

Voice-Track—a Multifunctional, Talking Repeater Controller —Part 1

With the Voice-Track, you can transform your repeater from commonplace to extraordinary!

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Since the early 1970s' boom of analog repeaters, there's been a need for controlling them remotely. This need became more demanding each year. At first, the control circuits could only remotely shut down the repeaters. As years passed and phone-patch-equipped repeaters became common, remote receivers and repeater links appeared, increasing the need for a powerful and efficient remote controller. This article describes the design of a straightforward universal repeater controller I've dubbed "Voice-Track." Voice-Track fills all of the existing—and most (if not all)—of the future needs for repeater remote controlling and telemetry data-acquisition. Voice-Track also allows for experimentation and for improving the flexibility of existing systems.

Voice-Track's Features

Voice-Track's design philosophy is simple: It provides an easy-to-use, flexible and friendly repeater controller environment that can be upgraded by simply plugging in a new EPROM. Hardware experimentation and improvements are made possible through the inclusion of expansion connectors that provide access to almost all of Voice-Track's innards.

Voice-Track's software includes complete control of the following features:

- Speaking S meter
- Voice identification
- Maximum-operation-time announcement
- Shut-down control
- Peripheral control
- Phone-patch control
- Full code squelch and pager functions

Later on, I'll cover the details of what these features do, how you can manipulate them to suit your needs, and describe Voice-Track's installation in Yaesu and non-Yaesu repeaters. First, let's briefly cover the computer and audio hardware.

Hardware Description

The Voice-Track is built on a double-sided, plated-through-hole PC-Board¹ with components mounted on *both* sides of the board; it's a project for experienced builders. To get a better understanding of the Voice-Track, refer to the block diagram (Figure 1) and the schematic (Figure 2).

Microprocessor Control Section

This section uses a MC6809 8-bit micro-processor (U11) and a companion 2764 EPROM (U12) in which the program (written in assembler) resides (see Note 1). U17, an MC6821 peripheral interface adapter (PIA) with two 8-bit input/output (I/O) ports is used to communicate with the outside world, with the four interrupt lines of the PIA handling the 100-Hz timer interrupt, a future ring interrupt from the phone patch, the DTMF decoder interrupt and the repeater squelch-state interrupt.

U14, a 6264 RAM IC, stores the user-defined parameters and temporary working variables. The RAM is backed up by a lithium battery (BT1) so data isn't lost when the external power supply is shut off or disconnected. There's also a "creative" reset circuit that monitors the +5 V power supply. When the voltage drops to 4.5 V, the RAM is disabled. A few milliseconds later, the microprocessor and the PIA are reset. During start-up, the reset circuit keeps the microprocessor and the PIA in the reset state while it waits for the power supply voltage to rise to 4.5 V. When this point is reached, the reset circuit enables the RAM and, a few hundred milliseconds later, it enables the microprocessor and the PIA. This way, during start-up and shut-down, the microprocessor can't write garbage to the RAM, assuring that the parameters of the Voice-Track will *never* be lost. (I hate to lose the memories in my 50-W, 2-meter FM rig when I forget to turn off the rig before disconnecting it from my car battery!)

U4, a CIC9203 DTMF decoder, is connected to the audio output of the repeater's receiver and decodes the incoming DTMF tones. This decoder uses a 3.58-MHz clock, which is provided by the microprocessor's crystal-controlled oscillator. All of the peripheral devices that communicate with the microprocessor are addressed through U13, a 74HC138 decoder/demultiplexer used as an address decoder.

U18, an ADC0804 8-bit ADC, measures the receiver's second-IF level. The computer uses this information for the speaking S meter. The connection from the ADC to the 455-kHz IF is done through a variable-gain IF amplifier (U16) followed by a diode rectifier and a logarithmic network. This device was carefully designed to have a high input impedance (approximately $25\text{ k} + j0\ \Omega$) to avoid deterioration of the receiver's performance.

The Audio Section

The heart of the audio section is an MC34115 (U5) continuously variable slope delta (CVSD) modulator/demodulator with a three-bit algorithm. This IC performs the tasks of recording and reproducing high-quality audio at very low bit rates. It works with a crystal-controlled and software-variable clock frequency of 31.982642 kHz, with an 8× oversampling scheme. The data rate is software-selectable so it can be changed in future applications.

Digitized audio is stored in three 62256 RAM banks (U8, U9 and U10) of 256 kbits each. These memories, too, are backed up by the Voice-Track's lithium battery. For improved security, the microprocessor cannot write directly to these memories. A mechanical switch must be activated to enable the memories' write mode.

The three RAM ICs are addressed somewhat creatively. They need a 15-bit address bus; the microprocessor address bus has only 13 bits left for this purpose. So, the circuit uses two bits of the microprocessor's *data* bus as two extra address lines. Another problem area was that the RAM ICs I/O bus is 8-bit parallel, and the CVSD uses a serial format. An innovative converter—half digital, half analog—handles the conversion.

In reproduction mode, the RAM data buses are connected to an 8-bit analog multiplexer/demultiplexer (U6, an MC14051) that selects one of the eight bits and sends it to digital input of the delta converter. The three-bit address lines of U6 are connected to a quad latch (U7, an MC14042) that latches the three least-significant bits of addressing from the microprocessor (which correspond to three data-bus lines), so that they remain latched during the entire delta-converter clock cycle.

In record mode, the data flow is reversed. The delta converter data stream is sent to the demultiplexer (demux), U6. Each input bit is routed to one of the eight output bits of the demux. At these outputs are eight 0.0015- μ F capacitors that work as dynamic RAMs, maintaining the appropriate logic data (1 or 0) while the other bits are written. Once the eight bits are written to the eight capacitors, the microprocessor enables a RAM write operation and stores the bits in parallel 8-bit form.

The analog input/output section includes a Chebyshev low-pass filter (U2A and associated components) with a -3 dB cutoff frequency of 4 kHz. This furnishes the necessary filtering of the delta-converter audio output. In record mode, this filter provides the required alias rejection. The filter is simple because the delta converter works with an 8× oversampling clock, reducing the need of sharp and complex filters.

The filtered signal is fed to a level-adjust potentiometer (R3). Finally, in U2B, the signal is mixed with the signals from

the external phone patch, the repeater receiver and the software-controlled oscillator, ready to feed the repeater's transmitter.

