency. If you use a strong rf signal or a normal tone level rather than a weak tone as we suggested, then adjust R4 just a little further cw than the point at which the decoder first responds. Then, weak signals will be able to access the repeater too.

The only other adjustment is the transmit audio level (R11) which is discussed on page 2 under the section on Option to Transmit Encoded Tone. If you do not use this option, R11 can be left in any position.

TROUBLESHOOTING.

The circuit is relatively simple. With the theory of operation presented on page 1 and the following list of dc and signal levels, troubleshooting should be straight forward. An oscilloscope is usually essential in troubleshooting, although it may be possible to get by with just a voltmeter.

Unless otherwise specified, the following test data is taken with 13.6Vdc at the B+ input (8Vdc out of the voltage regulator) and a 100 Hz tone applied from one of our receivers with 300 Hz tone deviation. That results in about 200 mV p-p tone level at input terminal E1. Current drain of the unit is about 20 mA.

TABLE 4. TYPICAL TEST VOLTAGES.

Location	Typical Indication
E1	4Vdc with 200mV p-p tone
Q1-base	4Vdc with 200mV p-p tone
Q1-coll	8 Vdc
Q1-emit	3.3Vdc & 200mV p-p tone
U2-1	5 Vdc
U2-2	5.8Vdc
U2-3	2Vdc (tone 75mV p-p min to be able to decode)
U2-4	8Vdc
U2-5	7V p-p square wave centered at 3.7Vdc
U2-6	2V p-p triangle wave centered at 4 Vdc
U2-8 & Q2-base	0Vdc with tone received & 1.2 Vdc with tone absent
Q3-base	1V p-p rounded triangle wave centered at 1.3Vdc
Q3-emit	Same waveform at 0.6Vdc
Q3-coll	3V p-p rounded triangle wave centered at 5.8Vdc

PARTS LIST.

Ref #	Value	(marking)
C1	2.2 uf electrolytic	
C2	47 uF electrolytic	

C3-C4	.033 uF mylar
C5	.01 uF monolithic (103)
C6	2.2 uF electrolytic
C7	10 uF electrolytic
C8	47 uF electrolytic
C9-C14	0.15 uF polyester
C15	2.2 uF electrolytic
CR1	1N4148
Q1-Q3	2N3904 or 2N4124
R1-R3	47K
R4	20K or 22K pot (203, 223, or 22K)
R5	27K
R6	5K, 20-turn pot
R7	10K in series with 2.2K (frequency dependent, see text)
R8-R10	27K
R11	20K pot
R12	3.3K
R13	10K
U1	78L08 8Vdc regulator
U2	NE567P PLL Tone Detector