Features Descriptions

Speaking S Meter

The speaking S meter allows repeater users to get uniformly objective signal-strength reports audibly to test antennas quickly and easily. It's a useful tool for periodically verifying that your station is working as it should. The speaking S meter is also helpful in checking repeater integrity and correcting desensitization problems that affect the repeater. Once a repeater is equipped with the speaking S meter, you—and every other repeater user—will become addicted to it! By simply pressing the PTT switch and the **3** key on your DTMF-pad-equipped rig, the speaking S-meter responds, for example, with “You are reaching the repeater with an S5!”

Voice Identification of the Repeater

There are four different situations in which the Voice-Track performs an ID. The first—and most common occurrence—is when the repeater has not been activated for a specified duration (xxxx). The duration can be changed in steps of 1/100 of a second (for more details refer to the Programming Mode section that follows). The second situation occurs when, after a certain period of inactivity (yyyy), the repeater is activated. The duration of the inactive period can also be incremented in 1/100-second steps. The third instance *forces* a remote ID by your transmitting to the repeater a specific DTMF digit—by default, 8.

The fourth way to ID the repeater is similar to the third in that it is forced by the user. This situation, however, does not rely on the reception of a DTMF tone. This fourth method is called the *Instant Mode* and is recommended for use only with CTCSS-equipped repeaters. The logic behind this approach is that if a user transmits to the repeater for a very short time, the Voice-Track will ID the repeater. By default, the thresholds for the transmission duration are set to 30 ms minimum and 500 ms maximum.

Maximum-Operating-Time Announcement

Most repeaters have a maximum-operating-time disabler. In addition, Voice-Track says that the repeater will be shut down. For example: “Maximum operating time exceeded,” followed by the *kerchunk* of the repeater shutting down. This voice announcement can be enabled or disabled remotely. Similarly, the maximum-operating timer can be enabled or disabled with the time-out period alterable in 1/100-second steps from a minimum of 2 seconds to a maximum of 10 minutes.

Shutting Down the Repeater

This feature is a widely used technique to control repeater traffic. The main difference between other repeater controllers and Voice-Track is the security and integrity of the system. To shut down the repeater, you need first to enter the programming mode (described later). Only then are you able to issue the shut-down command. This way, the overall code length is between 5 and 19 digits, depending on the length of the programming-mode entry code. Once the programming mode has been entered, repeater transmission is disabled, so the code corresponding to the shut-down command is not transmitted by the repeater. Finally, you can remotely change the programming-mode entry code.

Peripheral Control

Today's repeaters manage more and more peripheral equipment: radio links between repeaters, satellite receivers for increasing the coverage area, a variety of antennas that can be selected depending on communication needs and a number of other custom functions such as changing the repeater's squelch sensitivity depending on the QRM, band conditions, etc. All of these peripherals are connected to Voice-Track's USER pins. Voice-Track provides three USER pins (pins 8, 9 and 10 of J6) that are connected to open-collector transistors within U3, each transistor capable of sinking 400 mA. These remotely controlled outputs are separate from each other, and can be grounded or set to the high-impedance state, making them suitable for controlling peripheral devices.

Phone Patch Control

Built into the Voice-Track is all the logic needed for a phone patch. The only external component needed is a telephone hybrid.³ Since the access code of the phone patch is controlled by Voice-Track, you're able to remotely change the access code whenever necessary. This allows, for instance, the use of a different access code for each week of the year, minimizing the probability that unauthorized users will access the phone patch. The different codes can be related to a mathematical algorithm, so that phone-patch users can easily calculate the code for a given week.⁴ When a valid access code is entered, Voice-Track's open-collector **PATCH** pin is grounded. This pin is used to activate the on-hook relay coil of an external telephone hybrid. At the same time, Voice-Track holds the repeater in the transmit state. To end the telephone communication, you need only press the keypad's pound (#) key.

Voice-Track can also handle multiuser phone patches. In this case, the Voice-Track phone-patch code serves as a main access code, enabling the external multiuser phone patch via the **PATCH** pin, whenever it decodes a valid main access code. Then, the Voice-Track becomes transparent to the external phone patch. Therefore, it doesn't matter if you use an external phone patch, or if you use only an external telephone hybrid. You've got two important advantages: You can change the access code of the patch, and you can enable or disable the patch remotely (for more details, refer to the Programming Mode section).

Full Code Squelch and Pager Functions

Voice-Track can enable the repeater only when a valid code-squelch sequence is received, and disable it when a valid pause (longer than the hang-up timer) occurs.

In the Pager Mode, when the first three DTMF digits and the asterisk (*) are validated, Voice-Track enables the repeater. Thus, the last three DTMF digits are transmitted by the repeater and can activate a code-squelch receiver. This mode can be quite useful for custom environments, where, for example, a DTMF digit enables a series of repeaters through a network. (Note that for greater flexibility, the Voice-Track's Code Squelch and Pager Code could have any length from 1 to 15 digits).

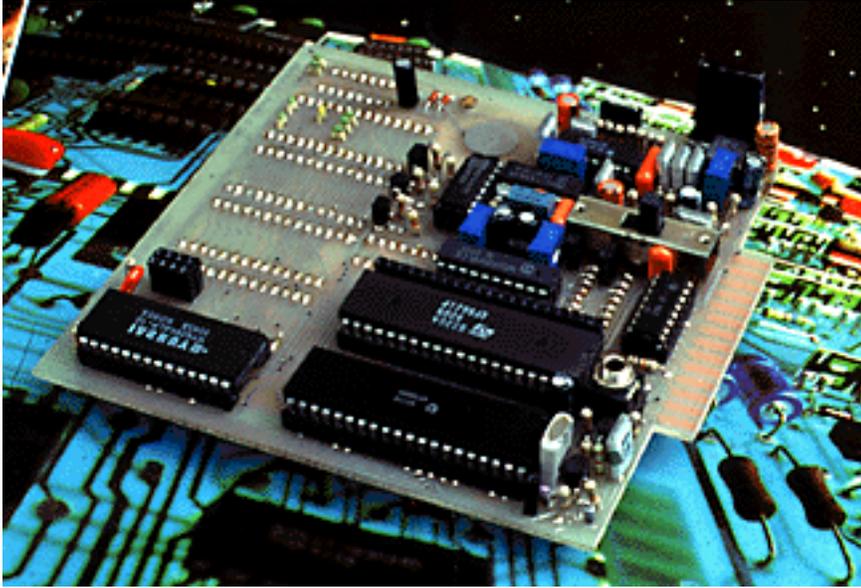
Part 2 will appear next month.

Notes

- (1) The following items are available from the author: a programmed EPROM, \$20, plus \$5 shipping; double-sided PC board and programmed EPROM, \$50, plus \$12 shipping; complete kit of parts, including the PC board and programmed EPROM, \$183, plus \$20 shipping. Payment can be made only by checks drawn on a US bank. Shipment will be made by UPS. Software for this project is available for personal, noncommercial use. It is available as 6809 source code and as binary format files used when programming the EPROM. Price: \$28, postpaid. Please specify 5.25 or 3.5-inch PC/MS-DOS disk size. The software is also available on the ARRL BBS (203-666-0578) as VOICETRK.ZIP. A PC-board template package is available free of charge from the ARRL. *This is a double-sided board requiring plated-through holes.* Components are mounted on *both* sides of the board. Address your request for the BONELLO VOICE-TRACK PC-BOARD TEMPLATE to the Technical Department Secretary, 225 Main St, Newington, CT 06111-1494. Please include a 9×12-inch envelope stamped with 55 cents of First-Class postage.
- (2) This oscillator is not used in the software version. Work is in progress on a beta version that will enable the system to generate CW transmissions, alarms, and will synthesize pure tones and beeps in the 50 to 2000-Hz range.
- (3) A transformerless telephone hybrid appears in the *1992 ARRL Handbook* in Chapter 14, page 21. Phone-patch connections to the telephone lines are subject to FCC rules and regulations, specifically Part 68.
- (4) A simple mathematical equation such as: $CODE = WEEK * 13 + MONTH$ will work fine for generating a two-digit access code. MONTH is a number from 1 to 12, and WEEK is a number from 1 to 5, representing the week number of the month.

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electronic school of the ITBA (Instituto Tecnológico Buenos Aires). He has worked for the Distec company, Buenos Aires, Argentina, designing software for robotic automated machines for the leather industry. He is co-founder of the Digiwave corporation. He taught electronics at the laboratory of Aula XXI High School. Presently he is with the Solidyne Corporation, Buenos Aires, Argentina, working on digital-audio transmission and processing designs.



The Voice-Track repeater controller. (photo by the author)

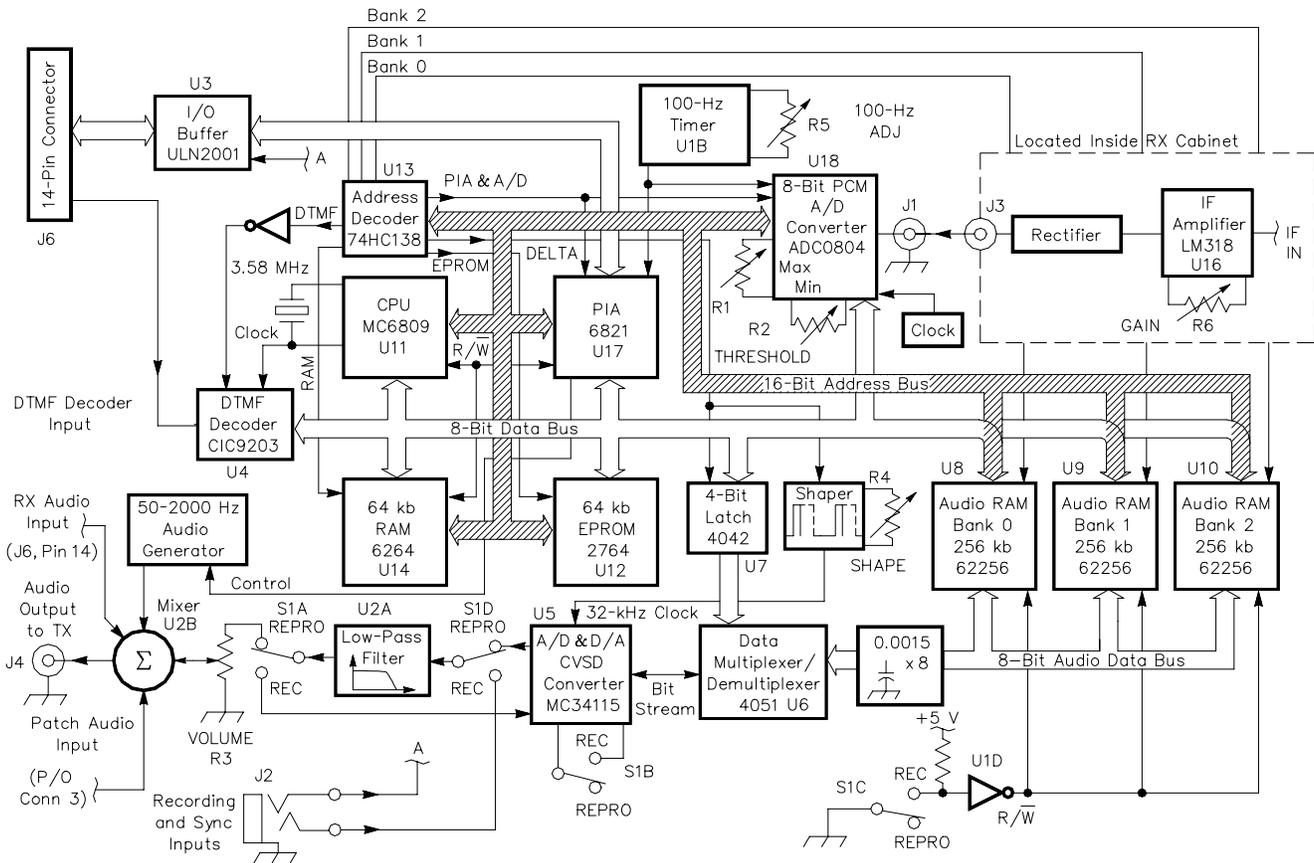


Figure 1—Block diagram of the Voice-Track.

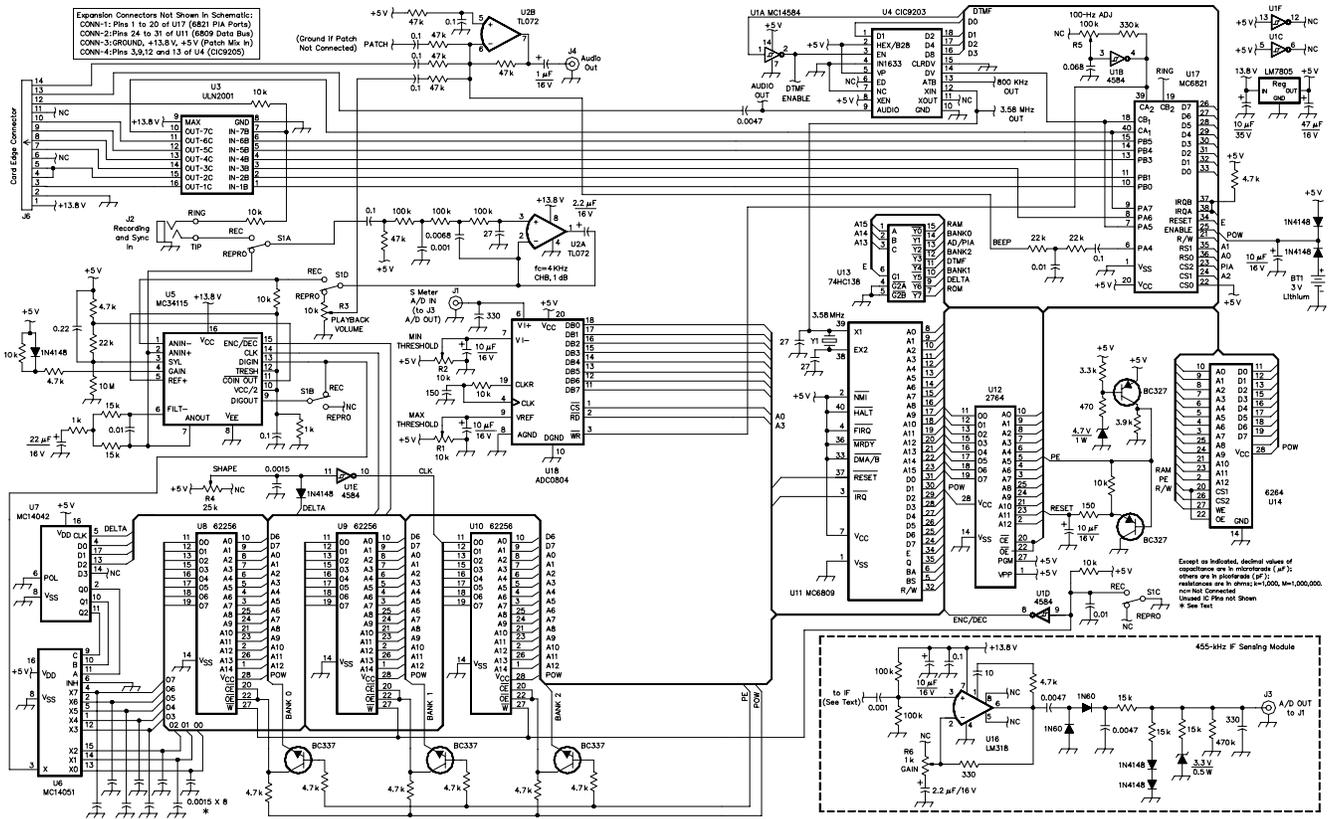


Figure 2—A simplified schematic of the Voice-Track repeater controller. Unless otherwise specified, all resistors are 1/8-W carbon composition or film units and capacitors are rated for 16 V. Although not shown in the schematic, all IC power-supply pins are bypassed with 0.1- μ F capacitors. The bottom-left inset describes four expansion connectors that are on the PC board, but are not shown in this schematic. PC boards and kits are available from the author (see Note 1). The lower-right inset shows the diagram of the IF Sensing Module that's used to feed the speaking S meter.

J6 Pin-Out Identification

Pin No.	Function
1	+13.8 V
2	GND
3	Patch (to enable external telephone hybrid or autopatch)
4	PTT (only in Yaesu mode)
5	PTT (only in Yaesu mode)
6	Not connected
7	TX disable in Yaesu mode; PTT in non-Yaesu mode
8	User pin 1
9	User pin 2

- 10 User pin 3
- 11 Not connected
- 12 Squelch input
- 13 DTMF audio input
- 14 Audio input (to the mixer)

Table 1

Quick Reference Guide for the Voice-Track Programming Mode

Parameters:

- 00 = Enable/disable RPT
- 01 = Enable/disable CTCSS (not yet implemented)
- 02 = CTCSS tone (not yet implemented)
- 03 = Enable/disable pager or code squelch
- 04 = Pager or code squelch code, 15 digits max: ([Code] + # + [Code] + #)
- 05 = Enable/disable phone patch use
- 06 = Enable/disable USER 1 pin
- 07 = Enable/disable USER 2 pin
- 08 = Enable/disable USER 3 pin
- 09 = Enable/disable max. operating time timer
- 10 = Max. operating time xxxx 1/100 sec: (00C7 <xxxx >[26])
- 11 = Enable/disable max. operating time phone announcement
- 12 = Enable/disable automatic phone identification utilities
- 13 = Time between IDs when RPT is not activated xxxx 1/100 sec (<00C7 <xxxx >[14])
- 14 = Time between IDs when RPT is just activated xxxx 1/100 sec (xxxx = 0 off /xxxx < [13])
- 15 = Enable/disable Identification by means of DTMF
- 16 = DTMF code for forced ID (1 digit) (x ≠ A / x ≠ C / x ≠ # / x ≠ * / x ≠ [21])
- 17 = Record message only (8 seconds); pin 12 = 1 starts REC
- 18 = Record All (24.47 seconds) (pin 12 = 1 starts REC)
- 19 = Play All (24.47 seconds) test mode
- 20 = Enable/disable the speaking S meter by means of DTMF
- 21 = DTMF code for the speaking S meter (1 digit) (x ≠ A / x ≠ C / x ≠ # / x ≠ * / x ≠ [16])
- 22 = Squelch tail time xxxx 1/100 sec (In Pager Mode, integration time also)
- 23 = Restore default values—Must be followed by 6666
- 24 = Enable/disable Working for YAESU FTR-710/2410/5410 FM repeaters (when disabled, it works as a full COR system)
- 25 = Enable/disable Instant Mode
- 26 = Instant Mode max admissible time for activation xxxx 1/100 sec (0003 <xxxx <[10])
- 27 = Instant Mode min. admissible time for activation xxxx 1/100 sec (0002 <xxxx <[26])
- 28 = Instant Mode function: 1 = ID / 0 = speaking S meter
- 98 = Change access code for phone patch: ([Code] + # + [Code] + #)
- 99 = Change access code for Programming Mode: ([Code] + # + [Code] + #)

Other Parameters

Phone Patch Code = A + [Access Code]

Boot up code = B
Programming Mode = C + [Access
code Code]
Exit Programming = *
Mode
Abort Parameter entry = #

Voice-Track—A Multifunctional, Talking Repeater Controller —Part 2

This month, we wrap up our description of the Voice Track. You'll learn about its programming mode, how to install Voice-Track in your repeater system and what to do to get it up and running.

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The Programming Mode

All of Voice-Track's features can be enabled or disabled independently. Voice-Track can be customized to meet your special needs by using a DTMF-equipped transceiver, allowing you to modify any of Voice-Track's 25 initial settings. All of the changes are accomplished by first entering the programming mode, which has a special DTMF access code that's 2 to 16 digits long. The default access code is C12345, so if you want to enter the programming mode, you should press the mike's PTT switch and send the DTMF sequence: C12345. In order to avoid leaving the programming mode, *don't release the PTT after this operation!*

Once you've sent the access code, the repeater's transmitter is automatically disabled. This way (if you have a second transceiver to monitor the repeater's output frequency), you can detect that the programming mode has been activated. The next step is to send a two-digit code referring to the number of the parameter you want to change (see Table 1 in Part 1). Each parameter has its own syntax. For example, to disable the repeater, you must first enter its parameter number (00), then another digit indicating whether to enable (1) or disable (0) the repeater.

Once the programming mode has been entered, you can modify several parameters, one after the other. For instance, let's say you enter 051, which means enable/disable phone patch (05); the 1 enables the patch. After this modification, you're returned to the main programming mode menu. If you enter 110, parameter 11 enables/disables the maximum operating time announcement. A 0 disables the phone announcement. You similarly modify all the parameters you desire.

If you make a keyboard error (say you wanted to enter function 00 and instead you entered 08), you send a #, which aborts the current entry and returns you to the main programming mode menu. Once you're there, enter the correct function number (00, in this example) and continue with the programming operation.

If you don't correctly follow the parameter syntax, Voice-Track ignores it. For instance, assume you key 004. Ordinarily, this changes the parameter 00 (repeater enable/disable), but instead of being followed by a 0 or a 1, you sent a 4. Voice-Track ignores the entry and retains the existing parameter and returns to the main programming-mode menu.

Exiting Programming Mode

Once you finish modifying parameters, you exit the programming mode by simply releasing the PTT switch. In case of DTMF interference at the repeater's input, exit the programming mode before ending your transmission. This is done by sending an asterisk (*) before releasing the PTT switch.

Time-Period Definition

Voice-Track uses a custom syntax for defining time periods. For example, if you want to change the time between IDs to 5 minutes 15 seconds, you should send: C12345 10 7B0D *. First, you send the access code (C12345), then the number of the parameter to change. In this case, that's the time between identifications (10). Lastly, you send the time. To

enter it, you must convert the minutes and seconds format to seconds: $5 \times 60 + 15 = 315$, then convert the seconds to hundredths of seconds: $315 \times 100 = 31500$. The resultant value must then be coded *hexadecimally*. Use a scientific calculator (or conversion table) for the base conversion. Note that values A, B, C, and D of the hexadecimal notation correspond to the same letters on the DTMF keypad. The hexadecimal values E and F can't be entered, so the maximum time that can be entered is DDDD (9 minutes 28 seconds).

The parameters for changing the different access codes use a redundancy syntax that works as follows: [enter new code] + # + [enter new code] + #. If the two entries are equal—and their lengths are between 1 and 15 digits—the code is validated. If the entries are different—or have an incorrect length—the existing access code is retained. For instance, let's say you want to change the programming mode code from the default value 12345 to 1994.⁵ You enter C12345 99 1994 # 1994 # *.

What you've done is enter the programming mode (C12345), followed by the parameter for changing the programming mode access code (99). Lastly, you typed the new code followed by the pound sign (1994 #), then entered the new code and the pound sign (1994 #). The access code has been changed, so you exit (*). From now on, to enter the programming mode, you must enter C1994.

System Start-Up

Once the repeater is powered on, Voice-Track does an internal self-check and keeps the repeater transmitter disabled during the first five seconds of operation. If you want to restore the default EPROM parameters, you can send a **B** (for *boot-up*) during this 5-second period (see Table 2). If you don't send the **B** during that time, Voice-Track enables the repeater, identifies it and loads the user-defined parameters.

Should you want to remotely restore the EPROM values, use parameter 23 of the programming mode menu. For security purposes, after entering 23, you must follow it by the number 6666 (arbitrarily chosen!).

Installing the Voice-Track in Yaesu Repeaters

The Voice-Track card is 100% compatible with the Yaesu FTR-710, FTR-2410 and FTR-5410 repeaters. The Voice-Track card-edge connector (J6) must be connected to the 14-pin female connector of the repeater where the optional DTMF unit⁶ goes (also identified as J6). Voice-Track's audio-output connector, J4, connects to pin 4 of the Yaesu repeater connector P7, where the optional ID unit goes.⁷ This connection is made through a shielded cable as shown in Figure 3. Voice-Track must be set to work in the Yaesu's environmental mode. To enable this working mode, enter the programming mode and set parameter 24 to 1, which is also the default value.

In Yaesu repeaters, the hang-up time cannot be changed by the Voice-Track because that operation is performed by the repeater's internal COR.

Installing the IF Sensor in Yaesu Repeaters

Connect the input to the IF sensor to the receiver's second IF, more precisely, to the collector of transistor Q09. Make the connection with a very short wire. Mount the sensor board using two screws to the inside of the receiver's shield cover. Power for the sensor must be derived from pin 8 (+) and pin 1 (-) of the receiver connector J03.

Installing Voice-Track in Other (Non-Yaesu) Repeaters

Voice-Track adapts quickly to practically any repeater because it works directly as a full COR, overriding the repeater's COR, and taking full control of the repeater (refer to Figure 4). You must disable the repeater's identifier, its maximum-operation-time timer and its hang-up timer (you should shorten it as much as possible). You must disable *all* the functions that are controlled by the repeater COR because Voice-Track performs them. (In most repeaters, these functions are disabled by means of DIP switches and trimmer pots; refer to the specific repeater manual for more information).

Intercept the audio and squelch lines from the repeater's receiver and connect Voice-Track to the lines (refer to

Figure 4B). Voice-Track's squelch input is pin 12 of J6. An open squelch (indicating a carrier is present) is represented by 0 V on this pin; a high-voltage state (more than 1.2 V) represents a closed squelch (no carrier present). Voice-Track's squelch output, pin 7 of J6, works with an opposite logic, so 0 V represents closed squelch, and a high-impedance state represents open squelch.

As seen in Figure 4B, an NPN transistor, used as an inverter, makes the input and the output squelch lines logic compatible. Figure 4B and 4C show that positive and negative logic can be accommodated by performing simple modifications such as changing the inverter transistor from the input line to the output one. This is the *only* customi-zation needed to make the Voice-Track work!

Finally, Voice-Track must be set to work as a full COR. To enable this working mode, enter the programming mode and set parameter 24 to 0. *The default value for this para-meter is 1 (Yaesu mode). If you try to use 1 with a non-Yaesu repeater, it will continuously transmit.*

Installing the IF Sensor

The input to the IF sensor must be connected to the receiver's second IF, preferably at the output of an amplifier stage, to avoid excessively loading the IF chain. Nevertheless, the sensor's input impedance is high (25 k + j0 Ω). Connect the IF sensor to an initial 455-kHz stage. I don't recommend connecting the sensor to one of the latter 455-kHz stages because they work as limiters and their signal is not proportional enough to drive an S meter. The maximum RF level at the chosen point must be between 120 mV and 5 V P-P. Those levels allow the IF sensor's variable-gain amplifier, U16, to compensate them. Make the connection with a very short lead. Finally, connect the rectified dc output of the IF sensor (J3) to the Voice-Track ADC input connector (J1) through a shielded cable.

The IF sensor power-supply leads must be connected directly to the repeater's 13.8-V supply. Note: The IF sensor *does not work properly with power-supply voltages less than 11.4 V.*

Voice-Track Calibration

Connect an oscilloscope to pin 10 of the MC14584 (U1E), then make the Voice-Track reproduce audio⁸ by pressing **8** on the keypad (using the default values forces repeater identification). I recommend enabling the Play All Test Mode (which is parameter 19 of the programming mode). That way, the Voice-Track reproduces all 24.5 seconds of audio, giving enough time to make the adjustment. Adjust R4 (**SHAPE**) until you get a symmetrical square wave on the oscilloscope, thus finishing the calibration of the delta sigma converter clock.

Make the Voice-Track reproduce audio again, and adjust the **PLAYBACK VOLUME** (R3) to have the same level as the retransmitted audio.⁹

Connect a frequency counter to pin 4 of the MC14584 (U1B), and adjust R5 (**100-Hz ADJ**) to get a 100-Hz wave. This calibrates the timer's reference clock.

Finally, calibrate the speaking S meter. Start by adjusting the variable-gain amplifier. First, connect an oscilloscope to the IF sensor rectified-output connector, J3 (**A/D OUT**). Then, place a signal generator's signal on the repeater's receive frequency. This carrier should be sufficiently strong to make the IF stages operate at full limiting. Then, adjust R6 (**GAIN**) for a 3-V dc readout on the scope.

Next, adjust the S meter's S1 threshold. Begin by connecting the oscilloscope to pin 9 of the ADC0804 (U18) and adjust R1 (**THRESHOLD MAX**) to get a 1-V readout. Then, connect the oscilloscope to pin 7 of U18 and adjust R2 (**THRESHOLD MIN**) to get a 0-V readout. Place the signal generator (or transmit with an H-T) on the repeater's receive frequency. The carrier should be very weak, and the S/N of the recovered audio should be just enough to drive the DTMF decoder (approximately 20 dB S/N). Activate the speaking S meter (by pressing **3** on the keypad) and readjust R2 until the Voice-Track gives you an S1.

To adjust the S9 threshold, first connect the oscilloscope to pin 9 of U18. Then adjust R1 for a 2.5-V readout. Use a signal generator (or H-T) to generate an S9 carrier on the receiver input. Activate the speaking S meter (by sending a **3**), listen to what Voice-Track says, and adjust R1 until it gives you an S9.

Audio Recording

Voice-Track has two different recording modes. In the first mode, *the ID only* is recorded. In the second mode, *all of the audio* is recorded. Those recording modes correspond to options 17 and 18, respectively, of the programming-mode menu. The recording procedure is the same for both of them.

Table 3 shows the audio-memory time distribution. As you can see, time errors must be kept to a minimum in the recording process. This can be achieved by using a tape recorder and synchronizing the starting time of the playback and the recording start (refer to Figure 5). The plug is inserted into J2 (see Figure 2).

Another approach (which I recommend) is to use a PC-based digital-audio card as the audio source. This way, you can digitally edit the audio on your PC before recording it in the Voice-Track. I've worked successfully with an Audicom card, which is intended for broadcast-station use and has built-in digital-compression algorithms. However, any commercially available multimedia card (such as a Sound Blaster) will work fine.

No matter which audio source you use, the recording procedure is the same. First, connect the recording plug as shown in Figure 5. Once the Voice-Track and the audio source have been linked, set the repeater squelch control fully counterclockwise, for the squelch to remain open during the entire recording procedure. Subsequently, you must enter the programming mode (by default, C12345) and then enter parameter 17 or 18. Next, turn the **Record/Reproduce** switch to the **Record** position. You're now ready to start recording. Set the audio source to playback mode, and at exactly the same time, press the **Start** button (see Figure 5). Voice-Track will start recording, and will stop automatically once the recording time limit is reached.

Once the recording process is finished, set the **Record/Reproduce** switch to the **Reproduce** position. Lock the switch in place. *All audio data stored in RAM can be corrupted or lost if the switch is left in the Record position. Avoid turning the switch to the Record position unless you are about to record the audio!*

Summary

This project presents equipment that shows state-of-the-art technology can be used by radio amateurs to improve the control and telemetry of remote radio communication equipment. This is the first time you can control remotely a repeater so precisely. You are able to switch antennas and see the change in the reception at the repeater, for instance. This is something that many hams have surely dreamed of, but wasn't technically possible only a few years ago.

The Voice-Track is much like the high-tech on-board control computers found in AMSAT satellites. It allows you to efficiently control your repeater, and every parameter of the repeater can be changed *remotely*.

The other fine feature of the Voice-Track is its ability to send *spoken* telemetry—this is the decade of speaking computers. And if you thought that only AT&T Labs had the technology for designing speaking telemetry control systems, you're wrong! Voice-Track shows that the international ham community is capable of designing high-grade control systems based on today's leading-edge technologies.

As Voice-Track is a software-based system, a world of possibilities for future expansion appear over the horizon. As Bob McGwier once said: "With software, all things are possible."¹⁰ Therefore, I request all the hams who are willing to improve the Voice-Track software keep me informed of the software changes, either by mail or by fax¹¹ so I can compile for distribution a full software version with all the features. If you have any question about the software, the hardware, the connection, the customization—or if you're just interested in a new software release, please don't hesitate to contact me. I'll be pleased to help you.

Acknowledgments

I'd like to thank all the hams who showed great interest in the project. Many thanks especially to Raul Prestifilippo, LU3EPH, who asked me to design "...just a simple phone identifier," and for all his trust in a (then) 16-year-old ham; Alfredo Mendoza, LW1ECK, President of the Pinamar Radio Club for supporting the project; Dario Oliver, LW8DFJ, for his

interest and help in the field tests; and Guillermo Ortiz, LU7AEU, for the diffusion he gave to the project in other nearby radio clubs.

Thanks, too, to Iniciativa Foundation staff members, especially to Sebastian Popik for encouraging my self-confidence; to all my friends for their love and support of this "little crazy teenager" my young brother, Leonardo, for all of his repetitive and exhausting testing of the Voice-Track. To my father, Oscar J. Bonello, LU3ACI, for his encouragement and his professional advice in the digital-audio field. To my mother, Maria Teresa, for her confidence and for providing the "sexy" repeater voice. Finally, I thank God for making all of this possible.

Notes

- (5) Note that Voice-Track always adds the letter C preceding the Programming Mode access code. For the phone patch, Voice-Track precedes the access code with an added letter A, which stands for Autopatch.
- (6) Refer to your repeater manual for more information.
- (7) Refer to the repeater unit connection diagram on page 73 of the Yaesu repeater manual for more information.
- (8) This adjustment can be performed before you have recorded the audio.
- (9) This adjustment *must* be performed *after* you have recorded the audio.
- (10) Martin Davidoff, K2UBC, *The Satellite Experimenter's Handbook*, (Newington: ARRL, 1990), Appendix B, page 32.
- (11) My fax number is 54-1-702-2375, accessible 24 hours a day.

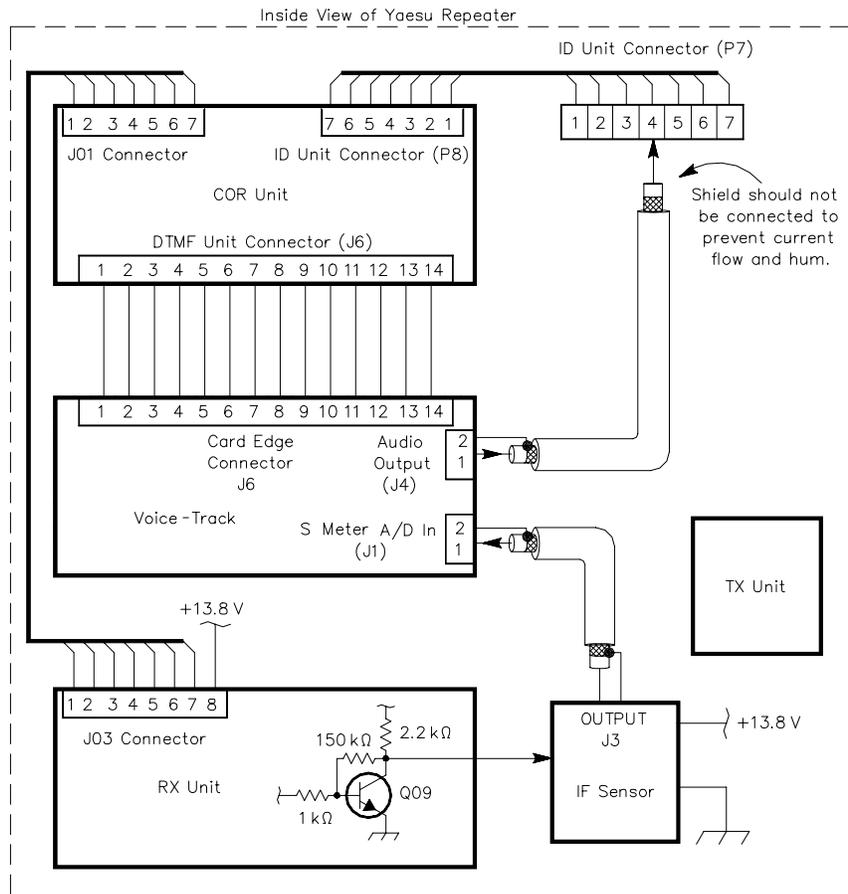


Figure 3—Voice-Track connection diagram for Yaesu repeaters. Notice that the audio-output cable of the Voice-Track is grounded only at one end to avoid inducing hum.

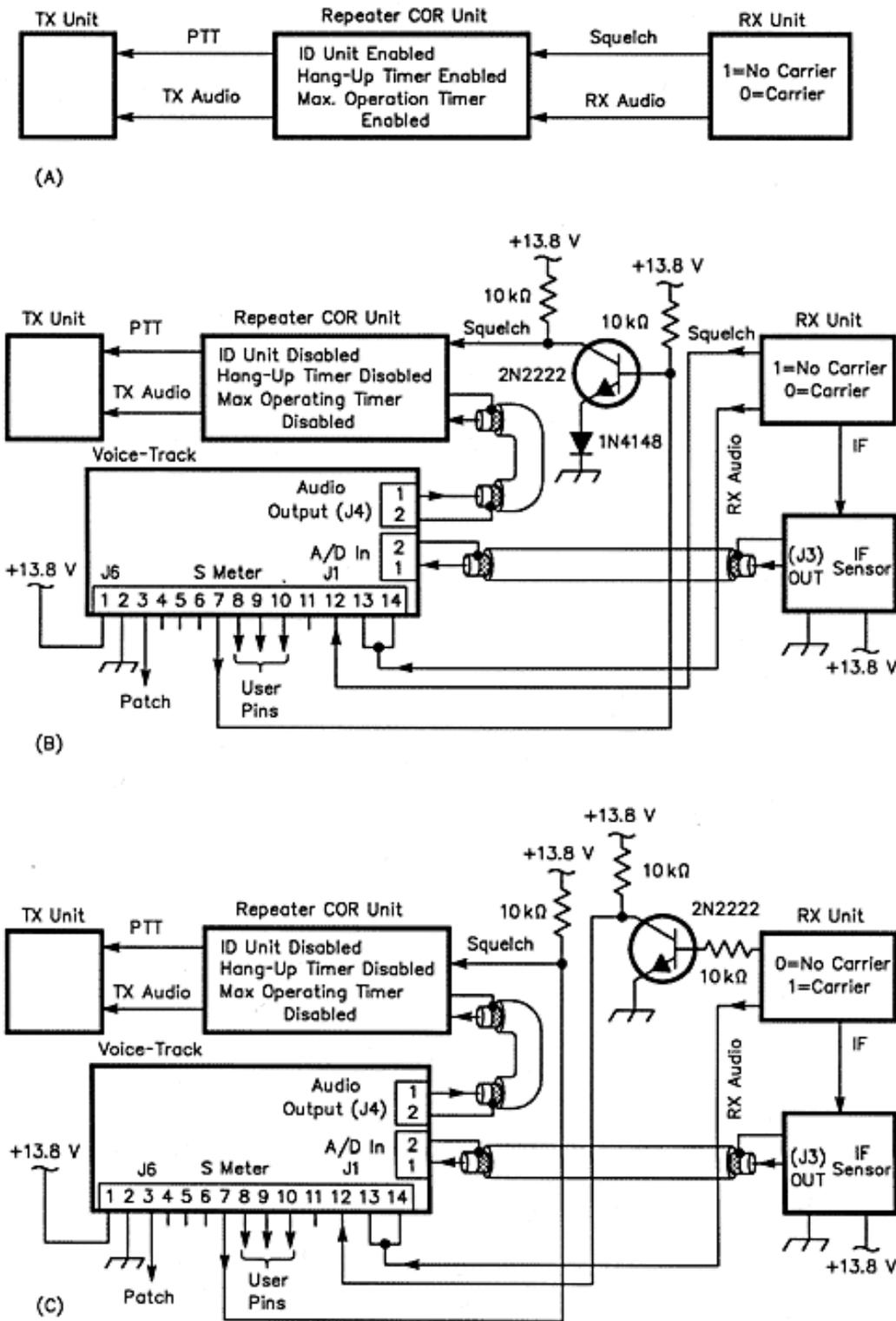
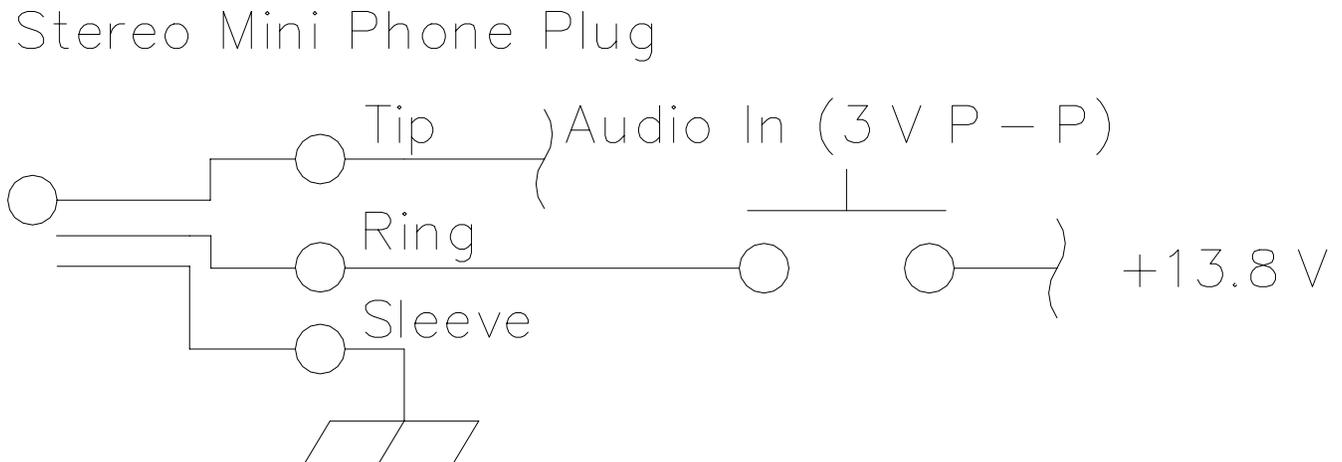


Figure 4—Voice-Track connection to non-Yaesu repeaters: (A) when a standard built-in repeater control is used; (B) the same repeater is connected to the Voice-Track, and (C) the same configuration is used, but with opposite logic from the receiver.



When the Pushbutton is Pressed,
the Recording Begins

Figure 5—Connection between the Voice-Track and an external audio source. For synchronization purposes, a pushbutton is used. Remember to always leave the repeater squelch *open* during a record operation.

Table 2

EPROM Default Values of the Voice-Track.

These values can be loaded by using option 23 of the programming mode menu, or by sending a B (for boot-up) just after the system is powered up.

- 00 = 1
- 01 = x (not yet implemented)
- 02 = x (not yet implemented)
- 03 = 0
- 04 = 111
- 05 = 1

06 = 0
07 = 0
08 = 0
09 = 1
10 = 3A98 (2 min, 30 sec)
11 = 1
12 = 1
13 = 4650 (3 min)
14 = 1D4C (1 min, 15 sec)
15 = 1
16 = 8
20 = 1
21 = 3
22 = 0064 (1 sec)
24 = 1
25 = 0
26 = 0032 (500 ms)
27 = 0003 (30 ms)
28 = 0
98 = 1210
99 = 12345

Table 3

Audio-RAM Distribution Segments

Example:

<i>TIME</i>	<i>RECORDED MESSAGE</i>
00-08	: Hi! I'm the computerized repeater of the Silicon Valley Radio Club. I'm transmitting with 50 watts from a height of 200 feet
08-12	: You are reaching the repeater with an S
12-13	: One
13-14	: Two
14-15	: Three
15-16	: Four
16-17	: Five
17-18	: Six
18-19	: Seven
19-20	: Eight
20-21	: Nine
21-24, 47	: Maximum operating time exceeded